ISMP2018
BORDEAUX

23rd International Symposium on
Mathematical Programming

July 1 – 6

The World Congress of Mathematical Optimization

Held triennially on behalf of the Mathematical Optimization Society

@ismp2018

https://ismp2018.sciencesconf.org

23*rd* International Symposium on Mathematical Programming (ISMP)

The World Congress of the Mathematical Optimization Society (MOS)

Bordeaux, July 1-6, 2018

Contents

Thanks to our sponsors:

Welcome Address

It is a great pleasure to welcome all of you to Bordeaux for this triennial international congress of mathematical optimization. ISMP is the symposium of the Mathematical Optimization Society (MOS). It gathers scientists from all over the world as well as industrial practitioners of mathematical optimization. Attendees present their most recent developments and results and discuss new challenges from theory and practice.

This 23rd edition of the symposium is organized by the mathematical optimization group of the University of Bordeaux with the contributions of other mathematical optimization researchers of the French community. The core of the local organizers is structured around the Inria project team Realopt which is a joint venture between the University, Inria and two CNRS research labs of the University: the Mathematics Institute (IMB - team OPTIMAL - in Mathematical Optimization, Stochastic Models and Statistics) and the Computer Science Lab (LaBRI - team Combinatorics and Algorithms). The practical organization is taken care of by the congress office of the University of Bordeaux, the communication office of Inria-Bordeaux, and the ADERA congress service, with the support of the University of Bordeaux Initiative of Excellence (Idex) and the Regional authorities of Nouvelle-Aquitaine.

This edition is the outcome of a collaborative venture involving the participation of many members of the international community. The program committee has done a great job in reaching out to invited speakers. It was headed by Michael Jünger who has also been so active in driving the special issue of Math Programming B. Through the scientific committee, we have put many people to work for co-opting invited sessions and performing the immense editorial task of gathering talks into sessions. The support services of our institutions and the local team have been largely put to contribution on all aspects of the organization. We want to highlight the tremendous job done by our engineers, Philippe Depouilly and Laurent Facq, to setup the editorial platform, and by our colleagues to optimize the schedule, in particular Pierre Pesneau who implemented the scheduler, while our students have contributed to deliver automation tools. Last but not least, we are deeply grateful to the cohort of volunteer students and staff who are key elements of the logistical organization during the ISMP week.

The happening is yours. Your scientific contributions are feeding the interesting program which we shall all benefit from. So thank you for your participation and let us enjoy this congress, learn from it, and build the network of your future collaborations.

François Vanderbeck
University of Bordeaux
& Inria Bordeaux

The Organization Committees

Conference Chair

General Chair:
François Vanderbeck, Prof., U. Bordeaux & Inria team Realopt

Co-Chair:
François Clautiaux, Prof., U. Bordeaux & Inria team Realopt

Program Committee

The program committee is in charge of inviting plenary, semi-plenary, and keynote speakers. The program committee chair acts as guest editor for this special MPB issue. The members are:

Chair:
Michael Jünger, Prof., University of Cologne, Germany

For Cluster 1: Discrete Optimization and Integer Programming
Dan Bienstock, Prof., Columbia University, USA
Gerard Cornuéjols, Prof., Carnegie Mellon University, USA
Michel Goemans, Prof., Massachusetts Institute of Technology, USA

For Cluster 2: Optimization under Uncertainty
Laurent El Ghaoui, Prof., UC Berkeley, USA
Simge Küçükyavuz, Prof., University of Washington, USA
Daniel Kuhn, Prof., Ecole Polytechnique Fédérale de Lausanne, Switzerland

For Cluster 3: Continuous Optimization
Frank Curtis, Asoc. Prof., Lehigh University, USA
Claudia Sagastizabal, Researcher, IMPA (Mathematical sciences research institute), Brasil
Stephen Wright, Prof., University of Wisconsin-Madison, USA

For Cluster 4: Problem Specific Models, Algorithm Implementations, and Software
Michael Ferris, Prof., University of Wisconsin-Madison, USA
Martine Labbé, Prof., Université Libre de Bruxelles, Belgium
Stefan Wild, Researcher, Argonne, USA

Representing the Organization Committee:
François Clautiaux, Prof., U. Bordeaux & Inria team Realopt
François Vanderbeck, Prof., U. Bordeaux & Inria team Realopt (Vice Chair)

Scientific Committee

The scientific committee is in charge of the scientific content of the parallel sessions, co-opting scientific personnalities to propose a whole session, and gathering contributed talks into coherent sessions. The members are:

1. **Cluster on Discrete Optimization and Integer Programming**
   (a) IPtheory: Integer Programming Theory (Polyhedral Study, Lattices, Extented Formulations...):
   Michele Conforti, Fritz Eisenbrand, Volker Kaibel, Ridha Majhoub
   (b) IPpractice: Integer Programming Algorithms (Branch-and-cut, Reformulations and Decomposition, ...)
   Sanjeeb Dash, Adam Letchford, Ivana Ljubic, Marc Pfetsch
   (c) MINLP: Mixed Integer Non-linear Programming
   Jeff Linderoth, Andrea Lodi, Jean-Philippe Richard, Frédéric Roupin
   (d) APPROX: Complexity, Approximation and Online Algorithms
   Lionel Eyraud-Dubois, David P. Williamson, Rico Zenklusen
   (e) COMB: Combinatorial Optimization and Graph Theory
   Laura Sanità, Gianpaolo Oriolo, Arnaud Pêcher, Nicolas Trotignon
   (f) CP: Constraint Programming
   Louis-Martin Rousseau, Ruslan Sadykov, Pascal Van Hentenryck

2. **Cluster on Optimization under Uncertainty**
   (a) Stoch: Stochastic Optimization
   Boris Detienne, James Luedtke, Alexander Shapiro
   (b) Robust: Robust Optimization
   Dimitris Bertsimas, Christoph Buchheim, Michael Poss
   (c) Markov: Dynamic Programming, Markov Decision Processes, and Simulation
   François Dufour, Stéphane Gaubert, Huseyin Topaloglu
   (d) Game: Game theory, Bi-level and Multi-Objective Optimization
   Luce Brotecorne, Roberto Cominetti, Kathrin Klamroth

3. **Cluster on Continuous Optimization**
   (a) NLP:Linear and Nonlinear Optimization, Sparse Optimization and applications
   Immanuel Bomze, Jean-Charles Gilbert, Jérôme Malick
   (b) Global: Global Optimization
   Mirjam Dür, Jean-Baptiste Hiriart-Urruty, Yaroslav Sergeyev
   (c) NonSmooth: Nonsmooth Optimization
   Jean-François Aujol, Amir Beck, Antonio Frangioni, Yurii Nesterov
   (d) SDP: Conic Programming, Quadratic Programming and Semi-Definite Programming
   Sourour Elloumi, Franz Rendl, Angelika Wiegele
   (e) Variat : Variational Analysis, Variational Inequalities and Complementarity.
   Samir Adly, Xiaojun Chen, Boris Mordukhovich
   (f) RandomM: Random Methods for Continuous Optimization (Stochastic Gradient, . . .)
   Guanghui (George) Lan, Artur Pessoa, Lin Xiao
   (g) DerFree: Derivative-free and Simulation-based Optimization
   Charles Audet, Serge Gratton, Katya Scheinberg
   (h) Control: Optimal Control, PDE Constrained Optimization, and Multi-level Methods
   Jean-Bernard Lasserre, Stefan Ulbrich, Emmanuel Trelat

4. **Cluster on Problem Specific Models, Algorithm**
   (a) Learning: Machine Learning, Big Data, Cloud Computing, and Huge-Scale Optimization
   Alexandre d'Aspremont, Olivier Beaumont, Peter Richtarik, Suvrit Sra
   (b) Network: Network Flow, Network Design, and Applications in Telecom and Traffic Management
   Bernard Fortz, Bernard Gendron, Luis Gouveia
   (c) Logistics: Packing, Logistics, Location, and Routing
   Jean-François Cordeau, Frédéric Semet, Eduardo Uchoa, Daniele Vigo

(d) Scheduling: Scheduling, Planning and Applications in Manufacturing Systems and Healthcare
Tom McCornick, Gautier Stauffer, François Soumis, Matthieu VanVyve

(e) Energy: Optimization for Environmental, Energy, and Engineering Systems
Miguel Anjos, Claudia d'Ambrosio, Christine Shoemaker, Golbon Zakeri

(f) Sciences: Optimization in Sciences, Computational Biology, Societal Issues, Finance, and Economics
Sonia Cafieri, Leo Liberti, Britta Peis

(g) Algo: Math Programming Algorithm Implementations, Parallel Computing, and Software
Tobias Achterberg, Giacomo Nannicini, Pierre Pesneau, Andrea Tramontani

Local Committee

The organization committee is in charge of the logistic of the conference. The members are:

- Séverine Valerius and Flavie Attigui, Inria Bordeaux (Communication)
- Marie Henault and Sabine Raposo, University congress support team (Location)
- Joelle Lacoste-Rodrigues and Solène Audoux, Inria Bordeaux (Accomodation and administrative issues)
- Isabelle Voirin, Magalie Garcia, and Jean Rivenc, Adera support (PCO, Registration, and accounts)
- Philippe Depouilly and Laurent Facq, CNRS (Information technology)
- Pierre Pesneau, Assoc Prof., University of Bordeaux (Conference Program)
- François Vanderbeck, Prof., University of Bordeaux (Chair)

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GAMS is one of the leading tool providers for the optimization industry. With customers in more than 120 countries, GAMS is used by multinational companies in many different industries, universities, research institutions, and governments. GAMS combines the language of mathematics (algebra) with concepts from programming and introduces a model-based approach in order to efficiently describe and solve optimization problems. This concept is the most productive way to implement large-scale optimization models. Their mission is to make modelers from all areas more productive by providing them with the best possible tool for their optimization purposes. For more information, visit `https://www.gams.com`

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LINDO SYSTEMS INC.

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Useful Information

Conference Sites

The conference takes place in the center of the city of Bordeaux over two sites:

"Victoire" is the main site where all parallel sessions and keynote talks take place. It is located on Place de la Victoire, 33000 Bordeaux (the lower red dot on the map). The buildings are identified by a letter as presented below. This building reference is reported in the schedule along the name of the room.

"Auditorium" is the secondary site where all parallel plenary and semi-plenary sessions take place, as well as the opening ceremony. It is located on 9-11-13 cours Georges Clemenceau 33000 Bordeaux (the upper red dot on the map).

The two sites are within a 15 minutes walk or a two-stop ride per tramway (with one tramway every 3 to 5 minutes). The registration desk has 1500 tramway/bus pass to distribute to those of you who prefer to take the tramway rather then walking. Note that the tramway will be overcrowded if all of us attempt to transfer between the two sites via this line. Hence, please consider walking. Tramway/bus pass may be useful to attendees having their accommodation far away for the conference site. They will be distributed on the first come first served basis, but their number should be largely sufficient to cover all requests.

37 salles
7 amphis

Bâtiment A
Salle 45 : 3ème étage - 25 pax
Salle 46 : 3ème étage - 25 pax
Salle 47 : 3ème étage - 20 pax
Amphi Durkheim : 3ème étage -194 pax

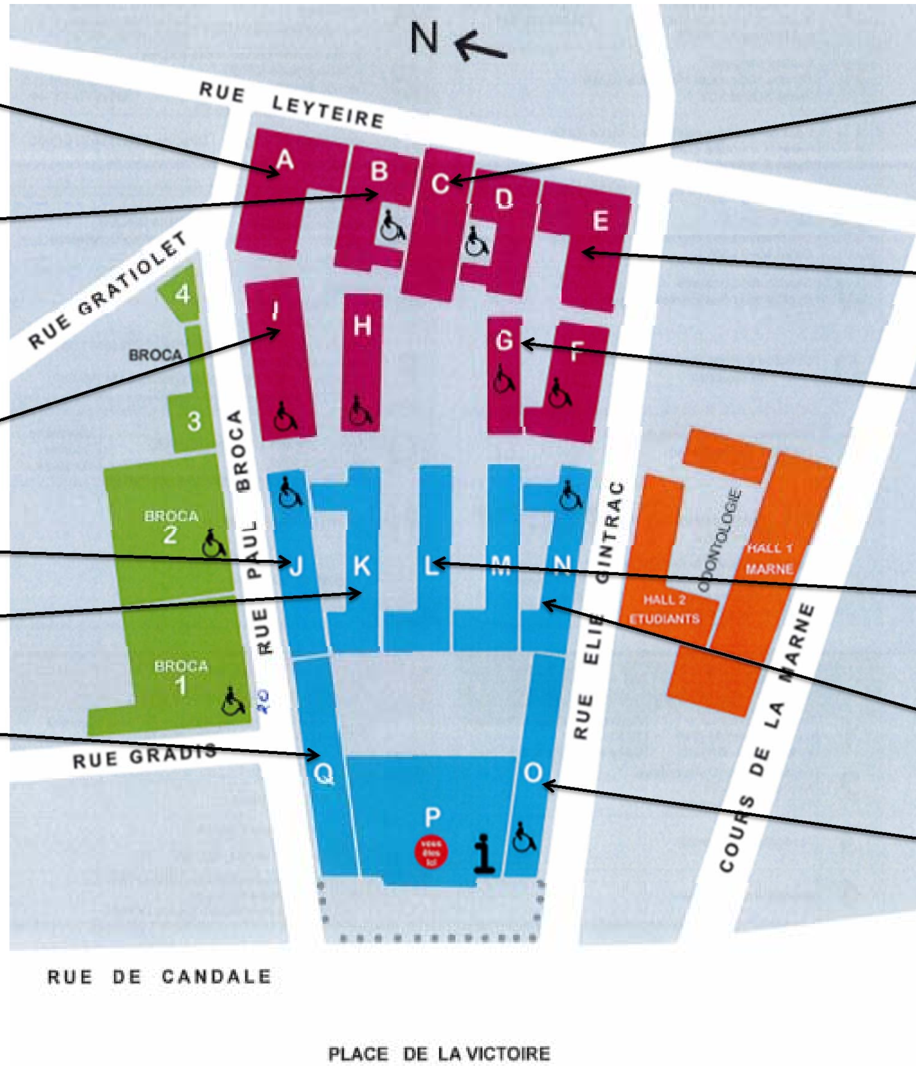
Bâtiment B
Salle 30 : RDC - 20 pax
Salle 31: RDC - 30 pax
Salle 32 : RDC - 40 pax
Salle 33 : RDC – 50 pax
Salle 34 : 1er étage – 50 Pax
Salle 35 : Entresol – 50 pax
Salle 36 : Entresol – 40 pax
Salle 37 : Entresol – 50 pax

Bâtiment I
Salle 16 : 2ème étage – 34 pax
Salle 18 : 1er étage – 25 Pax

Bâtiment J
Amphi Fabre : RDC – 80 pax

Bâtiment K
Salle KC6 : Entresol 1 – 40 pax
Salle KC7 : Entresol 1 – 30 pax

Bâtiment Q
Salle 05 :1er étage – 90 pax
Salle 06 : 1er étage – 90 pax
Salle Arnozan : RDC – 44 pax
(stockage du matériel des exposants le soir)
Salle Dénucé : RDC – 88 pax
Amphi Gintrac : RDC – 160 places



Bâtiment C
Salle 44: 3ème étage - 40 pax
Salle 43 : 3ème étage - 30 pax
Salle 42 : 3ème étage – 20 pax
Salle 41 :3ème étage – 40 Pax
Amphi Sigalas : 2ème étage – 190 pax
Amphi Deniges : RDC – 280 pax

Bâtiment E
Salle 40 : 3ème étage – 20 pax
Salle 39 :3ème étage – 40 Pax
Amphi E/Leyteire : 3ème étage – 172 pax

Bâtiment G
Salle Auriac : 1er étage – 40 pax
Salle 20 :1er étage – 60 Pax
Salle 21: Entresol – 40 Pax
Salle 22: 2ème étage – 25 Pax
Salle 23 :3ème étage – 40 Pax
Salle 24 : 3ème étage – 60 Pax

Bâtiment L
Salle LA3: Sous-sol – 16 pax
Salle LA 4:Sous-sol 1 – 36 Pax
Salle LC4: Entresol 1 – 38 Pax
Salle LC5: Entresol 1 – 40 Pax

Bâtiment N
Salle 8: 4ème étage – 60 pax
Salle 9 : 4ème étage – 25 Pax

Bâtiment O
Amphi pitres : RDC – 148 pax

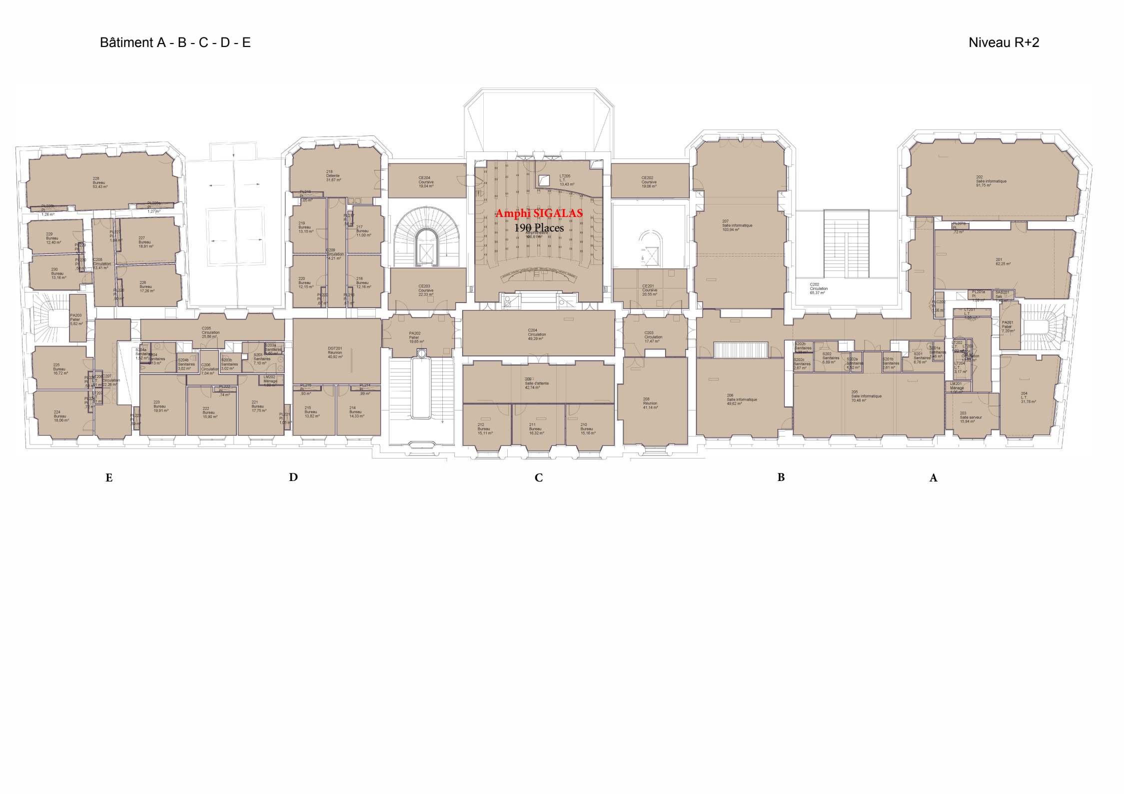
13/12/2017

Campus Zones

A partition of Victoire campus per zone rather than per building is described below. A **zone is associated to a floor** that spans over several builings of a given area of the campus. Zones are numbered in sequential order of their cummunitation link (stairway or corridor path).

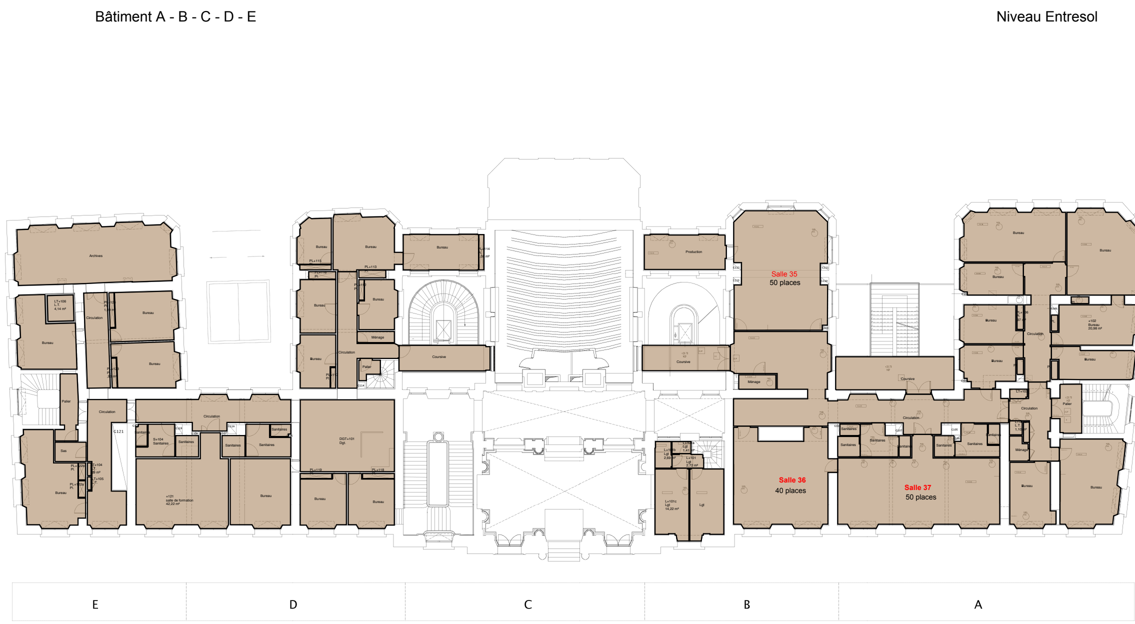
Zone 1 across buildings ABCDE, 3^d floor

Zone 2 across buildings ABCDE, 2^d floor

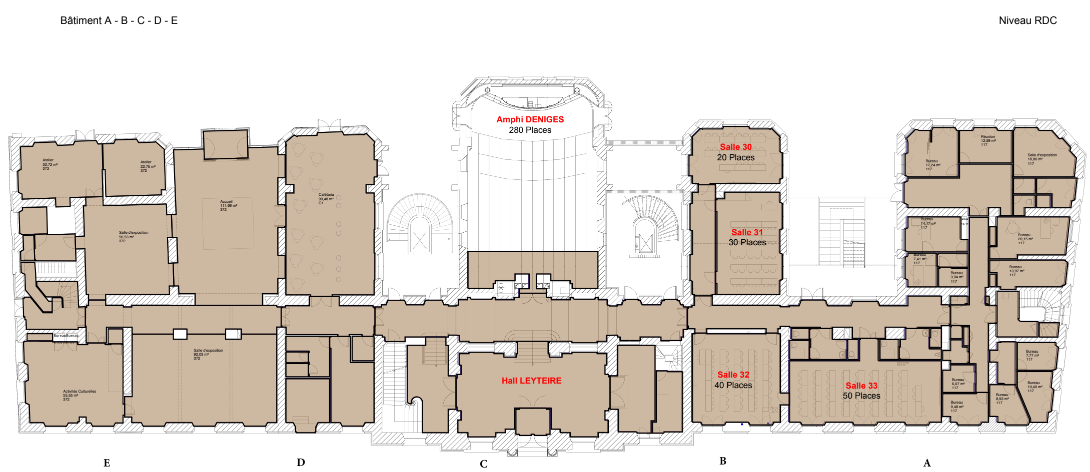


Zone 3 across buildings ABCDE, 1^{th} floor

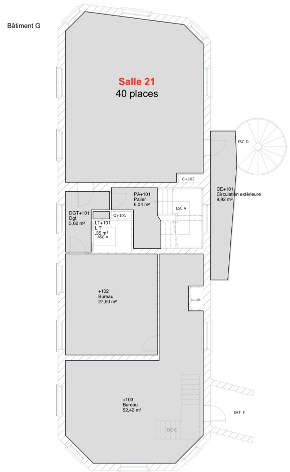
Zone 4 across buildings ABCDE, 1^{th} intermediate floor



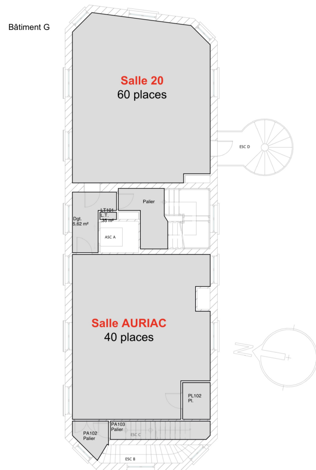
Zone 5 across buildings ABCDE, ground floor



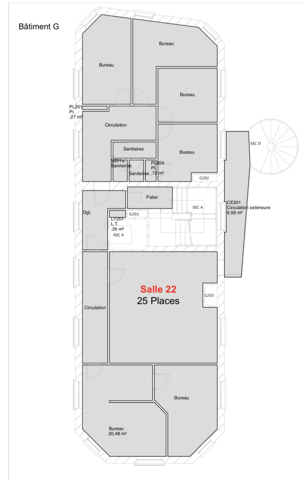
Zone 6 building G, all floors



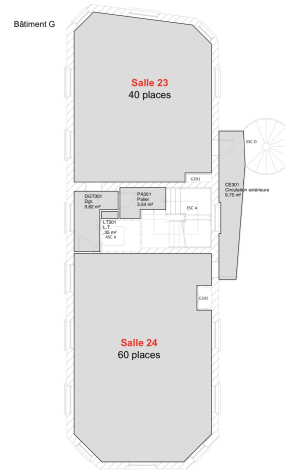
intermediate



1th floor



2d floor



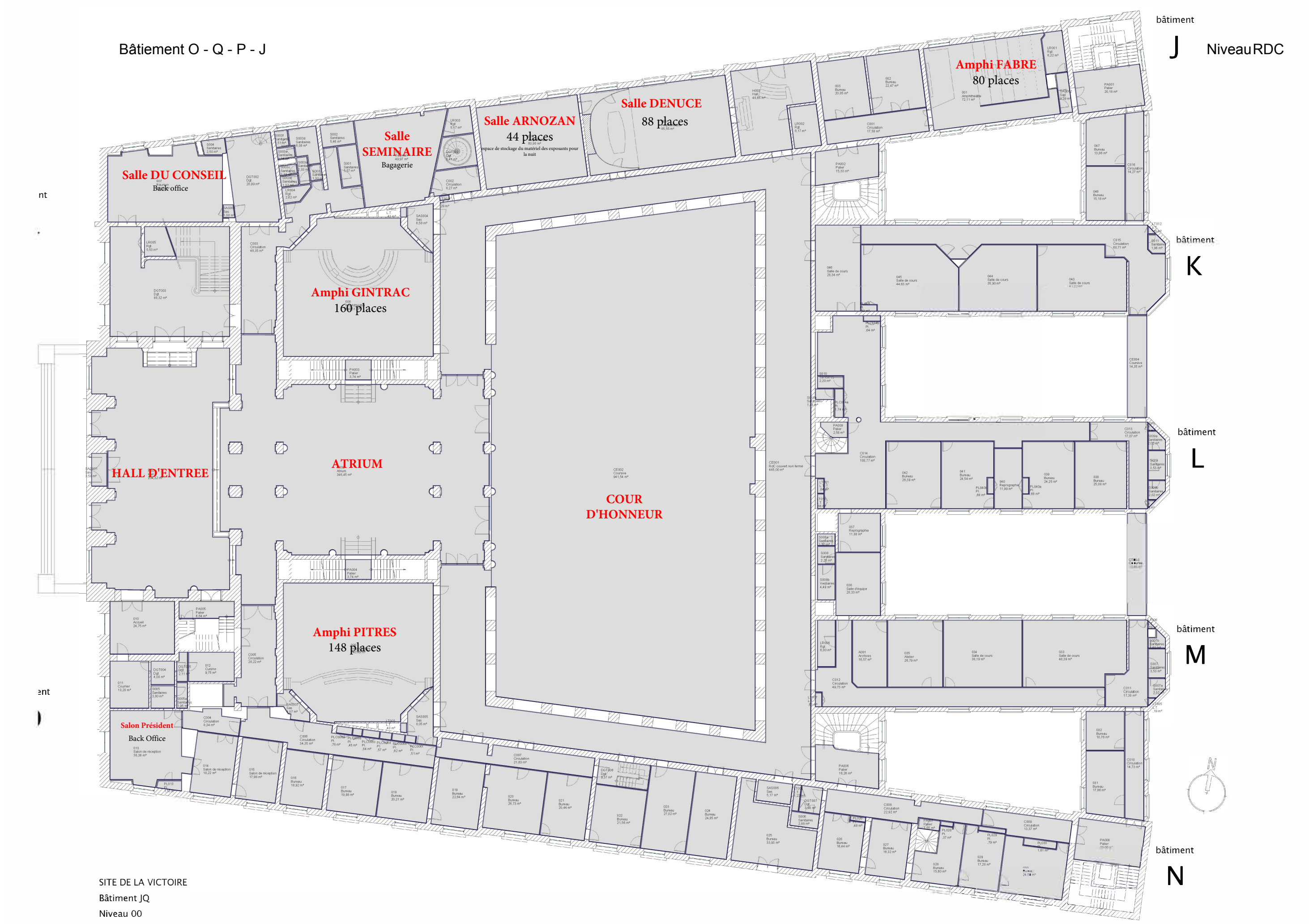
3d floor

Zone 7 building I, all floors

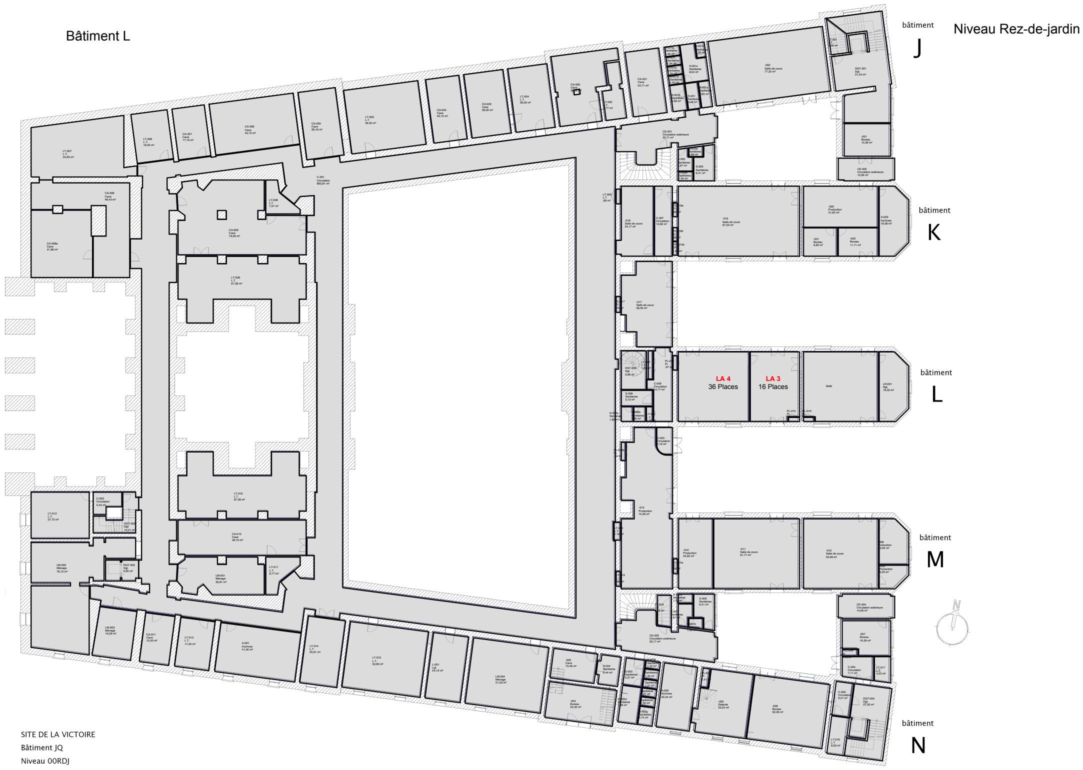
1th floor

2d floor

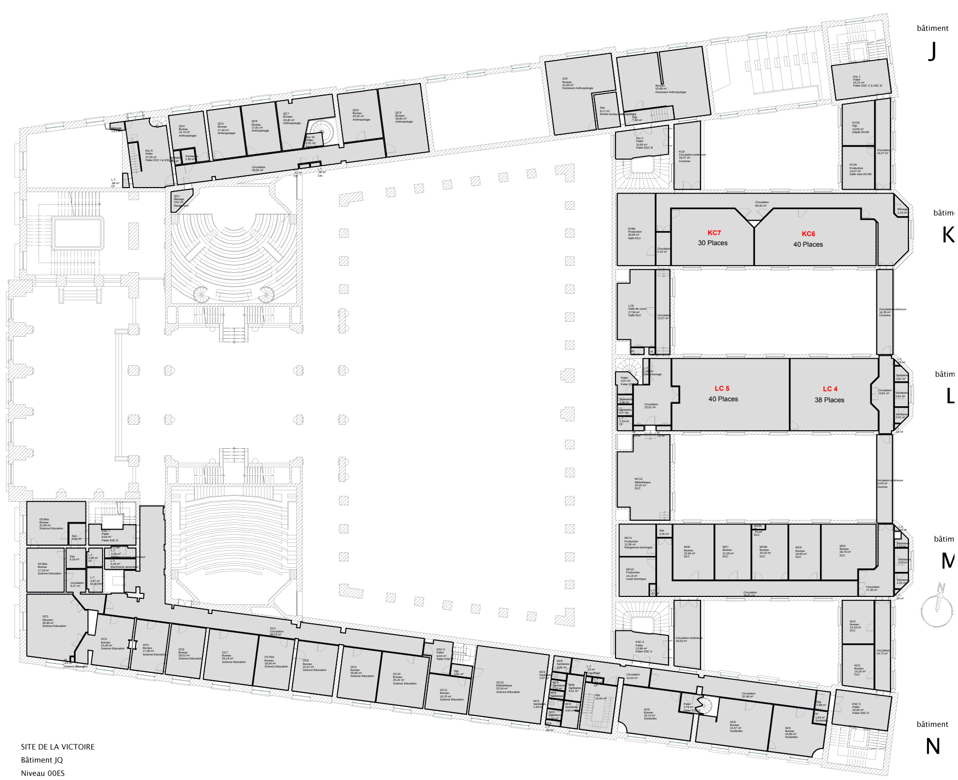
Zone 8 buildings JKLNOQ, ground floor



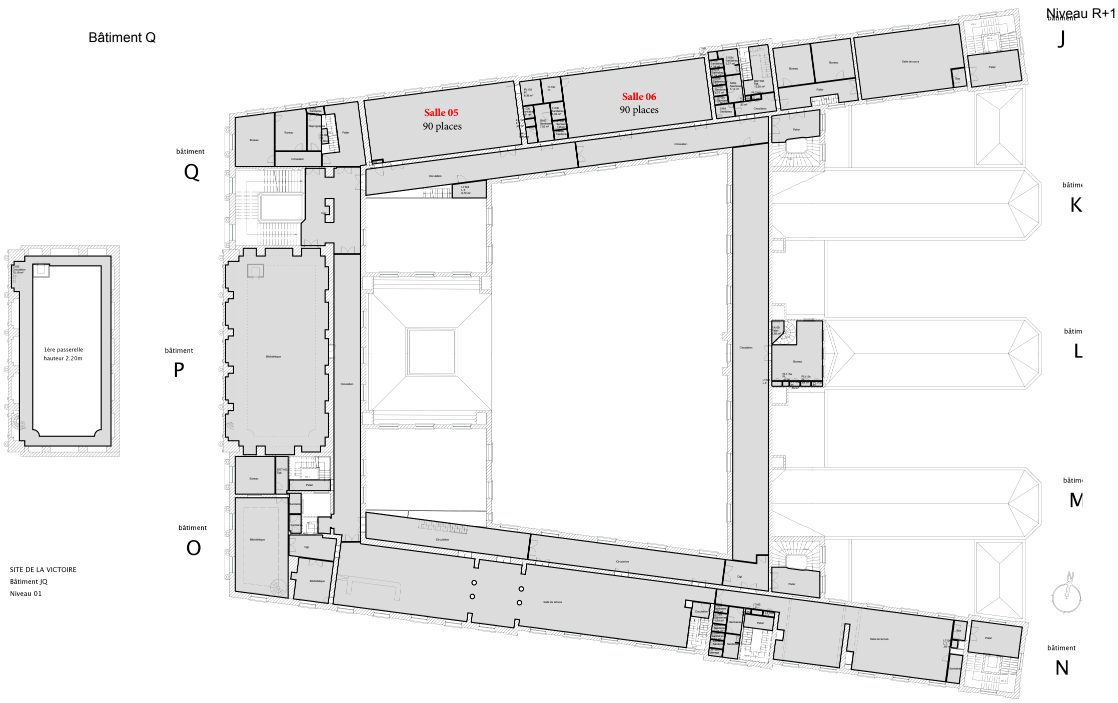
Zone 9 buildings JKLNOQ, 1^{th} intermediate floor



Zone 10 buildings JKLNOQ, 2^{d} intermediate floor



Zone 11 buildings JKLNOQ, 1^{th} floor



Zone 12 buildings JKLNOQ, 4^{th} floor

no picture

Registration

- The registration desk is at the entrance of the main Victoire site.
- Registration is open on Sunday July 1 from 2pm to 8pm. You are invited to collect your badge and goodies on your arrival.
- The registration desk will remain open all week for late arrival, on-site registration, and information queries from Monday to Friday from 8:30 am to 6:30pm.
- Note that no registration is possible at the secondary site of the Auditorium.
- We did send you by email a pdf file with your badge. So, if you cannot make it in time to the registration desk (or wish to avoid the queue) before attending your first session, you may get access to the conference by presenting your own print of your badge. It needs not be in color, a basic black and white copy will do as the access code printed on the badge can be read in B&W. In any case, a color copy is waiting for you at the registration desk.

ISMP App

The ISMP2018 App is available on `https://ismp2018.u-bordeaux.fr/program`. It allows you to consult the conference program, the authors list, and the room map.

- Talks are sorted by day and session. Select a day on the top bar. Click on a session to see the talk details.
- Swipe left on a talk to add it to your favorites. Swipe left on a favorite to remove it.
- For quicker navigation, you can use the filter menu to select only streams that are if interest to you. To unselect streams that you don't want usie the top right filter button.
- For offline mobile consultation: you can easily download the website app as an autonomous application (PWA). Under Android or iOS, go into your browser menu, and select "Add to Home screen".
- To refresh data on the schedule view, swipe down at the top of the page.

The Scheduler

You might be curious to know how the program has been established. From your talk submissions, the scientific committee of each stream has build sessions, indicating the expected attendance and the potential conflicts with other sessions of their own stream or with other streams. They also implemented time restrictions and precedence constraints. The scheduler had this information along side the expected attendance in each stream thanks to your input on the fraction of your time that you plan to spend in each stream. The scheduler went through a sequence of optimization stages to build a program with the following goals: first to minimize the number of parallel tracks in each thematic area; second to spread evenly the high profile sessions, while reducing the spread of the mini-symposia; third to avoid to schedule in parallel sessions that are destined to a same public (including the co-authors whishing to avoid having their talks in parallel); fourth to cluster streams geographically trying to keep their room assignment stable.

Lunch breaks

Lunches are on your own. The late morning and early afternoon sessions are purposely on different sites so as to spread the crowd in town for lunch. There are two food trucks on the Victoire site as well as a sandwich bar (the latter runs only from Tuesday onwards).

Coffee breaks

Coffee breaks are served in the morning from 10:30am to 11am on the ground floor at both end of the Victoire campus (Buildings C and P). French pastries are offered. There are no coffee breaks at the Auditorium. At the afternoon break, no coffee is served. However self-service expresso machines are disseminated on the Victoire campus along with water bottle for your comfort at any time of the day.

Wifi connection

At the Victoire site, you can connect using either your "eduroam" account, or on the REAUMUR network using the ISMP account:

Login: ISMP-n-1 Password: q3#bjkG

Instructions to Speakers

Each lecture room is equipped with a video projector requiring a **VGA connection**. Speakers are expected to bring their own laptop for their presentation. However, for easy transition between talks, we ask that all the speakers of a session collect their talks on a single computer (typically the laptop of the last speaker). Please introduce yourself to the chairman of the session before hand by getting to the lecture room at least 5 minutes prior to the session start time. We strongly advice speakers to have their slides in a **PDF format**. Please avoid powerpoint or any other specific software.

Instructions to Chairpersons

Please get to your lecture room at least 10 minutes prior to the session start time. Collect all the presentations, preferably in a pdf format, on a single computer and check that the video retransmission is working OK for each talk. It is absolutely necessary to keep to the exact time slots that are assigned in the conference program. Sessions do come in two formats, either 30 minute talks or 20 minute talks. Please do not take the liberty to change the length of time that is assigned to a speaker, as it is essential to allow the attendees to synchronize their selection as announced in the program. In the same line, if a talk is canceled, do not move other talks forward but leave the slot empty.

Video Retransmission

The opening ceremony, as well as the plenary and semi-plenary sessions, that take place at the Auditorium, are retransmitted on the Victoire site in the following rooms: **Amphi Broca** (external building, top floor), **Amphi Gintrac** (Building Q, ground floor) and **Amphi Pitres** (Building O, ground floor).

Welcome Event on Sunday

Alongside registration on Sunday afternoon from 2pm to 8pm, we have a wine tasting event at the Victoire site to welcome you in Bordeaux. Attendees who have not registered for this event can do it on site.

Conference Dinner on Wednesday

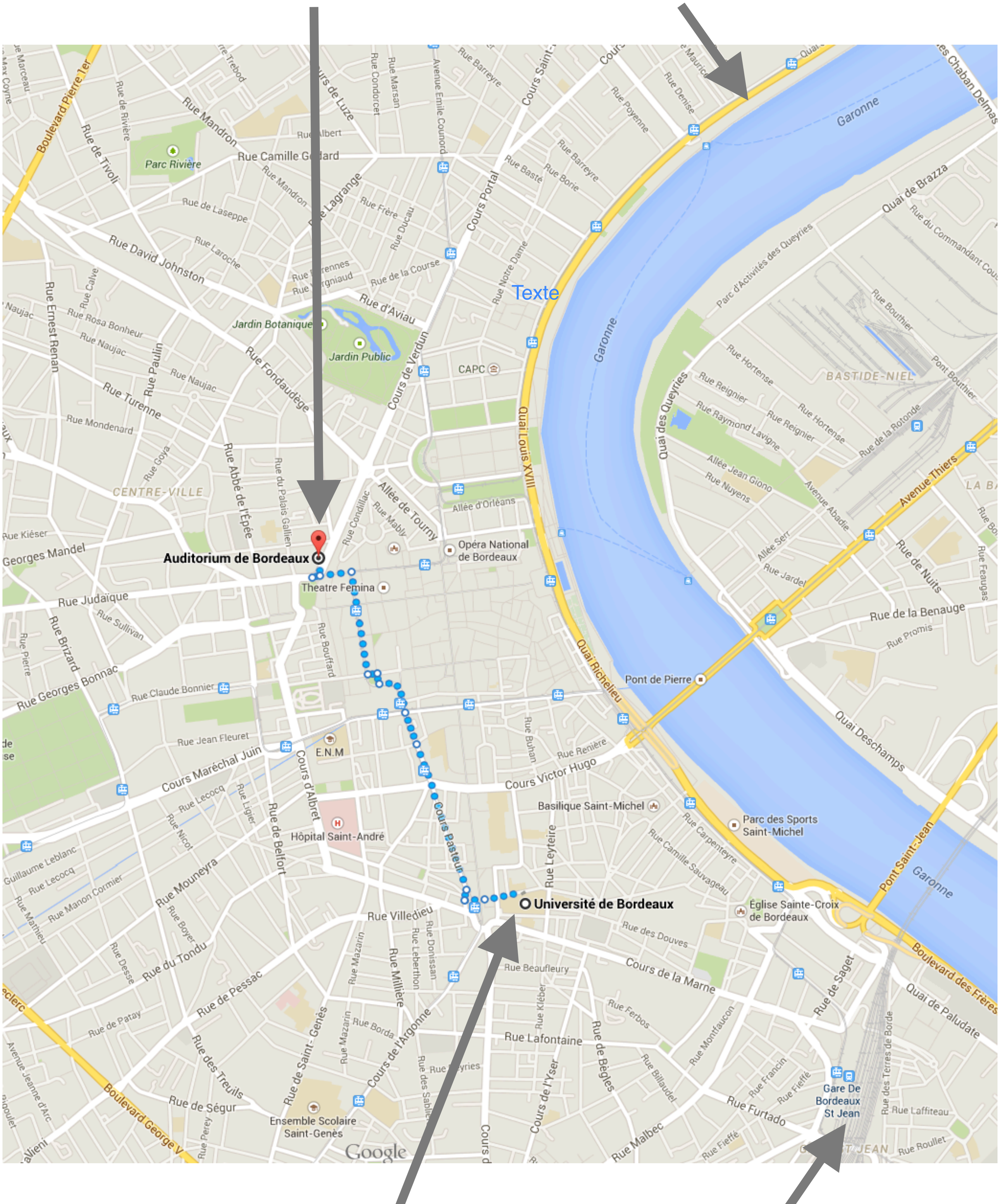
The conference dinner will take place on the Garonne river bank, at Hangar 14 (see the map below) from 7:30pm to 11:30pm. This casual banquet is organized to induce encountering between the 1000 participants. You will enjoy the wine of Chateau Couhins, a Pessac-Leognan, property of the research institute in agronomy (INRA). The finest catering is delivered by Lacoste.

Farewell Party on Friday

On Friday evening, we hold an informal banquet at the modern art museum, named CAPC (musée d'art contemporain de Bordeaux, Rue Ferrère, Entrepôt Lainé). Finger food and more, wine and draft beer, ... to enjoy the company of your friends before leaving.

Auditorium for Plenaries

Hanger 14 for Conf. Dinner



University buildings for Parallel Sessions

Train station

		Sun.01	Mon.02	Tue.03	Wed.04	Thu.05	Fri.06
8AM							
				Parallel Sessions 4x30 min	Parallel Sessions 4x30 min	Parallel Sessions 4x30 min	Parallel Sessions 4x30 min
9AM	A		Opening Cerenomy				
10AM				Coffee Break	Coffee Break	Coffee Break	Coffee Break
			Break				
11AM	B		Plenary Talk	Semi-Plenary + Keynote speakers	Semi-Plenary + Keynote speakers	Semi-Plenary + Keynote speakers	Semi-Plenary + Keynote speak- ers
12AM	C		Meeting of the MPC editorial board	Meeting of the MPA/B editorial boards	Meeting of MOS and Springer delegations	SIOPT board meeting	
1PM							
	D		Semi-Plenary + Keynote speakers	Plenary Talk	Plenary Talk	Plenary Talk	Plenary Talk
2PM		Registration and wine testing					
			Break	Break	Break	Break	Break
3PM							
	E		Parallel Sessions 3x30 min	Parallel Sessions 3x30 min	Parallel Sessions 3x30 min	Parallel Sessions 3x30 min	Parallel Sessions 3x30 min
4PM							
5PM	F		Parallel Sessions 4x20/3x30 min	MOS Business Meeting	Parallel Sessions 4x20/3x30 min	Parallel Sessions 4x20/3x30 min	Parallel Sessions 4x20/3x30 min
6PM							
			MOS council meeting	Optimization discussion group			
7PM							
					Conference Dinner		Farewell Party
8PM	G						
9PM							

Special Events

Business Meetings

- **Meeting of the MPC editorial board**: Monday July 2 at lunch time, salle Arnozan, building Q on the ground floor.
- **MOS council meeting**: Monday, July 2 at 6:30 pm, salle Arnozan, building Q on the ground floor.
- **Meeting of the MPA/B editorial boards**: Tuesday July 3 at lunch time, salle Arnozan, building Q on the ground floor.
- **MOS business meeting**: Tuesday, July 3 at 5:00 pm, Amphi Broca, external building, top floor.
- **Optimization discussion group** (sponsor: INFORMS Optimization Society): Tuesday, July at 6:30 pm, Amphi Deniges, building C, on the ground floor.
- **Meeting of MOS with Springer**: Wednesday at lunch time, salle Arnozan, building Q on the ground floor.
- **SIOPT board meeting**: Thursday at lunch time, salle Arnozan, building Q on the ground floor.

Opening Ceremony

The Opening Ceremony takes place Monday July 2 from 9am to 11am at the Auditorium (place Cambetta). It features the Prize Awards:

1. The **Paul Y. Tseng Memorial Lectureship in Continuous Optimization**, for outstanding contributions in continuous optimization.
2. The **A.W. Tucker Prize**, for an outstanding thesis in mathematical programming.
3. The **Lagrange Prize in Continuous Optimization**, for outstanding work in continuous optimization.
4. The **Beale - Orchard Hays Prize**, for outstanding work in computational mathematical programming.
5. The **Delbert Ray Fulkerson Prize**, for outstanding papers in discrete mathematics. Sponsored jointly by MOS and the American Mathematical Society.
6. The **George B. Dantzig Prize**, for original research having a major impact on mathematical optimization.

The Ceremony will conclude with a show given by the University Chorale, singing a canticorum jubilo by Haendel, a piece of Passereau, and Conquest Paradise by Vangelis.

Plenary Sessions

On the relationship between machine learning and optimization

by **Francis Bach**, INRIA - ENS, FR
PLENARY - Mo 11:00am-12:00am
INVITED SESSION 552
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Michel Goemans, MIT, US

Many machine learning frameworks are naturally formulated as optimization problems. Over the last few decades, this has led to fruitful exchanges between the two fields: optimization provides new learning algorithms, while machine learning requires solving new types of optimization problems with a specific structure. In this talk, I will present recent work at the interface between the two fields, highlighting the specificity of learning problems and some open problems.

Francis Bach is a researcher at Inria, leading since 2011 the machine learning team which is part of the Computer Science Department at Ecole Normale Supérieure. He graduated from Ecole Polytechnique in 1997 and completed his Ph.D. in Computer Science at U.C. Berkeley in 2005, working with Professor Michael Jordan. He spent two years in the Mathematical Morphology group at Ecole des Mines de Paris, then he joined the computer vision project-team at Inria/Ecole Normale Supérieure from 2007 to 2010. Francis Bach is primarily interested in machine learning, and especially in graphical models, sparse methods, kernel-based learning, large-scale convex optimization, computer vision and signal processing. He obtained in 2009 a Starting Grant and in 2016 a Consolidator Grant from the European Research Council, and received in 2012 the Inria young researcher prize. In 2015, he was program co-chair of the International Conference in Machine learning (ICML), and he will be general chair in 2018.

The Resurgence of Proximal Methods in Optimization

by **Marc Teboulle**, Tel Aviv University, IL
PLENARY - Tu 1:30pm-2:30pm
INVITED SESSION 555
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Claudia Sagastizabal, Unicamp, BR

Proximal based methods are nowadays starring in modern optimization algorithms based on first order information, e.g., function values and gradient/subgradients. This renewed interest is motivated by the current high demand in solving large scale problems arising in a wide spectrum of disparate modern applications. This talk will describe the fundamentals of a fairly general proximal framework, and its impact on some iconic first order optimization algorithms, including recent extensions. Convergence properties and applications in both the convex and nonconvex settings will be described.

Marc Teboulle is a Professor at the School of Mathematical Sciences of Tel Aviv University. He received his D.Sc. from the Technion, Israel Institute of Technology in 1985. He has held a position of Applied Mathematician at Israel Aircraft Industries, and academic appointments at Dalhousie University and the University of Maryland. He serves on the editorial board of several leading journals, and is the Area Editor of Continuous Optimization for Mathematics of Operations Research. His research interests are in the area of continuous optimization, including theory, algorithms, and its applications to many areas of science and engineering.

Relaxations and Approximations of Chance Constraints

by **Shabbir Ahmed**, Georgia Tech, US
PLENARY - We 1:30pm-2:30pm
INVITED SESSION 525
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Simge Kucukyavuz, University of Washington, US

A chance constrained optimization problem involves random constraints that are required to be satisfied with a prespecified probability. Such constraints are used to model reliability requirements in a variety of application areas such as finance, energy, service and manufacturing. Except under very special conditions, chance constraints impart severe nonconvexities making the optimization problem extremely difficult. In this talk we will review results on constructing tractable relaxations and approximate solutions for this hard class of problems. Extensions to distributionally robust chance constrained problems will also be discussed.

Shabbir Ahmed is the Anderson-Interface Chair and Professor in the H. Milton Stewart School of Industrial and Systems Engineering at the Georgia Institute of Technology. His research interests are in stochastic and discrete optimization. Dr. Ahmed is a past Chair of the Stochastic Programming Society. He serves on the editorial board of several journals including Operations Research, Mathematical Programming and the INFORMS Journal on Optimization. Dr. Ahmed's honors include the INFORMS Computing Society Prize, the National Science Foundation CAREER award, two IBM Faculty Awards, and the INFORMS Dantzig Dissertation award. He is a Senior Member of IEEE and a Fellow of INFORMS.

Randomness, risk and electricity prices

by **Andy Philpott**, University of Auckland, NZ
PLENARY - Th 1:30pm-2:30pm
Invited Session 554
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Michael Ferris, University of Wisconsin, US
Co-Authors: *Michael Ferris*,

Competitive markets for electricity supply have been around for over twenty years. They were introduced to support commercial investment in conventional generation plants with known costs and capacities, under predictable operating conditions. The design of these markets was therefore based primarily on deterministic optimization paradigms. Improvements in stochastic programming models and algorithms allied with the growth of intermittent and distributed generation and energy storage prompts a re-examination of these market designs. We examine the formation of electricity prices and incentives through a stochastic programming lens, where optimization models are used to yield efficient solutions and stochastic equilibrium models are used to study incentives. Differences between solutions to these models occur when agents are risk averse and markets for risk are incomplete. We illustrate using two case studies: stochastic optimization of ramping generation in markets with wind power and hydroelectric reservoir optimization with uncertain inflows.

Andy Philpott is Professor of Operations Research and co-director of the Electric Power Optimization Centre at the University of Auckland. His research interests are in stochastic optimization and game theory and their application to electricity markets. Dr Philpott currently serves on the editorial board of Operations Research, and has previously served on the editorial boards of Mathematical Programming and Operations Research Letters. Dr Philpott is an INFORMS Edelman Laureate and a Fellow of INFORMS.

Bounds for quantum graph parameters by conic and polynomial optimization

by **Monique Laurent**, CWI and Tilburg University, NL
PLENARY - Fr 1:30pm-2:30pm
Invited Session 553
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Frank Vallentin, University of Cologne, DE
Co-Authors: *Sander Gribling*, *David de Laat*, *Sabine Burgdorf*, *Teresa Piovesan*,

Quantum information is a rich source of challenging optimization problems. In particular, the study of quantum correlations, which are used to model the effect of quantum entanglement, leads to hard optimization problems where the variables may be instantiated to positive semidefinite matrices of arbitrary size (instead of nonnegative scalars in the classical case). This also leads to natural quantum analogues of classical graph parameters like minimum graph coloring and maximum stable sets. We will introduce the relevant concepts and discuss how to model and bound these quantum graph parameters, and other problems over quantum correlations, using tools from conic, semidefinite and noncommutative polynomial optimization.

Monique Laurent is researcher at Centrum Wiskunde and Informatica (CWI) in Amsterdam and she has a part-time appointment as full professor at Tilburg University. She received her Ph.D. in Mathematics at the University Paris Diderot in 1986 and was a researcher at CNRS in Paris before joining CWI in 1997. Her research focuses on algebraic and geometric methods for optimization problems in operations research, discrete and polynomial optimization, and quantum information. She co-authored the book Geometry of Cuts and Metrics (Springer) and she is a SIAM Fellow. Presently she serves on the editorial boards of Mathematical Programming, SIAM Journal on Discrete Mathematics and SIAM Journal on Mathematics of Data Science.

Semi-Plenary and Keynote Sessions

What's happening in nonconvex optimization? A couple of stories

by **Emmanuel Candes**, Stanford University, US
KEYNOTE - Mo 1:30pm-2:30pm
Invited Session 536
Room: SIGALAS Building: C, 2nd floor , Zone: 2
Chair: Jean-Baptist Hiriart-Urruty, Paul Sabatier University, FR
Co-Authors: *Yuxin Chen*,

In recent years, there has been astounding progress in the theory and practice (algorithms, professional-grade software development, applications) of convex optimization to the point that it has become a real pillar of modern engineering. On the other hand, the field of non-convex optimization is far less mature and may draw comparisons with 17th century medicine (ad-hoc methods, no performance guarantees, unreliable results, and so on). This is unfortunate because most problems of interest to information scientists are non-convex in nature; e.g. many maximum likelihood estimates are, in fact, solutions to non-convex problems, some of which being notoriously hard. This talk will briefly review a rapidly emerging literature showing that, perhaps surprisingly, some important non-convex problems may not be as hard as they seem. We will discuss some of this exciting research emphasizing applications in signal and image processing such as phase retrieval, and in machine learning such as low-rank factorization.

Emmanuel Candès is the Barnum-Simons Chair in Mathematics and Statistics, and professor of Electrical Engineering (by courtesy) at Stanford University, where he currently chairs the Department of Statistics. Emmanuel's work lies at the interface of mathematics, statistics, information theory, signal processing and scientific computing. Candès graduated from the Ecole Polytechnique in 1993 with a degree in science and engineering, and received his Ph.D. in Statistics from Stanford University in 1998. He received the 2006 Alan T. Waterman Award from NSF, the 2013 Dannie Heineman Prize from the Academy of Sciences at Göttingen, the 2010 George Polya Prize awarded by the Society of industrial and Applied Mathematics (SIAM), and the 2015 AMS-SIAM George David Birkhoff Prize in Applied Mathematics. He is a member of the National Academy of Sciences and the American Academy of Arts and Sciences. Candès has been named a 2017 MacArthurFellow, an honor popularly known as the genius grant.

Theoretical Analysis of Cutting-Planes in IP Solvers.

by **Santanu Dey**, GaTech, US
KEYNOTE - Mo 1:30pm-2:30pm
Invited Session 538
Room: DENIGES Building: C, Ground Floor , Zone: 5
Chair: Gerard Cornuejols, Carnegie Mellon University, US
Co-Authors: *Marco Molinaro*,

While many classes of cutting-planes are at the disposal of integer programming solvers, our scientific understanding is far from complete with regards to cutting-plane selection, that is the task of selecting a portfolio of cutting-planes to be added to the LP relaxation at a given node of the branch-and-bound tree. In order to keep the underlying linear program sparse, most commercial Mixed integer linear programming solvers consider sparsity of cuts as an important criterion for cutting-plane selection and use. The use of sparse cutting-planes may be viewed as a compromise between two competing objectives. On the one hand, the use of sparse cutting-planes aids in solving the linear programs encountered in the branch-and-bound tree faster. On the other hand, it is possible that important facet-defining or valid inequalities for the convex hull of the feasible solutions are dense and thus without adding these cuts, one may not be able to attain significant integrality gap closure. We analyze various aspects of sparsity in cutting-plane selection and use.

Santanu S. Dey is an Associate Professor in the H. Milton Stewart School of Industrial and Systems Engineering at Georgia Institute of Technology. Dr. Dey holds a Ph.D. in Industrial Engineering from Purdue University. Prior to joining Georgia Tech, he worked as a post-doctoral fellow at the Center for Operations Research and Econometrics (CORE) of the Catholic University of Louvain in Belgium. Dr. Dey's research interests are in the area of non convex optimization, and in particular mixed integer linear and nonlinear programming.

Multiobjective Optimization with PDE Constraints

by **Michael Hintermüller**, WIAS Berlin, DE
SEMI - Mo 1:30pm-2:30pm
Invited Session 550
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Stephen Wright, U Wisconsin-Madison, US

Motivated by engineering applications, but in particular also by applications in economics, where multi-agent market models integrate the physics of underlying processes (e.g., leading to spot markets with transport in connection with production and distribution of gas through a network of pipelines), generalized Nash games with partial differential equations (PDEs) and further private as well as global constraints are considered. The PDE typically models the underlying physics, may be subject to further constraints on the physical state and is influenced by the individual agents through their decision making process. The talk addresses some mathematical modeling issues with a particular focus on the interplay of constraint types and underlying topologies in infinite dimensions and the analysis of existence of Nash equilibria. It also includes aspects of an efficient numerical treatment of the problem class. Concerning the latter, path-following semi smooth Newton schemes are highlighted as they exhibit mesh independent convergence upon discretizing the original infinite dimensional problem. With respect to path-following techniques, sensitivity based Moreau-Yosida approaches, e.g. suitable for pointwise constraints on the state or its derivatives, will be intertwined with Nikaido-Isoda techniques for addressing the underlying game structure. Some numerical results for model problems, but also for a simplified spot market model with transport will be reported on. The talk closes by an outlook on possible future research in the field.

Michael Hintermüller is Professor of Applied Mathematics at Humboldt-Universität zu Berlin, Director of the Weierstrass Institute for Applied Analysis and Stochastics, and Speaker of the Einstein-Center for Mathematics Berlin. He received his PhD from the University of Linz in Austria and held positions at the University of Graz (Austria), Rice University (USA) and Sussex University (UK). He is SIAM Fellow and editor of several international peer-reviewed journals such as SIAM J. Num. Analysis or ESAIM COCV. His research interests include PDE-constrained optimization, quasi-variational inequalities and Nash games as well as variational image processing. Concerning applications, he is involved in interdisciplinary projects, e.g. focusing on energy markets or the design of next generation microprocessor, as well as in cooperations with industry.

Asymptotic Lagrangian duality for nonsmooth optimization

by **Regina Burachik**, UniSA, AU
KEYNOTE - Tu 11:00am-12:00am
Invited Session 541
Room: DENIGES Building: C, Ground Floor , Zone: 5
Chair: Xiaojun Chen, Hong Kong Polytechnic Univ., HK

For nonconvex optimization problems, zero duality gap and saddle-point properties can be established by using a generalized Lagrangian function that verifies suitable properties. The latter fact was originally proved by Rockafellar and Wets in 2007 in finite dimensions and extended in various ways in the last decade. The main advantage of this approach is that the resulting dual problem is convex and hence tractable via standard techniques. In this way, the optimal value, and sometimes even a solution, of the original problem, can be obtained by solving the dual problem using nonsmooth convex techniques. In the first part of the talk, we will recall some recent advances and applications of this fact in nonconvex duality. We will show how techniques from nonsmooth convex analysis can be incorporated into this duality scheme and provide a solution of the original (nonconvex/nonsmooth problem). In the second part of the talk, we will report on some new results involving a sequence of dual problems that converge (in a suitable sense) to a given dual problem (called asymptotic dual problem). This model can be useful within an iterative scheme in which (i) we use a sequence of smooth approximations of a nonsmooth Lagrangian, or (ii) we want to incorporate current information to update the Lagrangian at each iteration. For the asymptotic duality, we establish hypotheses under which zero duality gap holds. We illustrate the new results in the context of equality constrained problems and nonlinear semi-definite problems.

Regina Burachik is an Associate Professor in Optimization at University of South Australia. She publishes extensively in nonsmooth/convex/nonconvex optimization, variational inequalities, and set-valued analysis. She co-authored the Springer research-level book:"Set-Valued Analysis and Monotone Mappings". Her interest is in both theoretical and practical aspects of nonsmooth optimization and related areas, including variational inequalities, maximal monotone maps, convex analysis, and duality theory for nonconvex optimization. She is part of editorial boards of around 10 international journals in the area of optimization, including JOTA, SIOPT, SVVAN and Optimization Letters.

Lower bounds on the size of linear programs

by **Thomas Rothvoss**, University of Washington, US
KEYNOTE - Tu 11:00am-12:00am
Invited Session 545
Room: BROCA Building: W, 3rd floor , Zone: 0
Chair: Volker Kaibel, OVGU Magdeburg, DE

For half a century, proving that certain computational problems cannot be solved efficiently by a computer has turned out to be one of the hardest mathematical questions, with very little to no progress at all. However, in many scenarios it is very natural to consider restricted computational models, and here the situation is more promising. For example, a very standard approach in Operations Research is to model a computational problem as a linear program; this has the natural geometric interpretation of writing the solution space as projection of a higher dimensional polytope with few facets. There has been remarkable progress in the last few years in understanding this model, leading to almost tight lower bounds that we will describe in this talk.

Thomas Rothvoss is Assistant Professor in the Department of Mathematics and the Department of Computer Science and Engineering at the University of Washington. He is working in the intersection of theoretical computer science and discrete optimization. He received a STOC 2010 Best Paper Award, a SODA 2014 Best Paper Award and a STOC 2014 Best Paper Award. His research is supported by an Alfred P. Sloan Research Fellowship (2015), a David and Lucile Packard Foundation Fellowship (2016) as well as an NSF CAREER Award (2016).

Adaptive Robust Optimization with Scenario-wise Ambiguity Sets

by **Melvyn Sim**, NUS, SG
SEMI - Tu 11:00am-12:00am
Invited Session 551
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Daniel Kuhn, EPFL, CH
Co-Authors: *Chen Zhi*, *Peng Xiong*,

We present a tractable format for optimization under uncertainty based on the framework of adaptive robust optimization via a new class of scenario-wise ambiguity sets. The new format naturally unifies classical stochastic programming and robust optimization, and also incorporates the more recent distributionally robust optimization with ambiguity sets based on generalized moments, mixture distribution, Wasserstein (or Kantorovich-Rubinstein) metric, ϕ-divergence, and new ones such as k-means clustering, among others. We introduce a compatible scenario-wise affine recourse approximation, which is developed on the classical affine recourse approximation (a.k.a. linear decision rule or affine policy), to provide tractable solutions to adaptive robust optimization problems.

Dr. Melvyn Sim is Professor and Provost's Chair at the Department of Analytics and Operations, NUS Business school. His research interests fall broadly under the categories of decision making and optimization under uncertainty with applications ranging from finance, supply chain management, healthcare to engineered systems. He is one of the active proponents of Robust Optimization and has given invited talks in this field at international conferences.

Monotone Operator Theory in Convex Optimization

by **Patrick Combettes**, North Carolina State Univ., US
KEYNOTE - We 11:00am-12:00am
Invited Session 537
Room: BROCA Building: W, 3rd floor , Zone: 0
Chair: Samir Adly, Laboratoire XLIM, FR

Several aspects of the interplay between monotone operator theory and convex optimization are discussed. The crucial role played by monotone operators in the analysis and the numerical solution of convex minimization problems is emphasized. We review the properties of subdifferentials as maximally monotone operators and, in tandem, investigate those of proximity operators as resolvents. In particular, we study transformations which map proximity operators to proximity operators, and establish connections with self-dual classes of firmly nonexpansive operators. In addition, algorithmic considerations are discussed.

Online Competitive Algorithms for Resource Allocation

by **Maryam Fazel**, Univ. of Washington, US
KEYNOTE - We 11:00am-12:00am
Invited Session 539
Room: DENIGES Building: C, Ground Floor , Zone: 5
Chair: Frank Curtis, Lehigh University, US

In online optimization with budgets, the data in the optimization problem is revealed over time, and at each step a decision variable needs to be set without knowing the future inputs, while there is a budget constraint that couples the decisions across time. In this talk, we consider an online optimization setup that includes problems such as online (budgeted) resource allocation with a fixed inventory, and the 'Adwords' problem popular in online advertising. We examine two classes of primal-dual algorithms, with a focus on the competitive ratio, i.e., the ratio of the objective achieved by the algorithm to that of the optimal offline sequence of decisions. We give a bound on this ratio and show how certain smoothing of the objective function can improve the bound, and how to seek the optimal smoothing by solving a convex design problem. This approach allows us to design effective smoothing customized for a given cost function and problem structure. We will illustrate this approach in several classical examples, as well as a few new ones.

Maryam Fazel is an Associate Professor of Electrical Engineering at the University of Washington, with adjunct appointments in Computer Science and Engineering, Mathematics, and Statistics. Maryam received her MS and PhD from Stanford University, her BS from Sharif University of Technology in Iran, and was a postdoctoral scholar at Caltech before joining UW. Her current research interests are in mathematical optimization and applications in machine learning. She is a recipient of the NSF Career Award, the UWEE Outstanding Teaching Award, UAI conference Best Student Paper Award (with her student), and coauthored a paper on low-rank matrix recovery selected as a Fast-Breaking paper by Science Watch (2011). She co-leads the NSF Algorithmic Foundations for Data Science Institute at UW, and is an associate editor of SIAM journals on Optimization and on Mathematics of Data Science.

Model-Based Methods, Sampling Models, and A New Second-Order Model-Based Method

by **Luis Nunes Vicente**, University of Coimbra, PT
KEYNOTE - We 11:00am-12:00am
Invited Session 546
Room: LEYTEIRE Building: E, 3rd floor , Zone: 1
Chair: Stefan Wild, Argonne National Laboratory, US

The use of modeling in numerical optimization is ubiquitous. The accuracy of a model depends on how much we know about the problem function, in particular about its derivatives. A model can be used as a surrogate either to directly compute an approximate solution to the problem at hand or in a subproblem for the step computation of some iterative method, such as a trust-region method. In this talk we will first review new complexity results for trust-region methods when the exact gradient is not available, covering the cases of inexact gradients, random models whose accuracy is provided with some probability, and derivative-free optimization where models are recovered using only function values. Such a rich background can deliver a model recovery in other scenarios. One can sample Hessian vector products where we do function values to build models with approximate curvature. Based on this idea, we will present a new Hessian free second-order model-based method.

Luis Nunes Vicente is a Professor of Mathematics at the University of Coimbra, Portugal. His research interests include Continuous Optimization, Computational Science and Engineering, and Machine Learning and Data Science. He obtained his PhD from Rice University in 1996, under a Fulbright scholarship, receiving from Rice the Ralph Budd Thesis Award. He was one of the three finalists of the 94-96 A. W. Tucker Prize of the Mathematical Optimization Society (MOS). In 2015, he was awarded the Lagrange Prize of SIAM (Society for Industrial and Applied Mathematics) and MOS for the co-authorship of the book - Introduction to Derivative-Free Optimization, MPS-SIAM Series on Optimization, SIAM, Philadelphia, 2009. He held visiting positions at the IBM T.J. Watson Research Center and the IMA/University of Minnesota in 2002/2003, at the Courant Institute of Mathematical Sciences/NYU and the Université Paul Verlaine of Metz in 2009/2010, and at Roma/Sapienza and Rice University in 2016/2017. He has served on numerous editorial boards, including SIAM Journal on Optimization (2009-2017), EURO Journal on Computational Optimization, and Optimization Methods and Software. He is currently Editor-in-Chief of Portugaliae Mathematica, the Portuguese Mathematical research journal published by the European Mathematical Society.

Insights via volumetric comparison of polyhedral relaxations

by **Jon Lee**, University of Michigan, US
SEMI - We 11:00am-12:00am
Invited Session 548
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Andrea Lodi, Polytechnique Montreal, CA

I will survey some mathematical results (many quite recent) concerning volumes of polytopes of interest in non-convex optimization. The motivation is in geometrically comparing relaxations in the context of mixed-integer linear and nonlinear optimization, with the goal of gaining modeling and algorithmic insights. We consider relaxations of: fixed-charge formulations, vertex packing, boolean-quadric polytopes, and relaxations of graphs of monomials on box domains. Besides surveying the area, I will highlight some good open problems.

Jon Lee is the G. Lawton and Louise G. Johnson Professor of Engineering at the University of Michigan. He received his Ph.D. from Cornell University. Jon is the author of the text - A First Course in Combinatorial Optimization- (Cambridge University Press), and the open-source book - A First Course in Linear Optimization- (Reex Press). He was the founding Managing Editor of the journal Discrete Optimization, he is currently Editor-in-Chief of the journal Mathematical Programming. Jon was Chair of the Executive Committee of the Mathematical Optimization Society, and Chair of the INFORMS Optimization Society. He was awarded the INFORMS Computing Society Prize, and he is a Fellow of INFORMS.

Cutting Planes in the Extended Space

by **Oktay Gunluk**, IBM Research, US
KEYNOTE - Th 11:00am-12:00am
Invited Session 543
Room: BROCA Building: W, 3rd floor , Zone: 0
Chair: Adam Letchford, Lancaster University, GB

For a given formulation of an optimization problem, an extended formulation is one which uses additional variables to represent the same problem in an extended space. In integer programming literature there is a significant body of work that focuses on constructing compact polyhedral descriptions of integer programs in this framework. In this talk, we take a different approach and study the effect of adding cutting planes in the extended space for mixed-integer programs. We show that for 0-1 problems, even when the initial extended formulation is not stronger than the original LP formulation, it is possible to obtain the convex hull of integer solutions after adding one round of split cuts. This idea also leads to an lift-and-project operator with better theoretical properties than other similar operators. We also consider what we call binarization schemes that produce extended formulations by expressing each bounded integer variable with a collection of auxiliary binary variables. We present a hierarchy of such binarization schemes and present numerical experiments.

Oktay Gunluk is a research staff member at IBM Research. He has received his BS and MS degrees from Bogazici University and his Ph.D. in operations research from Columbia University. His research interests are mainly mixed-integer programming and discrete optimization. His applied work spans various industrial problems including production planning, fleet scheduling, port optimization, vehicle routing, oil pipeline scheduling and site selection in agriculture. He has served on the editorial boards of Networks, Mathematical Programming Computation, and MOS/SIAM Book Series on Optimization. He is currently an associate editor for Operations Research and Optimization and Engineering journals. He has served on the program committees for MIP, IPCO, and ISCO and currently serves in the IPCO steering committee.

Effective Scenarios and Scenario Reduction for Risk-Averse Stochastic Programs

by **Tito Homem-de-Mello**, Universidad Adolfo Ibanez, CL
KEYNOTE - Th 11:00am-12:00am
Invited Session 544
Room: DENIGES Building: C, Ground Floor , Zone: 5
Chair: Jim Luedtke, University of Wisconsin-Madiso, US
Co-Authors: *Sebastian Arpon*, *Bernardo Pagnoncelli*, *Hamed Rahimian*, *Guzin Bayraksan*,

In this talk we discuss some scenario reduction methods for risk-averse stochastic optimization problems. Scenario reduction techniques have received some attention in the literature and are used by practitioners, as such methods allow for an approximation of the random variables in the problem with a moderate number of scenarios, which in turn makes the optimization problem easier to solve. The majority of works for scenario reduction are designed for classical risk-neutral stochastic optimization problems; however, it is intuitive that in the risk-averse case one is more concerned with critical scenarios that correspond to high cost. The identification of such critical scenarios can be accomplished using the notion of effective scenarios recently introduced in the literature in the context of distributionally robust optimization problems. According to that notion, a scenario is effective if the removal of that scenario — defined in a precise way — causes a change in the optimal objetive function value; in some cases, it is posible to identify the effective scenarios analytically. By building upon these tools, we propose a scenario reduction technique for stochastic optimization problems where the objective function is a Conditional Value-at-Risk. The numerical results presented with problems from the literature illustrate the performance of the method and indicate the general cases where we expect it to perform well.

Tito Homem-de-Mello is a Professor in the School of Business at Universidad Adolfo Ibañez, Santiago, Chile. He obtained his Ph.D. in Industrial and Systems Engineering from Georgia Institute of Technology, and a B.Sc. in Computer Science and M.S. in Applied Mathematics from University of São Paulo, Brazil. His research focuses on optimization of systems under uncertainty. In particular, he studies theory and algorithms for stochastic optimization as well as applications of such methods in several areas such as risk management, energy, and transportations. He was co-Chair of the Program Committee of the XIV International Conference on Stochastic Programming, held in Brazil in 2016. Dr. Homem-de-Mello has been awarded prizes for Best Paper from IIE Transactions (2012), INFORMS Revenue Management and Pricing Section (2007), and INFORMS George Nicholson student paper competition (1998).

The BARON software for MINLP

by **Nikolaos Sahinidis**, Carnegie Mellon University, US
SEMI - Th 11:00am-12:00am
Invited Session 547
Room: Auditorium Building: Symphony Hall, Zone: 0

Chair: Claudia D Ambrosio, LIX, FR

The BARON project for the global optimization of NLPs and MINLPs began in the early 1990s. The project has led to the introduction of a number of methodologies to the forefront of global optimization, including domain reduction techniques, finite branching schemes for continuous problems, polyhedral relaxations, dynamic convexity detection, and the use of multi-term relaxations, multi-constraint relaxations, integer programming relaxations, and portfolios of relaxations in branch-and-bound algorithms. In this talk, we review key developments in the history of BARON, and present computational results on benchmarks and an application in symbolic regression.

Nick Sahinidis is John E. Swearingen Professor and Director of the Center for Advanced Process Decision-making at Carnegie Mellon University. He joined Carnegie Mellon in 2007 after a sixteen-year long career at the University of Illinois at Urbana, where he taught in Industrial Engineering and Chemical Engineering. His research addresses the development of theory, algorithms, and the BARON software for global optimization of mixed-integer nonlinear programs, as well as applications in a variety of fields, including process systems optimization and machine learning. His honors have included the INFORMS Computing Society Prize, the Beale-Orchard-Hays Prize, the Computing in Chemical Engineering Award, the Constantin Carathéodory Prize, and the National Award and Gold Medal from HELORS. Professor Sahinidis is a fellow of INFORMS and AIChE. He is the Editor-in-Chief of Optimization and Engineering.

Majority judgment

by **Michel Balinski**, CNRS and Ecole Polytechnique, FR
KEYNOTE - Fr 11:00am-12:00am
Invited Session 535
Room: LEYTEIRE Building: E, 3rd floor , Zone: 1
Chair: Martine Labbé, Université Libre de Bruxelles, BE

Every well-known voting procedure in use today hides important vices that can deny the will of the electorate including majority vote with only two candidates (the domination paradox), approval voting, and all methods that ask voters to rank-order candidates. The reason: voters cannot adequately express their opinions. Majority judgment asks voters to express their opinions by evaluating every candidate in a common language of ordinal grades such as: Great, Good, Average, Poor, or Terrible. Majorities determine the electorate's evaluation of each candidate and the ranking between every pair of candidates (necessarily transitive), with the first-placed among them the winner. Majority judgment is described together with real examples of its use. It was specifically designed to (1) permit voters to express their opinions, (2) be meaningful in the sense of measurement theory, (3) guarantee a transitive order-of-finish (avoiding Condorcet's paradox), (4) avoid Arrow's paradox (when the order-of-finish of two candidates depends on the presence/absence of another candidate), (5) combat strategic manipulation and encourage the honest expression of opinions. References M. Balinski and R. Laraki, Majority Judgment: Measuring, Ranking, and Electing, M.I.T. Press 2011. – and –, "Judge: Don't Vote!" Operations Research 62 (2014) 483-511.

Michel Balinski, a Williams College graduate, completed an M.S. in economics at MIT and a Ph.D. in mathematics at Princeton. He has taught at Princeton, Penn, CUNY Graduate Center, Yale and SUNY, Stony Brook. Beginning in 1982 he was Directeur de Recherche de classe exceptionnelle of the CNRS at the Ecole Polytechnique, Paris. He was awarded INFORMS's Lanchester Prize in 1965, the MAA's Lester R. Ford Award in 1976 and in 2009, an honorary degree in mathematics from the University of Augsburg in 2004, and INFORMS's John von Neumann Theory Prize in 2013. He is the founding editor of Mathematical Programming and a past President of the Mathematical Optimization Society. He is the author of Fair Representation: Meeting the Ideal of One Man, One Vote (1982, reissued 2001, with H. P. Young), Le suffrage universel inachevé (2004), and Majority Judgment: Measuring, Ranking and Electing (2011, with R. Laraki), and the author or co-author of about 150 articles. His principal current interest is the design of electoral systems. One of his electoral systems is used in several Swiss cantons.

Submodularity in mixed-integer quadratic and conic quadratic optimization

by **Alper Atamturk**, UC Berkeley, US
KEYNOTE - Fr 11:00am-12:00am

INVITED SESSION 540
Room: DENIGES Building: C, Ground Floor , Zone: 5
Chair: Daniel Bienstock, Columbia University, US

Submodularity plays an important role in developing effective methods for numerous combinatorial optimization problems. However, its use beyond 0-1 optimization, especially for problems with continuous variables, has been limited. In this talk, we review the recent progress in exploiting submodularity or partial submodularity in mixed 0-1 quadratic and conic quadratic optimization for deriving strong formulations and effective algorithms.

Alper Atamturk is a Professor of Industrial Engineering and Operations Research at the University of California, Berkeley. He received his Ph.D. from the Georgia Institute of Technology in 1998 with a major in Operations Research and minor in Computer Science. His research interests are in optimization, integer programming, optimization under uncertainty with applications to energy, portfolio and network design, cancer therapy, and defense. Dr. Atamturk is a national security fellow (NSSEFF) of the US Department of Defense. He serves on the editorial boards of Mathematical Programming A, Mathematical Programming C, Discrete Optimization, and Journal of Risk.

Modern Branch-and-Cut Implementation

by **Matteo Fischetti**, University of Padua, IT
KEYNOTE - Fr 11:00am-12:00am
INVITED SESSION 542
Room: BROCA Building: W, 3rd floor , Zone: 0
Chair: Marc Pfetsch, TU Darmstadt, DE

The Branch and Cut (B and C) method was proposed in 1990's by Manfred Padberg and Giovanni Rinaldi, and is nowadays the method of choice for the exact solution of Mixed-Integer Linear Programs (MILPs). A typical use of the MILP technology consists in writing a computer program (in any high-level programming language such as C/C++, Python, Matlab, etc.) that reads the input data, internally generates the model of interest, and solves it by invoking appropriate functions provided by the solver. Open-source and commercial MILP solvers provide a wide set of parameters to control its execution. In some cases, however, one is interested in customizing the solver even further, by exploiting some problem-specific knowledge. To this end, modern MILP codes provide so-called "callback functions" that are automatically invoked by the solver at some critical points of its execution. By default, the callbacks are not installed, meaning that they are not active and the solver uses its own default solution strategy. By installing her own callbacks, an advanced user can then take control of the solution algorithm and fully customize it. In the talk we will quickly describe the most-used callback functions for a generic B and C solver for MILPs. As an example of application, we will show how callback functions can be used to allow a given MILP solver to handle (nonconvex) bilinear terms of the form $z_i = x_i y_i$, thus producing a fully-general B and C solver for mixed-integer quadratic problems.

Matteo Fischetti is full professor of Operations Research at the Department of Information Engineering of the University of Padova, Italy. He is Associate Editor of the international journals "Operations Research" and "Mathematical Programming Computation". He won, among others, the Best Ph.D. Dissertation on Transportation prize awarded by the Operations Research Society of America (1987) and the INFORMS Edelman award (2008). In 2015 he was awarded the Harold Larnder Prize by the Canadian Operational Research Society. His research interests include Integer Programming, Combinatorial Optimization, Railway Optimization, Vehicle Routing and Crew Scheduling Problems.

Tseng Memorial Lectureship in Continuous Optimization

SEMI - Fr 11:00am-12:00am
INVITED SESSION 549
Room: Auditorium Building: Symphony Hall, Zone: 0
Chair: Yaxiang Yuan, Chinese Academy of Sciences, CN

Mini-Symposia

A.W. Tucker Prize Session

A.W. Tucker Prize Session

INTERFACE - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

CONTRIBUTED SESSION 559
Chair: Simge Kucukyavuz, University of Washington, US

Interface

Stochastic optimization

INTERFACE - We 8:30am-10:30am, Format: 4x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

CONTRIBUTED SESSION 314
Chair: Alexei Gaivoronski, NTNU, NO

1 - Using disjunctive programming to represent Risk Aversion policies
Speaker: Bernardo Costa, UFRJ, BR, talk 790
Co-Authors: *Filipe Cabral*, *Joari Costa*,

2 - SDDP with stagewise-dependent objective coefficient uncertainty
Speaker: Anthony Downward, University of Auckland, NZ, talk 1187
Co-Authors: *Oscar Dowson*, *Regan Baucke*,

3 - Stochastic optimization of simulation models: management of
Speaker: Alexei Gaivoronski, NTNU, NO, talk 1416
Co-Authors: *Giovanni Sechi*, *Paola Zuddas*,

4 - Demand Response To Electricity Prices In Flexible Manufacturing
Speaker: Kazem Abbaszadeh, UoA, NZ, talk 794
Co-Authors: *Golbon Zakeri*, *Geoffrey Pritchard*,

Logistics

INTERFACE - We 3:15pm-4:45pm, Format: 3x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

CONTRIBUTED SESSION 388
Chair: Frieder Smolny, Technical University Berlin, DE

1 - Using OpenStreetMap data for route optimization: extraction and reduction
Speaker: Kaj Holmberg, Linkoping University, SE, talk 842

2 - Modeling the Periodic Vehicle Routing Problem in an industrial context
Speaker: Gwénaël Rault, Mapotempo, FR, talk 1625
Co-Authors: *Adeline Fonseca*, *Frédéric Rodrigo*,

3 - Multiscale optimization of logistics networks
Speaker: Frieder Smolny, Technical University Berlin, DE, talk 1268
Co-Authors: *Karl Däubel*, *Martin Skutella*, *Torsten Mütze*, *Guillaume Sagnol*,

Solvers and softwares

INTERFACE - We 5:00pm-6:30pm, Format: 4x20 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

CONTRIBUTED SESSION 390

Chair: François Clautiaux, Université de Bordeaux, FR

1 - Solving packing, routing and scheduling problems using LocalSolver
Speaker: Julien Darlay, LocalSolver, FR, talk 578

2 - Applied mixed integer programming: The why and how
Speaker: Pawel Lichocki, Google, PL, talk 1443

3 - Solving MIPs with Gurobi Instant Cloud
Speaker: Robert Luce, Gurobi, DE, talk 714
Co-Authors: *Michel Jaczynski*, *Edward Rothberg*,

4 - Creating an optimization web app with FICO Xpress
Speaker: Johannes Müller, FICO Xpress Optimization, DE, talk 977
Co-Authors: *Susanne Heipcke*, *Yves Colombani*,

Energy

INTERFACE - Th 8:30am-10:30am, Format: 4x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2
Contributed Session 387
Chair: Kazem Abbaszadeh, UoA, NZ

1 - Optimization Models for Geothermal Energy
Speaker: Rishi Adiga, The University of Auckland, NZ, talk 934
Co-Authors: *Andy Philpott*, *John O'Sullivan*,

2 - Static robustness for EDF nuclear long term production planning
Speaker: Rodolphe Griset, EDF-INRIA, FR, talk 1647
Co-Authors: *Boris Detienne*, *Francois Vanderbeck*, *Marc Porcheron*, *Pascale Bendotti*, *Hugo Gevret*,

3 - Optimization of district heating production operations
Speaker: Gabriela Maschietto, Veolia, FR, talk 1297
Co-Authors: *Phillipe Sampaio*, *Damien Chenu*, *Stephane Couturier*, *David Mouquet*,

4 - Demand and reserve co-optimization for a price-making consumer of electricity
Speaker: Mahbubeh Habibian, University of Auckland, NZ, talk 947
Co-Authors: *Golbon Zakeri*, *Anthony Downward*,

Planning

INTERFACE - Th 5:00pm-6:30pm, Format: 4x20 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2
Contributed Session 389
Chair: Jeanjean Antoine, Recommerce Group, FR

1 - Planning model for recommerce activities
Speaker: Jeanjean Antoine, Recommerce Group, FR, talk 1251
Co-Authors: *Nabil Absi*, *Xavier Schepler*,

2 - A Propagation Approach for Railway Rolling Stock Optimization
Speaker: Boris Grimm, Zuse Institute Berlin, DE, talk 1332
Co-Authors: *Ralf Borndörfer*, *Stanley Schade*, *Markus Reuther*, *Thomas Schlechte*,

3 - Real Size Exam Timetabling at Montpellier University (France)
Speaker: Eric Bourreau, LIRMM, FR, talk 687
Co-Authors: *Valentin Pollet*,

4 - An Hypergraph Model for the Rolling Stock Rotation Planning and Train Selection
Speaker: Mohamed Benkirane, IMB and SNCF, FR, talk 1599
Co-Authors: *François Clautiaux*, *Boris Detienne*, *Jean Damay*,

Mixed-integer optimization with differential equations

Optimal Control Problems with Discrete Switches

MINLP - Fr 8:30am-10:30am, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 102
Organizer: Christian Kirches, TU Braunschweig, DE

1 - An Algorithm for Model-Predictive Control of Switched Nonlinear Dynamic Systems
Speaker: Adrian Bürger, Karlsruhe UAS, DE, talk 828
Co-Authors: *Angelika Altmann-Dieses*, *Moritz Diehl*, *Clemens Zeile*, *Sebastian Sager*,
2 - Approximation algorithms for MIOCPs with discontinuous switch costs
Speaker: Felix Bestehorn, TU Braunschweig, DE, talk 1043
Co-Authors: *Christian Kirches*,
3 - Numerical Modeling of Switched Systems with Jumps in Optimal Control Problems
Speaker: Matthias Schloeder, IAM Heidelberg University, DE, talk 570
Co-Authors: *Ekaterina Kostina*,

Outer Convexification and Mixed-Integer Optimal Control

MINLP - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Invited Session 103
Organizer: Sebastian Sager, University Magdeburg, DE

1 - Improved Regularity Assumptions for Partial Outer Convexification of MIPDECOs
Speaker: Paul Manns, TU Braunschweig, DE, talk 833
Co-Authors: *Christian Kirches*,
2 - Combinatorial Integral Approximation Decompositions for Mixed-Integer Control
Speaker: Clemens Zeile, University of Magdeburg, DE, talk 505
Co-Authors: *Tobias Weber*, *Sebastian Sager*,
3 - Global optimization of ODE constrained network problems
Speaker: Oliver Habeck, TU Darmstadt, DE, talk 376
Co-Authors: *Marc Pfetsch*, *Stefan Ulbrich*,

Mixed-Integer PDE-Constrained Optimization

MINLP - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 63
Organizer: Sven Leyffer, Argonne National Laboratory, US

1 - Inversion of Convection-Diffusion PDE with Discrete Source
Speaker: Meenarli Sharma, IIT Bombay, IN, talk 1094
Co-Authors: *Sven Leyffer*, *Lars Ruthotto*,
2 - Shape optimization towards binary variables with PDE constraints
Speaker: Martin Siebenborn, Universität Hamburg, DE, talk 607
3 - Set-valued steepest descent for binary topology and control optimization
Speaker: Mirko Hahn, OvGU Magdeburg, DE, talk 1036
Co-Authors: *Sebastian Sager*, *Sven Leyffer*,

Convexification and more

Convexification and more (I)

MINLP - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Invited Session 62
Organizer: Jon Lee, University of Michigan, US

1 - Treating indefinite quadratic and bilinear forms in MINLP
Speaker: Marcia Fampa, UFRJ, BR, talk 620
Co-Authors: *Jon Lee*,
2 - Valid inequalities for QCQPs
Speaker: Amélie Lambert, Cedric-Cnam, FR, talk 745
3 - More Virtuous Smoothing
Speaker: Luze Xu, University of Michigan, US, talk 772
Co-Authors: *Jon Lee*, *Daphne Skipper*,

Convexification and more (II)

MINLP - Th 5:00pm-6:30pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1

INVITED SESSION 106
Organizer: Akshay Gupte, Clemson University, US

1 - Binary Programming with Semilinear Elliptic PDE-constraints
Speaker: Christoph Buchheim, TU Dortmund, DE, talk 374
Co-Authors: *Renke Kuhlmann*, *Christian Meyer*,
2 - Using algebraic structure to accelerate polyhedral approximation
Speaker: Christopher Coey, MIT, US, talk 692
Co-Authors: *Juan Pablo Vielma*,
3 - Quadratic optimization with M-matrices and semi-continuous variables
Speaker: Andres Gomez, University of Pittsburgh, US, talk 220
Co-Authors: *Alper Atamturk*,

MIP under Uncertainty

MIP under Uncertainty 1

IPTHEORY - Tu 8:30am-10:30am, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

INVITED SESSION 231
Organizer: Fatma Kilinc-Karzan, Carnegie Mellon University, US

1 - Distributionally Robust Combinatorial Optimization
Speaker: Shabbir Ahmed, Georgia Tech, US, talk 1562
Co-Authors: *Ruiwei Jiang*, *Mohit Singh*,
2 - Risk-Averse Set Covering Problems
Speaker: Simge Kucukyavuz, University of Washington, US, talk 927
Co-Authors: *Hao-Hsiang Wu*,
3 - Mixed-Integer Recourse via Prioritization
Speaker: Ruiwei Jiang, University of Michigan, US, talk 1189
Co-Authors: *Yuanyuan Guo*,

MIP under Uncertainty 2

IPTHEORY - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

INVITED SESSION 232
Organizer: Simge Kucukyavuz, University of Washington, US

1 - Two-stage stochastic p-order conic mixed integer programs
Speaker: Manish Bansal, Virginia Tech, US, talk 154
Co-Authors: *Yingqiu Zhang*,
2 - Inexact cutting plane techniques for two-stage stochastic mixed-integer programs
Speaker: Ward Romeijnders, University of Groningen, NL, talk 228
Co-Authors: *Niels van der Laan*, *Suvrajeet Sen*,
3 - Solving Stochastic and Bilevel Mixed-Integer Programs via a Generalized Value F.
Speaker: Andrew Schaefer, Rice University, US, talk 560
Co-Authors: *Onur Tavaslioglu*, *Oleg Prokopyev*,

Decomposition for multistage stochastic problems

Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 1

STOCH - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 32 Building: B, Ground Floor, Zone: 5

INVITED SESSION 246
Organizer: Vincent Leclère, ENPC, FR

1 - Computing parameter sensitivities for discrete time Markov decision processes
Speaker: David Wozabal, Technical University of Munich, DE, talk 1002
Co-Authors: *Goncalo Terca*,
2 - Modeling time-dependent randomness in stochastic dual dynamic programming
Speaker: Nils Löhndorf, University of Luxembourg, LU, talk 849
Co-Authors: *Alexander Shapiro*,
3 - Computing ellipsoidal controlled invariant sets for stochastic programming
Speaker: Benoît Legat, UCLouvain, BE, talk 1243
Co-Authors: *Raphaël Jungers*,

Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 2

STOCH - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 32 Building: B, Ground Floor, Zone: 5

INVITED SESSION 247
Organizer: Vincent Leclère, ENPC, FR

1 - The practitioners guide to SDDP: lessons from SDDP.jl
Speaker: Oscar Dowson, University of Auckland, NZ, talk 439
2 - Decomposing Dynamic Programming equations: from global to nodal value functions
Speaker: François Pacaud, CERMICS, FR, talk 615
Co-Authors: *Carpentier Pierre*, *Michel De Lara*,
3 - Energy portfolio optimization for Brazilian distribution companies: a multistage
Speaker: Vitor de Matos, Plan4, BR, talk 1373
Co-Authors: *Guilherme Ramalho*, *Paulo Larroyd*, *Rodrigo Antunes*, *Luis Baran*, *Julia Paul*, *Marcos Coelho*,
4 - Stochastic programming framework for risk aversion representation with SDDP
Speaker: Luiz Carlos da Costa Junior, PSR, BR, talk 1498
Co-Authors: *Raphael Chabar*, *Joaquim Dias Garcia*,

Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 3

STOCH - Fr 8:30am-10:30am, Format: 4x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

INVITED SESSION 245
Organizer: Vincent Leclère, ENPC, FR

1 - Distributionally Robust Dual Dynamic Programming
Speaker: David Morton, Northwestern University, US, talk 435
Co-Authors: *Daniel Duque*,
2 - Stochastic dual dynamic integer programming
Speaker: Andy Sun, Georgia Institute of Technolog, US, talk 943
Co-Authors: *Shabbir Ahmed*, *Jikai Zou*,
3 - A deterministic algorithm for solving stochastic minimax dynamic programmes
Speaker: Regan Baucke, University of Auckland, NZ, talk 900
Co-Authors: *Anthony Downward*, *Golbon Zakeri*,
4 - Exact converging bounds for Stochastic Dual Dynamic Programming
Speaker: Vincent Leclère, ENPC, FR, talk 349
Co-Authors: *François Pacaud*, *Arnaud Lenoir*, *Jean-Philipp Chancelier*, *Carpentier Pierre*,

First-order methods for large-scale convex problems

First-order methods for large-scale convex problems

LEARNING - Th 8:30am-10:30am, Format: 4x30 min
Room: FABRE Building: J, Ground Floor, Zone: 8

INVITED SESSION 316
Organizer: Stephen Vavasis, University of Waterloo, CA

1 - A single potential governing convergence of CG, AG and Geometric Descent
Speaker: Stephen Vavasis, University of Waterloo, CA, talk 582
Co-Authors: *Sahar Karimi*,
2 - Robust Accelerated Gradient Method
Speaker: Mert Gurbuzbalaban, Rutgers University, US, talk 1106
3 - Randomized methods for convex feasibility problems and applications to ML
Speaker: Peter Richtarik, KAUST, SA, talk 385
Co-Authors: *Ion Necoara*, *Andrei Patrascu*,
4 - Bregman Divergence for Stochastic Variance Reduction
Speaker: Yaoliang Yu, University of Waterloo, CA, talk 937
Co-Authors: *Xinhua Zhang*, *Zhan Shi*,

First-order methods for large-scale convex problems II

LEARNING - Th 5:00pm-6:30pm, Format: 4x20 min
Room: FABRE Building: J, Ground Floor, Zone: 8

INVITED SESSION 318
Organizer: Stephen Vavasis, University of Waterloo, CA

1 - Convex Low Rank Semidefinite Optimization
Speaker: Madeleine Udell, Cornell, US, talk 770
Co-Authors: *Lijun Ding*, *Volkan Cevher*, *Joel Tropp*, *Alp Yurtsever*,
2 - Frank-Wolfe Splitting via Augmented Lagrangian Method
Speaker: Simon Lacoste-Julien, Université de Montréal, CA, talk 1514
Co-Authors: *Gautheir Gidel*, *Fabian Pedregosa*,
3 - Extending performance estimation beyond exact convex fixed-step methods
Speaker: Francois Glineur, UCLouvain, BE, talk 1072
Co-Authors: *Adrien Taylor*, *Théo Golvet*,
4 - Low-Storage Conditional Gradient Method for Low-Rank and Sparse Optimization
Speaker: Xuan Vinh Doan, The University of Warwick, GB, talk 1286
Co-Authors: *Stephen Vavasis*, *Jimit Majmudar*,

Advances in MINLP

MINLP (I)

MINLP - We 8:30am-10:30am, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

INVITED SESSION 65
Organizer: Daniel Bienstock, Columbia University, US

1 - Time-Varying Semidefinite Programs
Speaker: Bachir El Khadir, Princeton University, US, talk 1194
Co-Authors: *Amir Ali Ahmadi*,
2 - Strengthened Relaxations for Quadratic Optimization with Switching Variables
Speaker: Kurt Anstreicher, University of Iowa, US, talk 147
3 - A Simple Nearly-Optimal Restart Scheme For Speeding-Up First Order Methods
Speaker: James Renegar, Cornell University, US, talk 117
Co-Authors: *Benjamin Grimmer*,

MINLP (II)

MINLP - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

INVITED SESSION 66
Organizer: Daniel Bienstock, Columbia University, US

1 - Polyhedral relaxations for nonconvex quadratic functions
Speaker: Akshay Gupte, Clemson University, US, talk 1144
2 - Product convexification: A new relaxation framework for nonconvex programs
Speaker: Mohit Tawarmalani, Purdue University, US, talk 93
Co-Authors: *Taotao He*,
3 - Sparse conic optimization: low-rank solutions and near-linear time algorithms
Speaker: Javad Lavaei, UC Berkeley, US, talk 110
Co-Authors: *Richard Zhang*,

MINLP (III)

MINLP - We 5:00pm-6:30pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1

INVITED SESSION 67
Organizer: Daniel Bienstock, Columbia University, US

1 - Cardinality-constrained linear regression with sparse matrices
Speaker: Alberto Del Pia, UW-Madison, US, talk 167
Co-Authors: *Robert Weismantel*, *Santanu Dey*,
2 - Computational evaluation of new dual bounding techniques for sparse PCA
Speaker: Guanyi Wang, Georgia Tech, US, talk 935
Co-Authors: *Santanu Dey*, *Rahul Mazumder*,
3 - Cutting Planes for Linear Programs with Complementarity Constraints
Speaker: Jeff Linderoth, Univ. of Wisconsin-Madison, US, talk 1327
Co-Authors: *Alberto Del Pia*, *Haoran Zhu*,

Efficient Methods for Piecewise Algorithmic Differentiation

Numerically Efficient Methods for Piecewise Algorithmic Differentiation I

ALGO - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

INVITED SESSION 269
Organizer: Torsten Bosse, FSU Jena, DE

1 - Study of the numerical efficiency of structured abs-normal forms
Speaker: Sri Hari Narayanan, Argonne National Laboratory, US, talk 1505
Co-Authors: *Torsten Bosse*,
2 - (Almost) Matrix-free solver for piecewise linear functions in Abs-Normal form
Speaker: Torsten Bosse, FSU Jena, DE, talk 962
3 - An active signature method for piecewise differentiable/linear optimization.
Speaker: Andreas Griewank, Yachay Tech, EC, talk 1545
Co-Authors: *Andrea Walther*, *Lisa Hegerhorst*,
4 - Solving l_1 regularized minimax problems by successive piecewise linearization
Speaker: Angel Rojas, Yachay Tech, EC, talk 1549
Co-Authors: *Andreas Griewank*,

Numerically Efficient Methods for Piecewise Algorithmic Differentiation II

ALGO - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

INVITED SESSION 270
Organizer: Torsten Bosse, FSU Jena, DE

1 - Pushing the Algorithmic Differentiation tool Tapenade towards new languages
Speaker: Laurent Hascoet, INRIA, FR, talk 1534

Co-Authors: *Valerie Pascual*,
2 - Generalized Sensitivity Analysis of Nonlinear Programs
Speaker: Peter Stechlinski, University of Maine, US, talk 340
Co-Authors: *Kamil Khan*, *Paul Barton*, *Amir Akbari*, *Johannes Jaschke*,
3 - Evaluating generalized derivatives efficiently for nonsmooth composite functions
Speaker: Kamil Khan, McMaster University, CA, talk 1435
4 - Optimality Conditions for Nonsmooth Constrained Optimization Problems
Speaker: Lisa Hegerhorst, Leibniz Universität Hannover, DE, talk 726

Progress in Conic and MIP Solvers

Progress in MIP Solvers I

ALGO - We 8:30am-10:30am, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

INVITED SESSION 235
Organizer: Michael Winkler, Gurobi, DE

1 - New features and improvements in the SAS/OR optimization package
Speaker: Imre Polik, SAS Institute, US, talk 898
2 - MIPLIB 2017+1
Speaker: Thorsten Koch, ZIB and TU Berlin, DE, talk 370
Co-Authors: *The MIPLIB-team*,
3 - Benchmarks of commercial and noncommercial optimization software
Speaker: Hans Mittelmann, Arizona State University, US, talk 41

Progress in Conic and MIP Solvers

ALGO - We 3:15pm-4:45pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

INVITED SESSION 237
Organizer: Imre Polik, SAS Institute, US

1 - Artelys Knitro 11.0, a new conic solver and other novelties
Speaker: Jean-Hubert Hours, Artelys, FR, talk 556
Co-Authors: *Richard Waltz*, *Figen Oztoprak Topkaya*, *Michaël Gabay*, *Sylvain Mouret*,
2 - MOSEK version 9
Speaker: Erling Andersen, MOSEK, DK, talk 346
3 - Recent enhancements in MATLAB Optimization Toolbox solvers for LP and MILP
Speaker: Franz Wesselmann, The MathWorks GmbH, DE, talk 737

Progress in MIP Solvers II

ALGO - We 5:00pm-6:30pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

INVITED SESSION 234
Organizer: Hans Mittelmann, Arizona State University, US

1 - Benders Decomposition in IBM CPLEX
Speaker: Andrea Tramontani, IBM, IT, talk 895
2 - Gurobi 8.0 - What's new
Speaker: Michael Winkler, Gurobi, DE, talk 1393
3 - Recent Progress in the Xpress Solvers
Speaker: Michael Perregaard, FICO, GB, talk 658

Computational Integer Programming

Computational Integer Programming I

ALGO - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 273
Organizer: Domenico Salvagnin, University of Padova, IT

1 - Exploiting Degeneracy in MIP
Speaker: Tobias Achterberg, Gurobi, DE, talk 412
Co-Authors: *Zonghao Gu*, *Edward Rothberg*,
2 - Online Estimation of the Size of the Branch and Bound Tree in MIP Solvers
Speaker: Pierre Le Bodic, Monash University, AU, talk 197
3 - Multi-Row Intersection Cuts based on the Infinity Norm
Speaker: Alinson Xavier, Argonne National Laboratory, US, talk 858
Co-Authors: *Ricardo Fukasawa*, *Laurent Poirrier*,

Computational Integer Programming II

Algo - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8
Invited Session 274
Organizer: Domenico Salvagnin, University of Padova, IT

1 - Tighter LP relaxations for configuration knapsacks using extended formulations
Speaker: Gregor Hendel, Zuse Institute Berlin, DE, talk 381
Co-Authors: *Ralf Borndörfer*, *Marika Karbstein*, *Timo Berthold*, *Heide Hoppmann*,
2 - Lexicographic Optimization and Recovery in Two-Stage Robust Scheduling
Speaker: Dimitrios Letsios, Imperial College London, GB, talk 504
Co-Authors: *Ruth Misener*,
3 - Dynamic Row Disablement: a practical Implementation of the Kernel Simplex Method
Speaker: Roland Wunderling, IBM, AT, talk 861

Interior-point methods for large-scale problems

Implementation of interior-point methods for large-scale problems and applications I

Algo - Mo 3:15pm-4:45pm, Format: 2x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6
Invited Session 353
Organizer: Jordi Castro, Univ. Politècnica de Catalunya, ES

1 - A feasible direction interior point algorithm for linear programming
Speaker: Jose Herskovits, UFRJ, BR, talk 31
Co-Authors: *Miluzca Victorio*, *Nelson Maculan*,
2 - A specialized interior-point algorithm for very large minimum cost flows in bipa
Speaker: Stefano Nasini, IESEG School of Management, FR, talk 38
Co-Authors: *Jordi Castro*,

Implementation of interior-point methods for large-scale problems and applications II

Algo - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8
Invited Session 352
Organizer: Jordi Castro, Univ. Politècnica de Catalunya, ES

1 - On the implementation of the crossover algorithm
Speaker: Csaba Meszaros, FICO, GB, talk 992
2 - Interior point methods applied to context-free grammar parameter estimation
Speaker: Aurelio Oliveira, University of Campinas, BR, talk 1040
Co-Authors: *Sofia Lopez*,
3 - A new specialized interior-point method for support vector machines
Speaker: Jordi Castro, Univ. Politècnica de Catalunya, ES, talk 81

High-Performance Computing in Optimization

High-Performance Computing in Optimization I

ALGO - Th 8:30am-10:30am, Format: 3x30 min
Room: Salle 18 Building: I, 1st floor, Zone: 7

INVITED SESSION 271
Organizer: Kibaek Kim, ANL, US

1 - Performance Assessment for Parallel MILP Solvers
Speaker: Ted Ralphs, Lehigh University, US, talk 1347
Co-Authors: *Stephen Maher*, *Yuji Shinano*,
2 - Ubiquity Generator Framework to parallelize state-of-the-art B and B based solvers
Speaker: Yuji Shinano, Zuse Institute Berlin, DE, talk 1181
3 - Branching Strategies on Decomposition Methods for Mixed-Integer Programming
Speaker: Kibaek Kim, ANL, US, talk 1510
Co-Authors: *Brian Dandurand*,

High-Performance Computing in Optimization II

ALGO - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

CONTRIBUTED SESSION 466
Chair: Joaquim Dias Garcia, PSR and PUC-Rio, BR

1 - High-Performance Solver for Binary Quadratic Problems
Speaker: Timotej Hrga, University of Ljubljana, SI, talk 969
Co-Authors: *Janez Povh*, *Angelika Wiegele*,
2 - Bilevel optimization approaches for power system security
Speaker: Brian Dandurand, Argonne National Laboratory, US, talk 1413
Co-Authors: *Kibaek Kim*, *Sven Leyffer*,
3 - Genesys: Simulating Power Systems by Solving Millions of MIPs
Speaker: Joaquim Dias Garcia, PSR and PUC-Rio, BR, talk 1091
Co-Authors: *André Pinto*, *Raphael Chabar*, *Julio Dias*, *Luiz Carlos da Costa Junior*, *John Fazio*, *John Ollis*, *Dan Hua*,

MINLP methods in gas transport optimization

MINLP methods in gas transport optimization (I)

MINLP - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4

INVITED SESSION 162
Organizer: Lars Schewe, FAU, DE

1 - MIP techniques for instationary gas transport optimization and gas market models
Speaker: Lars Schewe, FAU, DE, talk 1298
2 - Solving MINLPs by Simultaneous Convexification with Application to Gas Networks
Speaker: Nick Mertens, TU Dortmund, DE, talk 742
Co-Authors: *Maximilian Merkert*, *Dennis Michaels*, *Frauke Liers*, *Alexander Martin*,
3 - Complementarity-Based Nonlinear Programming Techniques for Optimal Mixing in Gas
Speaker: Falk Hante, FAU Erlangen-Nürnberg, DE, talk 1288
Co-Authors: *Martin Schmidt*,

MINLP methods in gas transport optimization (II)

MINLP - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4

INVITED SESSION 163
Organizer: Lars Schewe, FAU, DE

1 - Exploiting acyclic orientations to solve nonlinear potential-based flow problems

Speaker: Benjamin Hiller, Zuse Institute Berlin, DE, talk 905
Co-Authors: *Kai-Helge Becker*,
2 - ASTS-Orientations on Undirected Graphs - A tool for optimizing network flows
Speaker: Kai Becker, Zuse-Institute Berlin, DE, talk 1446
Co-Authors: *Benjamin Hiller*,
3 - Robust Optimal Discrete Arc Sizing for Tree-Shaped Potential Networks
Speaker: Johannes Thürauf, Universität Erlangen-Nürnberg, DE, talk 546
Co-Authors: *Lars Schewe*, *Martin Schmidt*, *Martin Robinius*, *Detlef Stolten*, *Lara Welder*,

Parallel Sessions

Monday 02

CLUSTER: Discrete Optimization & Integer Programming

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
IPtheory		Salle 43 Bld C, 3rd floor Z 1 F 3x30 min **Provable guarantees for Cut Generating Functions** Organizer: Amitabh Basu, session 220	Salle 34 Bld B, 1st floor Z 3 F 3x30 min **Lattice methods in Integer Optimisation** Organizer: Iskander Aliev, session 78
IPpractice		Salle 44 Bld C, 3rd floor Z 1 F 3x30 min **IP Practice I** Chair: Maurice Queyranne, session 506	Salle 44 Bld C, 3rd floor Z 1 F 4x20 min **Data Mining** Chair: Marcus Poggi, session 504
IPpractice			Salle 36 Bld B, Intermediate Z 4 F 4x20 min **IP Practice II** Chair: Petra Bartmeyer, session 508
MINLP		Salle 39 Bld E, 3rd floor Z 1 F 3x30 min **Exact Optimization Algorithms for Compressed Sensing** Organizer: Marc Pfetsch, session 56	DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **Mixed-Integer Conic Optimization** Organizer: Sven Wiese, session 57
MINLP		Salle 34 Bld B, 1st floor Z 3 F 3x30 min **Tight relaxations in nonconvex MINLP** Organizer: Ambros Gleixner, session 128	Salle 39 Bld E, 3rd floor Z 1 F 3x30 min **Polynomial optimization in binary variables** Organizer: Elisabeth Rodriguez-Heck, session 58
MINLP		Salle 35 Bld B, Intermediate Z 4 F 3x30 min **MINLP methods in gas transport optimization (I)** Organizer: Lars Schewe, session 162	Salle 35 Bld B, Intermediate Z 4 F 3x30 min **MINLP methods in gas transport optimization (II)** Organizer: Lars Schewe, session 163
APPROX		LEYTEIRE Bld E, 3rd floor Z 1 F 3x30 min **Geometry of Polynomials and Applications in Approximate Counting** Organizer: Shayan Oveis Gharan, session 99	LEYTEIRE Bld E, 3rd floor Z 1 F 3x30 min **Scheduling and File Migration** Chair: Asaf Levin, session 345
APPROX		Salle 36 Bld B, Intermediate Z 4 F 3x30 min **Matching and Matroids** Organizer: José Soto, session 341	Salle 43 Bld C, 3rd floor Z 1 F 4x20 min **Algorithms for matching markets** Organizer: Amin Saberi, session 467
COMB		SIGALAS Bld C, 2nd floor Z 2 F 3x30 min **On the Tree Augmentation Problem** Organizer: Laura Sanità, session 240	SIGALAS Bld C, 2nd floor Z 2 F 4x20 min **Combinatorial optimization and convexity** Chair: Yu Yokoi, session 424
COMB		Salle 41 Bld C, 3rd floor Z 1 F 3x30 min **Scheduling with setup, uncertainty and precedences** Organizer: Monaldo Mastrolilli, session 419	Salle 41 Bld C, 3rd floor Z 1 F 4x20 min **Practical aspects of network optimization** Chair: Kai Hoppmann, session 427
CP		DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **Global Optimization** Organizer: Hassan Hijazi, session 299	

Monday 02

CLUSTER: Optimization under Uncertainty

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Stoch		Salle 32 Bld B, Ground Floor Z 5 F 3x30 min **Scenario discretization techniques in stochastic optimization** Organizer: Fabian Bastin, session 287	Salle 32 Bld B, Ground Floor Z 5 F 3x30 min **Distributionally Robust Stochastic Programming: Theory and Applications** Organizer: Ran Ji, session 250
Stoch			Salle 30 Bld B, Ground Floor Z 5 F 3x20 min **Differentiability, convexity, and modeling in stochastic optimization** Chair: Kai Spuerkel, session 493
Robust		DENIGES Bld C, Ground Floor Z 5 F 3x30 min **Preference robust optimization** Organizer: Erick Delage, session 166	DENIGES Bld C, Ground Floor Z 5 F 3x30 min **Advances in Adjustable Robust Optimization** Organizer: Do Young Yoon, session 350
Robust		Salle 33 Bld B, Ground Floor Z 5 F 3x30 min **Distributionally Robust Optimization - New Theory and Applications** Organizer: Zhichao Zheng, session 356	Salle 37 Bld B, Intermediate Z 4 F 3x20 min **New models in robust optimization** Chair: Juan Borrero, session 459
Markov		Salle 31 Bld B, Ground Floor Z 5 F 3x30 min **Approximate dynamic programming** Organizer: David Brown, session 159	Salle 31 Bld B, Ground Floor Z 5 F 2x30 min **Learning and dynamic programming** Chair: Boxiao Chen, session 381
Game		Salle 30 Bld B, Ground Floor Z 5 F 3x30 min **Risk and Energy Markets** Chair: Julio Deride, session 376	

Monday 02

CLUSTER: Continuous Optimization

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
NLP		GINTRAC Bld Q, Ground Floor Z 8 F 3x30 min **Polynomial and tensor optimization I** Organizer: Jiawang Nie, session 5	GINTRAC Bld Q, Ground Floor Z 8 F 3x30 min **Gradient Methods for Constrained Optimization Problems** Organizer: Igor Konnov, session 4
NLP		Salle 05 Bld Q, 1st floor Z 11 F 3x30 min **Convex regularization and inverse problems** Organizer: Pierre Weiss, session 216	Salle 05 Bld Q, 1st floor Z 11 F 4x20 min **Polynomial and tensor optimization III** Organizer: Jiawang Nie, session 7
NLP		Salle KC7 Bld K, Intermediate 2 Z 10 F 3x30 min **Sparse Recovery** Chair: Mustafa Pinar, session 432	Salle 9 Bld N, 4th floor Z 12 F 3x20 min **Modeling in NLP** Chair: Laura Balzano, session 433
NonSmooth		Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Nonconvex Optimization: Theory and Methods - Part 1** Organizer: Shoham Sabach, session 184	Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Extending the Reach of First-Order Methods, Part I** Organizer: Haihao Lu, session 285
NonSmooth		Salle 9 Bld N, 4th floor Z 12 F 2x30 min **Adaptivity in non smooth optimization** Organizer: Masaru Ito, session 558	
SDP		Salle 20 Bld G, 1st floor Z 6 F 3x30 min **Using SDP relaxations and solving them faster** Organizer: Elisabeth Gaar, session 113	Salle 20 Bld G, 1st floor Z 6 F 3x30 min **Solving large scale convex composite programming** Organizer: Kim-Chuan Toh, session 130
SDP		Salle LC5 Bld L, Intermediate 1 Z 10 F 3x30 min **Algorithms for nonlinear conic problems** Chair: Takayuki Okuno, session 463	Salle LC5 Bld L, Intermediate 1 Z 10 F 3x30 min **Convergence and Approximation in Conic Programming** Chair: Tamás Terlaky, session 465
Variat		Salle 06 Bld Q, 1st floor Z 11 F 3x30 min **Proximal Methods for Structured Problems** Organizer: Ting Kei Pong, session 147	Salle 06 Bld Q, 1st floor Z 11 F 4x20 min **Nonlinear Optimization and Variational Inequalities VI** Organizer: Cong Sun, session 146
Variat		Salle ARNOZAN Bld Q, Ground Floor Z 8 F 3x30 min **Algorithms for optimization and variational problems with possibly nonisolated solutions I** Organizer: Andreas Fischer, session 152	Salle ARNOZAN Bld Q, Ground Floor Z 8 F 4x20 min **Variational Analysis 4** Organizer: Jo Brueggemann, session 370
RandomM		Salle KC6 Bld K, Intermediate 1 Z 10 F 3x30 min **Coordinate Descent and Randomized Direct Search Methods** Organizer: Martin Takac, session 211	Salle KC6 Bld K, Intermediate 1 Z 10 F 3x20 min **Complexity of Randomized Algorithms** Organizer: Raghu Pasupathy, session 347
DerFree		Salle 21 Bld G, Intermediate Z 6 F 3x30 min **Mixed-integer derivative-free optimization** Chair: Clément Royer, session 80	Salle 21 Bld G, Intermediate Z 6 F 3x30 min **Advances in DFO I** Chair: Sébastien Le Digabel, session 40
Control		Salle AURIAC Bld G, 1st floor Z 6 F 3x30 min **Theory and Methods for ODE- and PDE-Constrained Optimization 1** Chair: Carl Greiff, session 331	Salle AURIAC Bld G, 1st floor Z 6 F 4x20 min **Advances in optimization methods for time dependent problems:I** Organizer: Matthias Heinkenschloss, session 223

Monday 02

CLUSTER: Specific Models, Algorithms, and Software

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Learning		FABRE Bld J, Ground Floor Z 8 F 3x30 min **Distributed Optimization** Organizer: Franck Iutzeler, session 325	FABRE Bld J, Ground Floor Z 8 F 4x20 min **Riemannian geometry in optimization for learning** Organizer: Nicolas Boumal, session 320
Learning		Salle 16 Bld I, 2nd floor Z 7 F 3x30 min **Decisions and learning from data** Chair: Christopher McCord, session 481	Salle DENUCE Bld Q, Ground Floor Z 8 F 4x20 min **Exploiting structure in constrained optimization** Organizer: Mihai Cucuringu, session 334
Learning			Salle 22 Bld G, 2nd floor Z 6 F 4x20 min **Sparsity, variable selection and efficient algorithms** Chair: Alex Sholokhov, session 475
Logistics		PITRES Bld O, Ground Floor Z 8 F 3x30 min **Facility Layout** Chair: Anders Gullhav, session 450	Salle 16 Bld I, 2nd floor Z 7 F 3x20 min **Packing and Capacity Management** Chair: Eugene Zak, session 452
Scheduling		Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Combinatorial Optimization in Chip Design** Organizer: Stefan Hougardy, session 257	Salle 18 Bld I, 1st floor Z 7 F 4x20 min **Manufacturing** Chair: Younsoo Lee, session 530
Energy		Salle DENUCE Bld Q, Ground Floor Z 8 F 3x30 min **Progress in Algorithms for Optimal Power Flow Problems I** Organizer: Miguel Anjos, session 8	Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Novel data-driven OR techniques for power system operations and planning** Organizer: Juan Morales, session 52
Energy		Salle 24 Bld G, 3rd floor Z 6 F 3x30 min **Topics in power systems** Organizer: Alberto Lamadrid, session 438	Salle 24 Bld G, 3rd floor Z 6 F 3x30 min **Structure and Learning in Power Grid Optimization** Organizer: Deepjyoti Deka, session 135
Sciences		Salle LA4 Bld L, Basement Z 8 F 3x30 min **Portfolio Optimization** Chair: Bernardo Pagnoncelli, session 393	Salle LA4 Bld L, Basement Z 8 F 3x30 min **Structure from evidence** Organizer: Peter Gritzmann, session 386
Algo		Salle 22 Bld G, 2nd floor Z 6 F 2x30 min **Implementation of interior-point methods for large-scale problems and applications I** Organizer: Jordi Castro, session 353	PITRES Bld O, Ground Floor Z 8 F 3x30 min **Implementation of interior-point methods for large-scale problems and applications II** Organizer: Jordi Castro, session 352
Algo		Salle 18 Bld I, 1st floor Z 7 F 3x30 min **Advances in Linear, Non Linear and Mixed-Integer Optimization** Chair: Hiroshige Dan, session 400	

Tuesday 03

CLUSTER: Discrete Optimization & Integer Programming

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
IPtheory	Salle 43 Bld C, 3rd floor Z 1 F 4x30 min **Extended formulations** Organizer: Stefan Weltge, session 219	Salle 43 Bld C, 3rd floor Z 1 F 3x30 min **MIP under Uncertainty 2** Organizer: Simge Kucukyavuz, session 232	
IPtheory	Salle 34 Bld B, 1st floor Z 3 F 3x30 min **MIP under Uncertainty 1** Organizer: Fatma Kilinc-Karzan, session 231		
IPtheory	Salle 35 Bld B, Intermediate Z 4 F 4x30 min **Cutting Planes for Integer Programs** Chair: Matthias Köppe, session 512		
IPpractice	Salle 44 Bld C, 3rd floor Z 1 F 4x30 min **Machine Learning for Optimization** Organizer: Bistra Dilkina, session 138	Salle 44 Bld C, 3rd floor Z 1 F 3x30 min **Symmetry Handling in Integer Programs** Organizer: Christopher Hojny, session 129	
MINLP		DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **Applications in Mixed-Integer Quadratic Programming** Organizer: Boshi Yang, session 107	
MINLP		Salle 34 Bld B, 1st floor Z 3 F 3x30 min **Convex relaxations in MINLP** Organizer: Adam Letchford, session 278	
MINLP		Salle 35 Bld B, Intermediate Z 4 F 3x30 min **Applications of MINLP** Organizer: Dolores Romero Morales, session 281	
APPROX	LEYTEIRE Bld E, 3rd floor Z 1 F 4x30 min **Streaming** Organizer: Michael Kapralov, session 228	LEYTEIRE Bld E, 3rd floor Z 1 F 3x30 min **Algorithms in the Sharing Economy** Organizer: David Shmoys, session 22	
APPROX	Salle 36 Bld B, Intermediate Z 4 F 4x30 min **Approximation Algorithms for Clustering** Organizer: Chaitanya Swamy, session 256	Salle 36 Bld B, Intermediate Z 4 F 3x30 min **Local Search and Facility Location** Organizer: Felix Willamowski, session 342	
COMB	SIGALAS Bld C, 2nd floor Z 2 F 4x30 min **Matching games and beyond** Organizer: Jochen Koenemann, session 241	Salle 41 Bld C, 3rd floor Z 1 F 3x30 min **New developments in prophet inequalities and related settings** Organizer: Ruben Hoeksma, session 258	
COMB	Salle 41 Bld C, 3rd floor Z 1 F 4x30 min **Equilibrium Computation in Congestion Games** Organizer: Umang Bhaskar, session 242	Salle 39 Bld E, 3rd floor Z 1 F 3x30 min **Submodular optimization and beyond** Chair: Satoru Iwata, session 418	
COMB	Salle 39 Bld E, 3rd floor Z 1 F 4x30 min **Exact approaches for problems over lattices and graphs** Chair: Daniele Catanzaro, session 425		
CP	DURKHEIM Bld A, 3rd floor Z 1 F 4x30 min **Graphical Optimization Model 1** Organizer: Joris Kinable, session 295		

Tuesday 03

CLUSTER: Optimization under Uncertainty

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Stoch	DENIGES Bld C, Ground Floor Z 5 F 4x30 min **Risk-averse stochastic programming** Organizer: Andrzej Ruszczynski, session 252	Salle 32 Bld B, Ground Floor Z 5 F 3x30 min **Distributionally Robust and Stochastic Optimization: A Sampling/Scenario Perspective** Organizer: Guzin Bayraksan, session 249	
Robust	Salle 37 Bld B, Intermediate Z 4 F 3x30 min **Nonlinear Optimization with Uncertain Constraints** Organizer: Charlie Vanaret, session 110	Salle 33 Bld B, Ground Floor Z 5 F 3x30 min **Recent Advances in Robust Optimization I** Organizer: Phebe Vayanos, session 442	
Robust	Salle 33 Bld B, Ground Floor Z 5 F 3x30 min **Robust Optimization and Operations Mangement** Organizer: Chaithanya Bandi, session 410	DENIGES Bld C, Ground Floor Z 5 F 3x30 min **Recent Advances in Robust Optimization II** Organizer: Wolfram Wiesemann, session 445	
Markov	Salle 31 Bld B, Ground Floor Z 5 F 4x30 min **Algorithms for stochastic games : new approaches** Organizer: Hugo Gimbert, session 137	Salle 31 Bld B, Ground Floor Z 5 F 3x30 min **Market places and dynamic programming** Chair: Dan Iancu, session 380	
Game	Salle 30 Bld B, Ground Floor Z 5 F 4x30 min **Algorithmic Game Theory I** Organizer: Luce Brotcorne, session 311	Salle 30 Bld B, Ground Floor Z 5 F 3x30 min **Game Theory and Energy Markets** Chair: Didier Aussel, session 375	

Tuesday 03

CLUSTER: Continuous Optimization

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
NLP	GINTRAC Bld Q, Ground Floor Z 8 F 4x30 min **Stochastic and Nonlinear Optimization I** Organizer: Jorge Nocedal, session 47	GINTRAC Bld Q, Ground Floor Z 8 F 3x30 min **Sum-of-squares and moment problems: methods and applications** Organizer: Etienne De Klerk, session 2	
NLP	Salle 05 Bld Q, 1st floor Z 11 F 4x30 min **Machine learning and sparse optimisation** Organizer: Coralia Cartis, session 109	Salle KC7 Bld K, Intermediate 2 Z 10 F 3x30 min **Bridging NLP and Theoretical Computer Science** Organizer: Aleksander Madry, session 51	
NLP	Salle KC7 Bld K, Intermediate 2 Z 10 F 4x30 min **Unconstrained Optimization** Chair: Ekkehard Sachs, session 401	Salle 05 Bld Q, 1st floor Z 11 F 2x30 min **Interior Point Methods in Engineering Applications II** Organizer: Jacek Gondzio, session 61	
NLP		Salle 9 Bld N, 4th floor Z 12 F 3x30 min **Linear Optimization III** Chair: Rodrigo Mendoza Smith, session 439	
NonSmooth	Salle LC4 Bld L, Intermediate 1 Z 9 F 4x30 min **Advances in Bundle Methods for Convex Optimization** Organizer: Christoph Helmberg, session 93	Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Nonconvex Optimization: Theory and Methods - Part 2** Organizer: Russell Luke, session 186	
NonSmooth	Salle 8 Bld N, 4th floor Z 12 F 4x30 min **Addressing problems with complex geometries** Organizer: Edouard Pauwels, session 229		
SDP	Salle 20 Bld G, 1st floor Z 6 F 4x30 min **Algebraic and geometric aspects of semidefinite programming** Organizer: Hamza Fawzi, session 85	Salle 20 Bld G, 1st floor Z 6 F 3x30 min **Recent Advances in Conic Programming I** Organizer: Makoto Yamashita, session 82	
SDP	Salle LC5 Bld L, Intermediate 1 Z 10 F 4x30 min **Theory and algorithms in conic linear programming 1** Organizer: Gabor Pataki, session 88	Salle LC5 Bld L, Intermediate 1 Z 10 F 3x30 min **Relative Entropy Optimization II** Organizer: Venkat Chandrasekaran, session 112	
Variat	Salle 06 Bld Q, 1st floor Z 11 F 4x30 min **Nonlinear Optimization and Variational Inequalities V** Organizer: Xin Liu, session 145	Salle 06 Bld Q, 1st floor Z 11 F 3x30 min **Nonlinear Optimization and Variational Inequalities III** Organizer: Xin Liu, session 143	
Variat	Salle ARNOZAN Bld Q, Ground Floor Z 8 F 4x30 min **Optmization Algorithms and Variational Inequalites I** Organizer: Bo Jiang, session 148		
RandomM	Salle KC6 Bld K, Intermediate 1 Z 10 F 4x30 min **Larges Scale and Distributed Optimization** Organizer: Ermin Wei, session 214	Salle KC6 Bld K, Intermediate 1 Z 10 F 3x30 min **Recent Advances in Stochastic and Nonconvex Optimization II** Organizer: Mingyi Hong, session 304	
DerFree	Salle 21 Bld G, Intermediate Z 6 F 4x30 min **Bayesian and Randomized Optimization II** Chair: Youssef Diouane, session 79	Salle 21 Bld G, Intermediate Z 6 F 3x30 min **Advances in DFO II** Chair: Warren Hare, session 37	
Control	Salle AURIAC Bld G, 1st floor Z 6 F 4x30 min **Optimization Methods for PDE Constrained Problems** Organizer: Michael Ulbrich, session 221	Salle AURIAC Bld G, 1st floor Z 6 F 3x30 min **Optimal Control and PDE Constrained Optimization** Organizer: Hasnaa Zidani, session 233	

Tuesday 03

CLUSTER: Specific Models, Algorithms, and Software

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Learning	FABRE Bld J, Ground Floor Z 8 F 4x30 min **Optimization in Statistical Learning** Organizer: Quentin Berthet, session 326	Salle 16 Bld I, 2nd floor Z 7 F 3x30 min **Distributed and Asynchronous Learning** Organizer: Ion Necoara, session 323	
Learning	Salle DENUCE Bld Q, Ground Floor Z 8 F 4x30 min **Statistics meets optimization: going beyond convexity** Organizer: John Duchi, session 337	FABRE Bld J, Ground Floor Z 8 F 3x30 min **Advances in large-scale machine learning** Organizer: Mark Schmidt, session 327	
Learning	Salle 22 Bld G, 2nd floor Z 6 F 4x30 min **Pricing** Chair: Anastasiya Ivanova, session 478	Salle 22 Bld G, 2nd floor Z 6 F 2x30 min **Learning for mixed integer optimization** Chair: Hari Bandi, session 482	
Network	Salle 18 Bld I, 1st floor Z 7 F 4x30 min **Path and tree problems** Chair: Arthur Delarue, session 360		
Logistics	Salle 16 Bld I, 2nd floor Z 7 F 3x30 min **Facility Location** Chair: Ivan Contreras, session 414	PITRES Bld O, Ground Floor Z 8 F 3x30 min **Pricing Methods** Organizer: Rafael Martinelli, session 182	
Scheduling		Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Supply Chain and Lot Sizing** Chair: Simon Thevenin, session 534	
Energy	Salle 23 Bld G, 3rd floor Z 6 F 4x30 min **Electric Vehicles and Decarbonization** Chair: Martim Joyce-Moniz, session 519	Salle DENUCE Bld Q, Ground Floor Z 8 F 3x30 min **Equilibrium Modelling in Energy** Organizer: Thomas Kallabis, session 290	
Energy	Salle 24 Bld G, 3rd floor Z 6 F 4x30 min **Risk Models for Electricity Markets** Chair: Michael Ferris, session 521	Salle 24 Bld G, 3rd floor Z 6 F 3x30 min **Optimization Models for Renewable Energy Integration 2** Chair: Michel Denault, session 523	
Sciences	Salle LA4 Bld L, Basement Z 8 F 4x30 min **Interval Global Optimization** Organizer: Frederic Messine, session 339	Salle LA4 Bld L, Basement Z 8 F 3x30 min **Optimization in Medicine** Organizer: Sebastian Sager, session 394	
Algo	PITRES Bld O, Ground Floor Z 8 F 4x30 min **LP, Mixed Integer Convex Programming and Decomposition** Organizer: Thorsten Koch, session 236	Salle 18 Bld I, 1st floor Z 7 F 3x30 min **Optimization software and applications** Chair: Bartolomeo Stellato, session 399	

Wednesday 04

CLUSTER: Discrete Optimization & Integer Programming

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
IPtheory	Salle 43 Bld C, 3rd floor Z 1 F 4x30 min **Determinantal structures of IPs** Organizer: Martin Henk, session 131		Salle 43 Bld C, 3rd floor Z 1 F 2x30 min **IP-Formulations** Chair: Temitayo Ajayi, session 516
IPtheory	Salle 35 Bld B, Intermediate Z 4 F 4x30 min **Advances in Integer Programming** Organizer: Santanu Dey, session 230		
IPtheory	Salle 42 Bld C, 3rd floor Z 1 F 4x30 min **Primal Algorithms for Integer Programming Problems** Organizer: Daniel Aloise, session 338		
IPpractice	Salle 44 Bld C, 3rd floor Z 1 F 4x30 min **Benders Decomposition for Combinatorial and Bilevel Optimization** Organizer: Fabio Furini, session 171	Salle 44 Bld C, 3rd floor Z 1 F 3x30 min **Knapsack Problems** Organizer: Enrico Malaguti, session 185	Salle 44 Bld C, 3rd floor Z 1 F 3x30 min **Exact Approaches for Vehicle Routing and Variants** Organizer: Ricardo Fukasawa, session 288
IPpractice		Salle 36 Bld B, Intermediate Z 4 F 3x30 min **Decomposition I** Chair: Dieter Weninger, session 486	
MINLP	Salle 34 Bld B, 1st floor Z 3 F 3x30 min **MINLP (I)** Organizer: Daniel Bienstock, session 65	DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **Decomposition methods for MINLP** Organizer: Ivo Nowak, session 55	DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **MINLP (III)** Organizer: Daniel Bienstock, session 67
MINLP		Salle 34 Bld B, 1st floor Z 3 F 3x30 min **MINLP (II)** Organizer: Daniel Bienstock, session 66	Salle 34 Bld B, 1st floor Z 3 F 3x30 min **Robust Approaches for Challenging Uncertain Optimization Problems** Organizer: Frauke Liers, session 124
MINLP		Salle 35 Bld B, Intermediate Z 4 F 3x30 min **MINLP for Data Science** Organizer: Vanesa Guerrero, session 108	Salle 35 Bld B, Intermediate Z 4 F 3x30 min **Advances in MINLP** Organizer: Laura Palagi, session 165
APPROX	LEYTEIRE Bld E, 3rd floor Z 1 F 4x30 min **Approximation Algorithms for the Traveling Salesman Problem** Organizer: Anke van Zuylen, session 23	LEYTEIRE Bld E, 3rd floor Z 1 F 3x30 min **Clustering** Organizer: Mohammad Salavatipour, session 30	LEYTEIRE Bld E, 3rd floor Z 1 F 3x30 min **Approximation Algorithms for Geometric Packing Problems** Organizer: Fabrizio Grandoni, session 28
APPROX	Salle 36 Bld B, Intermediate Z 4 F 4x30 min **Approximation Algorithms for Scheduling Problems** Organizer: Nicole Megow, session 72	Salle 43 Bld C, 3rd floor Z 1 F 3x30 min **Network Design and Routing** Chair: Yuko Kuroki, session 346	Salle 36 Bld B, Intermediate Z 4 F 3x30 min **Online Optimization** Organizer: Kevin Schewior, session 35
COMB	Salle 41 Bld C, 3rd floor Z 1 F 4x30 min **Discrete Convex Analysis** Organizer: Akiyoshi Shioura, session 243	Salle 41 Bld C, 3rd floor Z 1 F 3x30 min **Variants of the Assignment problem** Organizer: Kavitha Telikepalli, session 266	Salle 41 Bld C, 3rd floor Z 1 F 4x20 min **Connectivity problems and Steiner trees** Chair: Andreas Feldmann, session 421
COMB	Salle 39 Bld E, 3rd floor Z 1 F 4x30 min **Optimization under uncertainty** Organizer: Marco Molinaro, session 261	Salle 39 Bld E, 3rd floor Z 1 F 3x30 min **Polyhedral aspects of combinatorial optimization problems** Chair: Guillerme Duvillié, session 404	Salle 39 Bld E, 3rd floor Z 1 F 4x20 min **Shortest paths and cutting stock** Chair: Arnaud Vandaele, session 426
CP	DURKHEIM Bld A, 3rd floor Z 1 F 4x30 min **Learning in CP** Organizer: Arnaud Lallouet, session 301		

Wednesday 04

CLUSTER: Optimization under Uncertainty

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Stoch	DENIGES Bld C, Ground Floor Z 5 F 4x30 min **Chance Constraint and Its Applications** Organizer: Jianqiang Cheng, session 253	Salle 32 Bld B, Ground Floor Z 5 F 3x30 min **Learning and Stochastic Programming** Organizer: Matthias Poloczek, session 254	DENIGES Bld C, Ground Floor Z 5 F 3x30 min **Stochastic Programming and Distributionally Robust Optimization Models with Endogenous Uncertainty** Organizer: Miguel Lejeune, session 248
Stoch	Salle 32 Bld B, Ground Floor Z 5 F 3x30 min **Sampling and stability in stochastic optimization** Chair: Harsha Honnappa, session 488		Salle 32 Bld B, Ground Floor Z 5 F 4x20 min **Stochastic optimization models and applications** Chair: F.-Javier Heredia, session 495
Robust	Salle 37 Bld B, Intermediate Z 4 F 4x30 min **Interfaces of Applied Probability and Optimization** Organizer: Omar El Housni, session 409	DENIGES Bld C, Ground Floor Z 5 F 3x30 min **Dynamic Optimization: Theory and Algorithms** Organizer: Vineet Goyal, session 100	Salle 37 Bld B, Intermediate Z 4 F 2x30 min **Robust Adaptive Control and Learning** Organizer: Siqian Shen, session 97
Robust	Salle 33 Bld B, Ground Floor Z 5 F 4x30 min **Robust combinatorial optimization IV** Chair: Arie Koster, session 449	Salle 37 Bld B, Intermediate Z 4 F 3x30 min **Cursing the Dimensionality: Two-Stage and Multi-Stage Robust Optimization** Organizer: Angelos Tsoukalas, session 443	Salle 33 Bld B, Ground Floor Z 5 F 4x20 min **Robust combinatorial optimization III** Organizer: Moritz Mühlenthaler, session 255
Markov		Salle 31 Bld B, Ground Floor Z 5 F 2x30 min **Dynamic programming applications** Chair: Susanne Hoffmeister, session 379	
Game	Salle 30 Bld B, Ground Floor Z 5 F 4x30 min **Risk and Financial Markets** Chair: Markku Kallio, session 377	Salle 30 Bld B, Ground Floor Z 5 F 3x30 min **Nonconvex and Complex Problems in Multiobjective Optimization** Chair: Gabriele Eichfelder, session 268	Salle 30 Bld B, Ground Floor Z 5 F 3x30 min **Aspects of Multiobjective Combinatorial Optimization** Organizer: Matthias Ehrgott, session 87

Wednesday 04

CLUSTER: Continuous Optimization

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
NLP	GINTRAC Bld Q, Ground Floor Z 8 F 4x30 min **Stochastic and Nonlinear Optimization III** Organizer: Jorge Nocedal, session 31	GINTRAC Bld Q, Ground Floor Z 8 F 3x30 min **The power and limits of the Lasserre hierarchy** Organizer: Markus Schweighofer, session 9	GINTRAC Bld Q, Ground Floor Z 8 F 3x30 min **Software for Nonlinear Optimization** Organizer: Sven Leyffer, session 133
NLP	Salle 05 Bld Q, 1st floor Z 11 F 4x30 min **Optimality conditions in NLP and conic problems** Organizer: Roberto Andreani, session 43	Salle 05 Bld Q, 1st floor Z 11 F 3x30 min **Subspace methods in NLP I** Organizer: Michal Kocvara, session 45	Salle 05 Bld Q, 1st floor Z 11 F 3x30 min **Conjugate Gradient Methods** Chair: Giovanni Fasano, session 362
NLP	Salle KC7 Bld K, Intermediate 2 Z 10 F 4x30 min **Computational advances in NLP** Chair: Jeffrey Pang, session 434	Salle 9 Bld N, 4th floor Z 12 F 3x30 min **Quadratic Optimization** Chair: Anders Forsgren, session 417	Salle 9 Bld N, 4th floor Z 12 F 3x30 min **Linear Optimization II** Chair: Julian Hall, session 416
NLP	Salle 9 Bld N, 4th floor Z 12 F 4x30 min **Fixed Point Approaches** Chair: Poom Kumam, session 435		Salle ARNOZAN Bld Q, Ground Floor Z 8 F 3x30 min **Interior Point Methods in LP and NLP** Chair: Andre Tits, session 430
NonSmooth	Salle LC4 Bld L, Intermediate 1 Z 9 F 4x30 min **Recent advances in first-order algorithms for non-smooth optimization** Organizer: Thomas Pock, session 198	Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Adaptivity in non-smooth optimization** Organizer: Volkan Cevher, session 187	Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Methods and Analysis for Nonsmooth Optimization** Organizer: Michael Overton, session 86
NonSmooth	Salle 8 Bld N, 4th floor Z 12 F 4x30 min **Dynamical Systems and Optimization** Organizer: Hedy Attouch, session 351		
SDP	Salle AURIAC Bld G, 1st floor Z 6 F 4x30 min **Recent Advances in Conic Programming II** Organizer: Sena Safarina, session 83	Salle 20 Bld G, 1st floor Z 6 F 3x30 min **SDP approaches to combinatorial and global optimization problems** Organizer: Etienne De Klerk, session 15	Salle 20 Bld G, 1st floor Z 6 F 3x30 min **Noncommutative polynomial optimization: semidefinite relaxations, free convexity and applications to quantum information I** Organizer: Monique Laurent, session 20
SDP	Salle 20 Bld G, 1st floor Z 6 F 4x30 min **Theory and algorithms in conic linear programming 2** Organizer: Gabor Pataki, session 89	Salle LC5 Bld L, Intermediate 1 Z 10 F 3x30 min **Reformulation-based solution methods for quadratic programming** Organizer: Dominique Quadri, session 215	Salle LC5 Bld L, Intermediate 1 Z 10 F 4x20 min **Completely Positive Cones and Applications** Chair: Patrick Groetzner, session 464
SDP	Salle LC5 Bld L, Intermediate 1 Z 10 F 4x30 min **New trends II** Chair: Frank Permenter, session 500		
Variat	Salle 06 Bld Q, 1st floor Z 11 F 2x30 min **Stochastic Optimization and Variational Inequalities II** Organizer: Alejandro Jofre, session 156	Salle 06 Bld Q, 1st floor Z 11 F 3x30 min **Optimization Algorithms and Variational Inequalities II** Organizer: Xiaoqi Yang, session 150	Salle 06 Bld Q, 1st floor Z 11 F 3x30 min **Complementarity Problems** Organizer: Samir Neogy, session 173
Variat	Salle ARNOZAN Bld Q, Ground Floor Z 8 F 4x30 min **Variational Analysis 1** Organizer: Samir Adly, session 364	Salle ARNOZAN Bld Q, Ground Floor Z 8 F 3x30 min **Nash equilibrium and games 1** Organizer: Lorenzo Lampariello, session 365	
RandomM	Salle KC6 Bld K, Intermediate 1 Z 10 F 4x30 min **First Order Methods for Non-Smooth Constrained Optimization** Organizer: Qihang Lin, session 305	Salle KC6 Bld K, Intermediate 1 Z 10 F 3x30 min **Fast Converging Stochastic Optimization Algorithms** Organizer: Francis Bach, session 213	Salle KC6 Bld K, Intermediate 1 Z 10 F 4x20 min **Non-Convex and Second-order Methods in Machine Learning** Organizer: Martin Takac, session 33
DerFree	Salle 21 Bld G, Intermediate Z 6 F 4x30 min **New derivative-free algorithms** Chair: Margherita Porcelli, session 34	Salle 21 Bld G, Intermediate Z 6 F 3x30 min **Surrogate-based algorithms for constrained derivative-free problems** Chair: Phillipe Sampaio, session 126	Salle 21 Bld G, Intermediate Z 6 F 3x30 min **Progress in methods and theory of derivative-free optimization** Chair: Serge Gratton, session 42
Control		Salle AURIAC Bld G, 1st floor Z 6 F 3x30 min **Risk-Averse PDE-Constrained Optimization–Methods and Applications** Organizer: Harbir Antil, session 222	Salle AURIAC Bld G, 1st floor Z 6 F 4x20 min **Advances in optimization methods for time dependent problems II** Organizer: Denis Ridzal, session 225

Wednesday 04

CLUSTER: Specific Models, Algorithms, and Software

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Learning	Salle 16 Bld I, 2nd floor Z 7 F 3x30 min **First-Order Methods for Machine Learning** Organizer: Fabian Pedregosa, session 319	Salle DENUCE Bld Q, Ground Floor Z 8 F 3x30 min **Second order methods for training ML models** Chair: Julien Mairal, session 474	FABRE Bld J, Ground Floor Z 8 F 3x30 min **Problems in the intersection of machine learning and optimization** Chair: Ross Anderson, session 328
Learning	FABRE Bld J, Ground Floor Z 8 F 4x30 min **Structured Optimization for Machine Learning and Signal Processing** Organizer: Lin Xiao, session 330	FABRE Bld J, Ground Floor Z 8 F 3x30 min **Convex optimization, distances and constraints** Chair: Pablo Parrilo, session 476	Salle 22 Bld G, 2nd floor Z 6 F 2x20 min **Large-scale convex optimization** Chair: Alexander Rogozin, session 479
Network	Salle 18 Bld I, 1st floor Z 7 F 4x30 min **Robust network optimization** Organizer: Dimitri Papadimitriou, session 357		
Logistics		Salle 16 Bld I, 2nd floor Z 7 F 3x30 min **Rail and Maritime Transportation** Chair: Kazuhiro Kobayashi, session 454	Salle 24 Bld G, 3rd floor Z 6 F 4x20 min **Location and Routing** Chair: Mustapha Oudani, session 451
Logistics			Salle 16 Bld I, 2nd floor Z 7 F 3x20 min **Production-Routing** Chair: Feng Gao, session 456
Scheduling		Salle 18 Bld I, 1st floor Z 7 F 3x30 min **Scheduling in Networks** Chair: Hamish Waterer, session 532	Salle 18 Bld I, 1st floor Z 7 F 3x20 min **Machine Scheduling 2** Chair: Guopeng Song, session 529
Energy	Salle DENUCE Bld Q, Ground Floor Z 8 F 4x30 min **Decomposition Techniques to Solve Large-Scale Optimization Problems for Electricity and Natural Gas Systems** Organizer: Ramteen Sioshansi, session 136	Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Conic Optimization and Power Systems** Organizer: Jakub Marecek, session 68	Salle DENUCE Bld Q, Ground Floor Z 8 F 4x20 min **Optimization and modeling of integrated energy systems** Organizer: Jalal Kazempour, session 71
Energy	Salle 23 Bld G, 3rd floor Z 6 F 4x30 min **Energy-aware planning and scheduling 1** Organizer: Sandra U. Ngueveu, session 177	Salle 24 Bld G, 3rd floor Z 6 F 2x30 min **Emerging Energy Markets** Organizer: Dennice Gayme, session 291	Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Energy Market Models** Chair: Sauleh Siddiqui, session 522
Energy	Salle 24 Bld G, 3rd floor Z 6 F 4x30 min **Distribution and Demand Flexibility** Chair: Golbon Zakeri, session 510		
Sciences	Salle LA4 Bld L, Basement Z 8 F 3x30 min **Energy markets** Organizer: Martine Labbé, session 50	Salle LA4 Bld L, Basement Z 8 F 3x30 min **Air Transportation and Air Traffic Management** Organizer: Sonia Cafieri, session 315	Salle LA4 Bld L, Basement Z 8 F 3x30 min **Resource-constrained assignment and scheduling** Organizer: Fabian Bastin, session 398
Algo	PITRES Bld O, Ground Floor Z 8 F 3x30 min **Progress in MIP Solvers I** Organizer: Michael Winkler, session 235	PITRES Bld O, Ground Floor Z 8 F 3x30 min **Progress in Conic and MIP Solvers** Organizer: Imre Polik, session 237	PITRES Bld O, Ground Floor Z 8 F 3x30 min **Progress in MIP Solvers II** Organizer: Hans Mittelmann, session 234
Algo	Salle 22 Bld G, 2nd floor Z 6 F 4x30 min **Numerically Efficient Methods for Piecewise Algorithmic Differentiation I** Organizer: Torsten Bosse, session 269	Salle 22 Bld G, 2nd floor Z 6 F 3x30 min **Structure Detection in Integer Programming** Organizer: Taghi Khaniyev, session 272	

Thursday 05

CLUSTER: Discrete Optimization & Integer Programming

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
IPtheory	Salle 34 Bld B, 1st floor Z 3 F 4x30 min **Integer linear programming, convex geometry, and lattices** Organizer: Sinai Robins, session 142	Salle 42 Bld C, 3rd floor Z 1 F 3x30 min **Non-Standard IP Methods** Chair: Ulf Friedrich, session 513	Salle 43 Bld C, 3rd floor Z 1 F 4x20 min **Advances in Integer Programming** Organizer: Robert Hildebrand, session 227
IPtheory	Salle 35 Bld B, Intermediate Z 4 F 4x30 min **Convexity and Polytopes** Chair: David Warme, session 518	Salle 43 Bld C, 3rd floor Z 1 F 3x30 min **Polynomial Time Solvable Problems and Complete Descriptions** Chair: Andreas Bärmann, session 520	Salle 42 Bld C, 3rd floor Z 1 F 3x30 min **Cutting Planes for Special Problems** Chair: Eleazar Madriz, session 517
IPpractice	Salle 44 Bld C, 3rd floor Z 1 F 4x30 min **Advanced Linear(ized) MIP Formulations for Zero-One Programs** Organizer: Sven Mallach, session 127	Salle 44 Bld C, 3rd floor Z 1 F 3x30 min **Computational Issues in Integer Programming** Organizer: Ricardo Fukasawa, session 289	Salle 36 Bld B, Intermediate Z 4 F 4x20 min **Matching Problems** Organizer: Sergio García Quiles, session 175
IPpractice			Salle 44 Bld C, 3rd floor Z 1 F 4x20 min **Cutting Planes** Chair: Fabrizio Marinelli, session 485
MINLP		Salle 39 Bld E, 3rd floor Z 1 F 3x30 min **Convexification and more (I)** Organizer: Jon Lee, session 62	DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **Convexification and more (II)** Organizer: Akshay Gupte, session 106
MINLP		Salle 34 Bld B, 1st floor Z 3 F 3x30 min **Heuristics in MINLP** Chair: Bertrand Travacca, session 276	Salle 34 Bld B, 1st floor Z 3 F 3x30 min **Relaxations in MINLP** Chair: Jan Kronqvist, session 280
MINLP		Salle 35 Bld B, Intermediate Z 4 F 3x30 min **MINLP with quadratic terms** Chair: Enrico Bettiol, session 282	Salle 35 Bld B, Intermediate Z 4 F 3x30 min **Applications in MINLP** Chair: Justo Puerto, session 283
APPROX	LEYTEIRE Bld E, 3rd floor Z 1 F 4x30 min **Submodular Maximization** Organizer: Moran Feldman, session 29	LEYTEIRE Bld E, 3rd floor Z 1 F 3x30 min **Approximation Algorithms for Clustering.** Organizer: Deeparnab Chakrabarty, session 32	LEYTEIRE Bld E, 3rd floor Z 1 F 3x30 min **Approximation Algorithms for Optimization under Uncertainty** Organizer: Marc Uetz, session 95
APPROX	Salle 43 Bld C, 3rd floor Z 1 F 4x30 min **Cycles and Trees** Organizer: Tobias Mömke, session 90	Salle 36 Bld B, Intermediate Z 4 F 3x30 min **Routing and Inventory** Organizer: Dorit Hochbaum, session 343	
APPROX	Salle 36 Bld B, Intermediate Z 4 F 4x30 min **Bin Packing** Chair: Frits Spieksma, session 344		
COMB	Salle 41 Bld C, 3rd floor Z 1 F 4x30 min **Graphs and clutters** Organizer: Gerard Cornuejols, session 263	SIGALAS Bld C, 2nd floor Z 2 F 3x30 min **Algorithms for TSP** Organizer: Ola Svensson, session 239	Salle 41 Bld C, 3rd floor Z 1 F 3x30 min **Approximation algorithms for combinatorial optimization problems** Organizer: Thomas Rothvoss, session 265
COMB	Salle 39 Bld E, 3rd floor Z 1 F 4x30 min **Graph theory** Chair: Thomas Bellitto, session 422		Salle 39 Bld E, 3rd floor Z 1 F 4x20 min **Heuristics for combinatorial optimization problems** Chair: Evren Guney, session 428
CP	DURKHEIM Bld A, 3rd floor Z 1 F 4x30 min **Parallel Computing and Sustainability** Organizer: Bistra Dilkina, session 296	DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **Applications of CP** Organizer: Louis-Martin Rousseau, session 284	
CP	Salle 47 Bld A, 3rd floor Z 1 F 4x30 min **Performance Analysis** Organizer: Charlotte Truchet, session 298		

Thursday 05

CLUSTER: Optimization under Uncertainty

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Stoch	DENIGES Bld C, Ground Floor Z 5 F 4x30 min **New results in chance-constrained optimization** Chair: Bismark Singh, session 489	Salle 32 Bld B, Ground Floor Z 5 F 3x30 min **Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 1** Organizer: Vincent Leclère, session 246	Salle 32 Bld B, Ground Floor Z 5 F 4x20 min **Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 2** Organizer: Vincent Leclère, session 247
Stoch	Salle 32 Bld B, Ground Floor Z 5 F 4x30 min **Topics in multistage and integer stochastic optimization** Organizer: Jim Luedtke, session 490		Salle 30 Bld B, Ground Floor Z 5 F 3x20 min **Topics in multistage stochastic optimization** Chair: Felipe Beltrán, session 492
Robust	Salle 37 Bld B, Intermediate Z 4 F 4x30 min **K-adaptability** Organizer: Anirudh Subramanyam, session 1	DENIGES Bld C, Ground Floor Z 5 F 3x30 min **Distributionally Robust Optimization With Marginals and Cones** Organizer: Divya Padmanabhan, session 354	DENIGES Bld C, Ground Floor Z 5 F 3x30 min **Robust Optimization under Data Uncertainty** Organizer: Omid Nohadani, session 98
Robust	Salle 33 Bld B, Ground Floor Z 5 F 3x30 min **New applications of robust optimizations** Chair: Mirjam Duer, session 461	Salle 37 Bld B, Intermediate Z 4 F 3x30 min **Non-linear robust optimization** Chair: Laurent Alfandari, session 460	Salle 37 Bld B, Intermediate Z 4 F 4x20 min **Combinatorial robust optimization I** Organizer: Marc Goerigk, session 167
Markov			Salle 31 Bld B, Ground Floor Z 5 F 3x30 min **Approximation in dynamic programming** Chair: Philip Placek, session 382
Game	Salle 30 Bld B, Ground Floor Z 5 F 4x30 min **Stackelberg Games** Chair: Stefano Coniglio, session 374	Salle 30 Bld B, Ground Floor Z 5 F 3x30 min **Generation and Representation Algorithms in Multiobjective Optimization** Organizer: Michael Stiglmayr, session 267	

Thursday 05

CLUSTER: Continuous Optimization

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
NLP	Salle ARNOZAN Bld Q, Ground Floor Z 8 F 4x30 min **First-order methods: advances and applications** Organizer: Immanuel Bomze, session 3	Salle 05 Bld Q, 1st floor Z 11 F 3x30 min **Methods of Optimization in Riemannian Manifolds** Organizer: Orizon Ferreira, session 21	Salle 05 Bld Q, 1st floor Z 11 F 4x20 min **Polynomial and tensor optimization II** Organizer: Jiawang Nie, session 6
NLP	GINTRAC Bld Q, Ground Floor Z 8 F 4x30 min **Recent advances in interior point methods and NLP** Organizer: Michael Todd, session 77		Salle KC7 Bld K, Intermediate 2 Z 10 F 3x20 min **First Order Methods II** Chair: Guillaume Berger, session 437
NLP	Salle 05 Bld Q, 1st floor Z 11 F 4x30 min **Machine learning for optimisation** Organizer: Coralia Cartis, session 176		
NLP	Salle KC7 Bld K, Intermediate 2 Z 10 F 4x30 min **First Order Methods I** Chair: Sandra Santos, session 436		
Global			Salle 20 Bld G, 1st floor Z 6 F 4x20 min **Global Optimization 3** Chair: Jean-Baptist Hiriart-Urruty, session 503
NonSmooth	Salle LC4 Bld L, Intermediate 1 Z 9 F 4x30 min **Universal methods in non-smooth analysis** Organizer: Alexander Gasnikov, session 53	Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Extending the Reach of First-Order Methods, Part II** Organizer: Robert Freund, session 286	Salle LC4 Bld L, Intermediate 1 Z 9 F 3x30 min **Efficient Semismooth Newton Methods for Large Scale Statistical Optimization Problems** Organizer: Defeng Sun, session 123
NonSmooth	Salle 8 Bld N, 4th floor Z 12 F 4x30 min **First-order methods for nonconvex and pathological convex problems** Organizer: Wotao Yin, session 183		Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Different faces of nonsmoothness in optimization** Organizer: Tim Hoheisel, session 212
NonSmooth	Salle 9 Bld N, 4th floor Z 12 F 4x30 min **Non smooth optimization for lage scale poblems** Organizer: Yu Du, session 556		
SDP	Salle 20 Bld G, 1st floor Z 6 F 4x30 min **Computer-assisted analyses of optimization algorithms I** Organizer: Adrien Taylor, session 19	Salle LC5 Bld L, Intermediate 1 Z 10 F 3x30 min **Noncommutative polynomial optimization: semidefinite relaxations, free convexity and applications to quantum information II** Organizer: Monique Laurent, session 18	Salle AURIAC Bld G, 1st floor Z 6 F 4x20 min **Recent Advances in Conic Programming III** Organizer: Masakazu Muramatsu, session 84
SDP	Salle LC5 Bld L, Intermediate 1 Z 10 F 4x30 min **Geometry and duality in convex optimization** Organizer: Javier Pena, session 160		Salle LC5 Bld L, Intermediate 1 Z 10 F 4x20 min **Using coning programming in problems solving** Chair: Kurt Majewski, session 497
Variat	Salle 06 Bld Q, 1st floor Z 11 F 4x30 min **Nonlinear Optimization and Variational Inequalities I** Organizer: Xin Liu, session 140	Salle 06 Bld Q, 1st floor Z 11 F 3x30 min **Nonlinear Optimization and Variational Inequalities II** Organizer: Cong Sun, session 141	Salle 06 Bld Q, 1st floor Z 11 F 3x30 min **VU-decomposition techniques for nonsmooth optimization** Organizer: Claudia Sagastizabal, session 158
Variat			Salle ARNOZAN Bld Q, Ground Floor Z 8 F 4x20 min **Variational Analysis 5** Organizer: David Sossa, session 371
RandomM	Salle KC6 Bld K, Intermediate 1 Z 10 F 4x30 min **Recent Advances on Stochastic Algorithms and Machine Learning** Organizer: Shiqian Ma, session 202	Salle KC6 Bld K, Intermediate 1 Z 10 F 3x30 min **Asynchronous Parallel and Distributed Optimization** Organizer: Wotao Yin, session 200	Salle KC6 Bld K, Intermediate 1 Z 10 F 3x20 min **Recent Progress on Second-order Type Optimization Methods** Organizer: Andre Milzarek, session 302
DerFree	Salle 21 Bld G, Intermediate Z 6 F 4x30 min **Bayesian and Randomized Optimization I** Chair: Stefan Wild, session 39		Salle 21 Bld G, Intermediate Z 6 F 3x30 min **Advances in DFO III** Chair: Juan Meza, session 496
Control	Salle AURIAC Bld G, 1st floor Z 6 F 4x30 min **Optimal Control of Variational Inequalities and Complementarity Systems** Chair: Alexandre Vieira, session 336	Salle AURIAC Bld G, 1st floor Z 6 F 2x30 min **Theory and Methods for ODE- and PDE-Constrained Optimization 2** Chair: Johann Schmitt, session 333	

Thursday 05

CLUSTER: Specific Models, Algorithms, and Software

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Learning	FABRE Bld J, Ground Floor Z 8 F 4x30 min **First-order methods for large-scale convex problems** Organizer: Stephen Vavasis, session 316	FABRE Bld J, Ground Floor Z 8 F 3x30 min **Accelerating Learning** Organizer: Martin Takac, session 322	FABRE Bld J, Ground Floor Z 8 F 4x20 min **First-order methods for large-scale convex problems II** Organizer: Stephen Vavasis, session 318
Learning	Salle DENUCE Bld Q, Ground Floor Z 8 F 4x30 min **Large-scale learning** Organizer: Lorenzo Rosasco, session 335	Salle 16 Bld I, 2nd floor Z 7 F 3x30 min **Robust first order methods** Organizer: Fatma Kilinc-Karzan, session 332	Salle 16 Bld I, 2nd floor Z 7 F 4x20 min **Advances in Reinforcement Learning Algorithms** Organizer: Lin Xiao, session 329
Learning	Salle 16 Bld I, 2nd floor Z 7 F 4x30 min **Dynamical systems, control and optimization** Chair: Benjamin Recht, session 470		Salle 22 Bld G, 2nd floor Z 6 F 4x20 min **Ranking and recommendation** Chair: Aleksandra Burashnikova, session 472
Network	Salle LA4 Bld L, Basement Z 8 F 4x30 min **Multi-commodity flows** Organizer: Ralf Borndörfer, session 358		
Logistics	PITRES Bld O, Ground Floor Z 8 F 3x30 min **Vehicle Routing I** Chair: Guy Desaulniers, session 411	PITRES Bld O, Ground Floor Z 8 F 2x30 min **Path Problems** Chair: Yanchao Liu, session 453	Salle 24 Bld G, 3rd floor Z 6 F 3x20 min **Vehicle Routing III** Chair: Raquel Bernardino, session 413
Scheduling		Salle 18 Bld I, 1st floor Z 7 F 3x30 min **Production Planning** Chair: Michel Siemon, session 531	Salle 18 Bld I, 1st floor Z 7 F 4x20 min **Supply Chain** Chair: Daniel Ramón-Lumbierres, session 533
Energy	Salle 23 Bld G, 3rd floor Z 6 F 4x30 min **Unit Commitment Problem and Applications** Organizer: Tiziano Parriani, session 94	Salle DENUCE Bld Q, Ground Floor Z 8 F 3x30 min **Optimization Models for Renewable Energy Integration 1** Organizer: Luis Zuluaga, session 120	Salle DENUCE Bld Q, Ground Floor Z 8 F 3x30 min **Equilibrium and Optimization in Energy Markets** Organizer: Asgeir Tomasgard, session 151
Energy	Salle 24 Bld G, 3rd floor Z 6 F 4x30 min **Mining Applications** Organizer: Alexandra Newman, session 172	Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Progress in Algorithms for Optimal Power Flow Problems II** Chair: Miguel Anjos, session 509	Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Gas Network and Market Optimization** Organizer: Jonas Schweiger, session 293
Energy		Salle 24 Bld G, 3rd floor Z 6 F 3x30 min **Electricity Generation Scheduling and Dispatch** Chair: Christophe Duhamel, session 511	
Sciences		Salle LA4 Bld L, Basement Z 8 F 3x30 min **Inverse Problems in Physics** Chair: Leo Liberti, session 391	Salle LA4 Bld L, Basement Z 8 F 4x20 min **Medicine and Metabolic engineering** Chair: Mahdi Doostmohammadi, session 396
Algo	Salle 22 Bld G, 2nd floor Z 6 F 4x30 min **Numerically Efficient Methods for Piecewise Algorithmic Differentiation II** Organizer: Torsten Bosse, session 270	Salle 22 Bld G, 2nd floor Z 6 F 3x30 min **High-Performance Computing in Optimization II** Chair: Joaquim Dias Garcia, session 466	Salle 9 Bld N, 4th floor Z 12 F 4x20 min **Large-scale combinatorial optimization implementations** Organizer: Aaron Archer, session 96
Algo	Salle 18 Bld I, 1st floor Z 7 F 3x30 min **High-Performance Computing in Optimization I** Organizer: Kibaek Kim, session 271		PITRES Bld O, Ground Floor Z 8 F 3x30 min **Computational OR in Julia/JuMP** Organizer: Miles Lubin, session 238

Friday 06

CLUSTER: Discrete Optimization & Integer Programming

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
IPtheory	Salle 43 Bld C, 3rd floor Z 1 F 4x30 min **Recent advances in Integer Optimization** Organizer: Alberto Del Pia, session 218	Salle 34 Bld B, 1st floor Z 3 F 3x30 min **Polyhedral theory in practice** Organizer: Mourad Baiou, session 309	Salle 34 Bld B, 1st floor Z 3 F 4x20 min **Machine Learning and Discrete Optimization** Organizer: Sebastian Pokutta, session 308
IPtheory	Salle 35 Bld B, Intermediate Z 4 F 4x30 min **Mixed Integer Programming Representability** Organizer: Juan Pablo Vielma, session 275	Salle 42 Bld C, 3rd floor Z 1 F 3x30 min **Extended Formulations** Chair: Bartosz Filipecki, session 514	
IPpractice	Salle 44 Bld C, 3rd floor Z 1 F 4x30 min **Integer Programming and Crew Scheduling** Organizer: Francois Soumis, session 292	Salle 44 Bld C, 3rd floor Z 1 F 3x30 min **Routing** Chair: Cole Smith, session 484	Salle 44 Bld C, 3rd floor Z 1 F 4x20 min **Decomposition II** Chair: Natashia Boland, session 487
IPpractice		Salle 36 Bld B, Intermediate Z 4 F 3x30 min **IP Practice III** Chair: Samuel Brito, session 507	Salle 36 Bld B, Intermediate Z 4 F 2x20 min **Dual Ascent** Chair: Sara Maqrot, session 505
MINLP	Salle 34 Bld B, 1st floor Z 3 F 3x30 min **Optimal Control Problems with Discrete Switches** Organizer: Christian Kirches, session 102	Salle 39 Bld E, 3rd floor Z 1 F 3x30 min **Outer Convexification and Mixed-Integer Optimal Control** Organizer: Sebastian Sager, session 103	DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **Mixed-Integer PDE-Constrained Optimization** Organizer: Sven Leyffer, session 63
MINLP		DURKHEIM Bld A, 3rd floor Z 1 F 3x30 min **Intersection cuts, disjunctions, and valid inequalities** Organizer: Eli Towle, session 180	Salle 39 Bld E, 3rd floor Z 1 F 3x30 min **Global Optimization for nonconvex MINLPs** Organizer: Hassan Hijazi, session 92
MINLP		Salle 35 Bld B, Intermediate Z 4 F 3x30 min **Branch-and-cut techniques** Organizer: Teodora Dan, session 277	Salle 35 Bld B, Intermediate Z 4 F 3x30 min **Recent Advances and Applications of MINLP** Organizer: Jose Ucha, session 139
APPROX	LEYTEIRE Bld E, 3rd floor Z 1 F 4x30 min **Data-Driven Revenue Management with Customer Choice** Organizer: Jacob Feldman, session 81	LEYTEIRE Bld E, 3rd floor Z 1 F 3x30 min **Submodular Maximization.** Organizer: Justin Ward, session 179	LEYTEIRE Bld E, 3rd floor Z 1 F 4x20 min **Algorithmic Fairness and Optimization** Organizer: Nisheeth Vishnoi, session 161
APPROX	Salle 36 Bld B, Intermediate Z 4 F 4x30 min **Clustering.** Organizer: Zac Friggstad, session 155	Salle 43 Bld C, 3rd floor Z 1 F 3x30 min **Submodular and Incremental Maximization** Organizer: Martin Gross, session 340	Salle 43 Bld C, 3rd floor Z 1 F 3x30 min **Algorithmic Discrepancy** Organizer: Nikhil Bansal, session 164
COMB	SIGALAS Bld C, 2nd floor Z 2 F 4x30 min **Matching and scheduling** Organizer: Seffi Naor, session 54	SIGALAS Bld C, 2nd floor Z 2 F 3x30 min **Combinatorial aspects of Linear Programming** Organizer: Daniel Dadush, session 259	SIGALAS Bld C, 2nd floor Z 2 F 3x30 min **Packing Steiner Trees** Organizer: Stephan Held, session 260
COMB	Salle 41 Bld C, 3rd floor Z 1 F 4x30 min **Recent progress in graph cut problems** Organizer: Karthekeyan Chandrasekaran, session 244		Salle 41 Bld C, 3rd floor Z 1 F 4x20 min **Optimization problems in graphs and related** Chair: Claudio Arbib, session 423
COMB	Salle 39 Bld E, 3rd floor Z 1 F 4x30 min **Algorithmic aspects of connectivity in network design** Organizer: Neil Olver, session 264		
CP	DURKHEIM Bld A, 3rd floor Z 1 F 4x30 min **Graphical Optimization Model 2** Organizer: Maria Restrepo, session 297		

Friday 06

CLUSTER: Optimization under Uncertainty

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Stoch	DENIGES Bld C, Ground Floor Z 5 F 4x30 min **Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 3** Organizer: Vincent Leclère, session 245	Salle 32 Bld B, Ground Floor Z 5 F 3x30 min **Risk-aware decision making** Organizer: Minseok Ryu, session 251	Salle 30 Bld B, Ground Floor Z 5 F 3x20 min **Topics in stochastic optimization** Chair: Quentin Mercier, session 494
Stoch	Salle 32 Bld B, Ground Floor Z 5 F 4x30 min **New methods for stochastic optimization and variational inequalities** Chair: Yunxiao Deng, session 491		
Robust	Salle 33 Bld B, Ground Floor Z 5 F 3x30 min **New Horizons in Robust Optimization** Organizer: Angelos Georghiou, session 447	Salle 33 Bld B, Ground Floor Z 5 F 3x30 min **Distributionally Robust Optimization: Models and Applications** Organizer: Selin Ahipasaoglu, session 355	Salle 37 Bld B, Intermediate Z 4 F 4x20 min **Robust Combinatorial Optimization II** Organizer: Agostinho Agra, session 168
Robust		DENIGES Bld C, Ground Floor Z 5 F 3x30 min **Distributionally Robust Optimization** Organizer: Daniel Kuhn, session 446	Salle 33 Bld B, Ground Floor Z 5 F 3x30 min **Wasserstein Distributionally Robust Optimization** Organizer: Peyman Mohajerin Esfaha, session 448
Markov	Salle 31 Bld B, Ground Floor Z 5 F 4x30 min **Advances in theory of dynamic programming** Chair: Stephane Gaubert, session 385	Salle 31 Bld B, Ground Floor Z 5 F 3x30 min **Discrete stochastic dynamic programming** Chair: Adam Narkiewicz, session 384	Salle 31 Bld B, Ground Floor Z 5 F 3x30 min **Tractability and approximation algorithms in dynamic programming** Chair: Alexander Hopp, session 383
Game	Salle 30 Bld B, Ground Floor Z 5 F 4x30 min **Algorithmic Game Theory II** Chair: Margarida Carvalho, session 372	Salle 30 Bld B, Ground Floor Z 5 F 3x30 min **Scalarization, representation and the comparison of methods in Multiobjective Optimization** Chair: Tyler Perini, session 378	

Friday 06

CLUSTER: Continuous Optimization

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
NLP	Salle 05 Bld Q, 1st floor Z 11 F 4x30 min **First order methods** Organizer: Gerardo Toraldo, session 27	GINTRAC Bld Q, Ground Floor Z 8 F 3x30 min **Interior Point Methods in Engineering Applications I** Organizer: Jacek Gondzio, session 60	GINTRAC Bld Q, Ground Floor Z 8 F 3x30 min **Moment relaxations for polynomial optimization with symmetries** Organizer: Markus Schweighofer, session 10
NLP	GINTRAC Bld Q, Ground Floor Z 8 F 4x30 min **Stochastic and Nonlinear Optimization II** Organizer: Jorge Nocedal, session 48	Salle 05 Bld Q, 1st floor Z 11 F 3x30 min **Nonlinear Optimization** Chair: Marc Steinbach, session 429	Salle KC7 Bld K, Intermediate 2 Z 10 F 3x30 min **Subspace methods in NLP II** Organizer: Panos Parpas, session 44
NLP	Salle KC7 Bld K, Intermediate 2 Z 10 F 4x30 min **Regularization and Iterative Methods in Large-Scale Optimization** Organizer: Jacek Gondzio, session 59		Salle 05 Bld Q, 1st floor Z 11 F 4x20 min **Primal-dual and ADMM algorithms for nonlinear programming** Organizer: Marco Sciandrone, session 91
NLP	Salle 9 Bld N, 4th floor Z 12 F 4x30 min **Decomposition Methods** Chair: Roger Behling, session 431		Salle 9 Bld N, 4th floor Z 12 F 3x20 min **Linear Optimization I** Chair: Jianming Shi, session 415
Global		Salle 20 Bld G, 1st floor Z 6 F 3x30 min **Global Optimization 2** Chair: Mirjam Duer, session 502	Salle 20 Bld G, 1st floor Z 6 F 3x30 min **Global Optimization 1** Chair: Jean-Baptist Hiriart-Urruty, session 501
NonSmooth	Salle LC4 Bld L, Intermediate 1 Z 9 F 4x30 min **Geometry in complexity analysis of non-smooth optimization methods** Organizer: Jalal Fadili, session 199	Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Advances in the first-order methods for convex optimization** Organizer: Angelia Nedich, session 73	Salle 8 Bld N, 4th floor Z 12 F 3x30 min **Nonsmooth DC optimization with applications** Chair: Napsu Karmitsa, session 46
NonSmooth	Salle 8 Bld N, 4th floor Z 12 F 4x30 min **Convergence analysis for non smooth optimization** Organizer: Robert Csetnek, session 557		Salle LC4 Bld L, Intermediate 1 Z 9 F 3x30 min **Nonconvex Optimization: Theory and Methods - Part 3** Organizer: Genaro Lopez, session 188
SDP	Salle 20 Bld G, 1st floor Z 6 F 4x30 min **Copositive and completely positive optimization** Organizer: Olga Kuryatnikova, session 24	Salle LC5 Bld L, Intermediate 1 Z 10 F 3x30 min **Relative Entropy Optimization I** Organizer: Venkat Chandrasekaran, session 111	Salle AURIAC Bld G, 1st floor Z 6 F 3x30 min **Computer-assisted analyses of optimization algorithms II** Organizer: Adrien Taylor, session 16
SDP	Salle LC5 Bld L, Intermediate 1 Z 10 F 4x30 min **Stability and scaling in conic programming** Chair: Diego Cifuentes, session 498		Salle LC5 Bld L, Intermediate 1 Z 10 F 3x30 min **Sparse Semidefinite Programming** Organizer: Somayeh Sojoudi, session 17
Variat	Salle 06 Bld Q, 1st floor Z 11 F 4x30 min **Stochastic Optimization and Variational Inequalites** Organizer: Hailin Sun, session 149	Salle 06 Bld Q, 1st floor Z 11 F 3x30 min **Algorithms for optimization and variational problems with possibly nonisolated solutions II** Organizer: Alexey Izmailov, session 153	Salle 06 Bld Q, 1st floor Z 11 F 3x30 min **Nonlinear Optimization and Variational Inequalities IV** Organizer: Cong Sun, session 144
Variat	Salle ARNOZAN Bld Q, Ground Floor Z 8 F 4x30 min **Variational Analysis 3** Organizer: Johanna Burtscheidt, session 369	Salle ARNOZAN Bld Q, Ground Floor Z 8 F 3x30 min **Nash equilibrium and Games 2** Organizer: Giancarlo Bigi, session 366	Salle ARNOZAN Bld Q, Ground Floor Z 8 F 4x20 min **Variational Analysis 2** Organizer: David Salas, session 367
RandomM	Salle KC6 Bld K, Intermediate 1 Z 10 F 3x30 min **Recent Advances in Coordinate Descent and Constrained Problems** Organizer: Ion Necoara, session 208		Salle KC6 Bld K, Intermediate 1 Z 10 F 4x20 min **Algorithms for Structured Statistical Optimization** Chair: Ilker Birbil, session 349
DerFree	Salle 21 Bld G, Intermediate Z 6 F 4x30 min **Challenging applications in DFO** Chair: Francesco Rinaldi, session 38	Salle 21 Bld G, Intermediate Z 6 F 3x30 min **Advances in DFO IV** Chair: Katya Scheinberg, session 125	Salle 21 Bld G, Intermediate Z 6 F 2x30 min **Derivative-free global optimization algorithms** Chair: Zaikun Zhang, session 41
Control	Salle AURIAC Bld G, 1st floor Z 6 F 3x30 min **Optimal Control in Engineering Applications** Chair: Maxime Grangereau, session 310		

Friday 06

CLUSTER: Specific Models, Algorithms, and Software

Stream	8:30-10:30 AM	3:15-4:45 PM	5:00-6:30 PM
Learning	FABRE Bld J, Ground Floor Z 8 F 3x30 min **Dimensionality reduction tools for learning: A sketchy session** Organizer: Robert Gower, session 313	Salle 16 Bld I, 2nd floor Z 7 F 3x30 min **Discrete methods for data centers and graphs** Organizer: Aaron Archer, session 477	FABRE Bld J, Ground Floor Z 8 F 4x20 min **Spectral and Semidefinite Methods for Learning** Organizer: Martin Jaggi, session 321
Learning	Salle 16 Bld I, 2nd floor Z 7 F 4x30 min **Dealing with non-convexity** Chair: Damek Davis, session 473	FABRE Bld J, Ground Floor Z 8 F 3x30 min **Classification, regression and clustering** Chair: Dimitris Bertsimas, session 480	
Network	Salle 18 Bld I, 1st floor Z 7 F 4x30 min **Telecommunications** Organizer: Edoardo Amaldi, session 361		Salle 18 Bld I, 1st floor Z 7 F 4x20 min **Transportation networks** Chair: Bernard Gendron, session 359
Logistics	PITRES Bld O, Ground Floor Z 8 F 4x30 min **Hybrid Algorithms and Matheuristics for VRP** Organizer: Thibaut Vidal, session 181	Salle 24 Bld G, 3rd floor Z 6 F 3x30 min **Vehicle Routing II** Chair: Chris Potts, session 412	Salle 16 Bld I, 2nd floor Z 7 F 2x20 min **Logistics Networks** Chair: El Hassan Laaziz, session 468
Scheduling	Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Scheduling Applications** Chair: Mauricio de Souza, session 526	Salle 18 Bld I, 1st floor Z 7 F 3x30 min **Machine Scheduling 1** Chair: Renan Trindade, session 527	
Energy	Salle 24 Bld G, 3rd floor Z 6 F 3x30 min **Power Systems Models with Discrete Decision Variables** Organizer: Adolfo Escobedo, session 26	Salle DENUCE Bld Q, Ground Floor Z 8 F 3x30 min **Estimation and Learning for Power Systems** Organizer: Javad Lavaei, session 25	Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Energy-aware planning and scheduling 2** Organizer: Christian Artigues, session 178
Energy	Salle DENUCE Bld Q, Ground Floor Z 8 F 4x30 min **Machine Learning in State Estimation and Situational Awareness in Power Grids** Organizer: Deepjyoti Deka, session 134	Salle 22 Bld G, 2nd floor Z 6 F 3x30 min **Optimization in Energy** Chair: Andrea Simonetto, session 515	Salle 24 Bld G, 3rd floor Z 6 F 3x20 min **Stochastic Methods for Energy Optimization** Chair: Tristan Rigaut, session 294
Energy		Salle 23 Bld G, 3rd floor Z 6 F 3x30 min **Optimization for Energy System Planning** Chair: Andrew Liu, session 524	
Sciences	Salle LA4 Bld L, Basement Z 8 F 3x30 min **Finance and Portfolio Optimization** Organizer: Asaf Shupo, session 395	Salle LA4 Bld L, Basement Z 8 F 3x30 min **Industrial dynamics and Environmental policy** Organizer: Inmaculada Garcia Fernandez, session 392	Salle LA4 Bld L, Basement Z 8 F 4x20 min **Optimization and Game Theory** Organizer: Veerle Timmermans, session 402
Algo	Salle 22 Bld G, 2nd floor Z 6 F 4x30 min **New Developments in Optimization Modeling Software** Organizer: Robert Fourer, session 101	PITRES Bld O, Ground Floor Z 8 F 3x30 min **Computational Integer Programming I** Organizer: Domenico Salvagnin, session 273	PITRES Bld O, Ground Floor Z 8 F 3x30 min **Computational Integer Programming II** Organizer: Domenico Salvagnin, session 274

Program per Time Slot

Room	Invited Talks - Monday 11:00 AM – 12:00 AM			
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**On the relationship between machine learning and optimization**, *Organizer*: Michel Goemans, session 552 PLENARY Francis Bach, On the relationship between machine learning and optimization			

Room	Invited Talks - Monday 1:30 PM – 2:30 PM			
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**Multiobjective Optimization with PDE Constraints**, *Organizer*: Stephen J Wright, session 550 SEMI Michael Hintermüller, Multiobjective Optimization with PDE Constraints			
SIGALAS Build C, Z 2 2nd floor 1x60 min	**What's happening in nonconvex optimization? A couple of stories**, *Organizer*: Jean-Baptist Hiriart-Urruty, session 536 KEYNOTE Emmanuel Candes, What's happening in nonconvex optimization? A couple of stories			
DENIGES Build C, Z 5 Ground Floor 1x60 min	**Theoretical Analysis of Cutting-Planes in IP Solvers.**, *Organizer*: Gerard Cornuejols, session 538 KEYNOTE Santanu Dey, Theoretical Analysis of Cutting-Plane Selection in IP Solvers.			

Room	Discrete Optimization & Integer Programming - Monday 3:15 PM – 4:45 PM			
Salle 43 Build C, Z 1 3rd floor 3x30 min	**Provable guarantees for Cut Generating Functions**, *Organizer*: Amitabh Basu, session 220 IPtheory Joseph Paat, Using the geometry of S-free sets to find mixed-integer cut-generating functions	Sriram Sankaranarayanan, Can cut generating functions be good and efficient?	Amitabh Basu, Optimal cutting planes from the group relaxations	
Salle 44 Build C, Z 1 3rd floor 3x30 min	**IP Practice I**, *Chair*: Maurice Queyranne, session 506 IPpractice Raphael Hauser, IP models for dimensionality reduction and feature selection in categorical da	Carlos Cardonha, Network models for multiobjective discrete optimization	Maurice Queyranne, Optimum Turn-Restricted Paths, Nested Compatibility, and Optimum Convex Polygons	
Salle 39 Build E, Z 1 3rd floor 3x30 min	**Exact Optimization Algorithms for Compressed Sensing**, *Organizer*: Marc E Pfetsch, session 56 MINLP Christoph Brauer, A primal-dual homotopy algorithm for sparse recovery with inf. norm constraints	Andreas Tillmann, SparkMIP: Mixed-Integer Programming for the (Vector) Matroid Girth Problem	Frederic Matter, Complex-valued ℓ_0 minimization problems with constant modulus constraints	
Salle 34 Build B, Z 3 1st floor 3x30 min	**Tight relaxations in nonconvex MINLP**, *Organizer*: Ambros Gleixner, session 128 MINLP Emily Speakman, Using mixed volume theory to compute convex hull volume for trilinear monomials	Stefan Vigerske, Revising the handling of nonlinear constraints in SCIP	Ambros Gleixner, Two-dimensional Projections for Separation and Propagation of Bilinear Terms	
Salle 35 Build B, Z 4 Intermediate 3x30 min	**MINLP methods in gas transport optimization (I)**, *Organizer*: Lars Schewe, session 162 MINLP Lars Schewe, MIP techniques for instationary gas transport optimization and gas market models	Nick Mertens, Solving MINLPs by Simultaneous Convexification with Application to Gas Networks	Falk Hante, Complementarity-Based Nonlinear Programming Techniques for Optimal Mixing in Gas	
LEYTEIRE Build E, Z 1 3rd floor 3x30 min	**Geometry of Polynomials and Applications in Approximate Counting**, *Organizer*: Shayan Oveis Gharan, session 99 APPROX Guus Regts, On a conjecture of Sokal on the location of roots of the independence polynomial	Piyush Srivastava, Zeros of polynomials and Ising partition functions	Nima Anari, A Deterministic Approximation Algorithm for Counting Bases of Matroids	
Salle 36 Build B, Z 4 Intermediate 3x30 min	**Matching and Matroids**, *Organizer*: José A Soto, session 341 APPROX Maximilien Burq, Maximizing Efficiency in Dynamic Matching Markets	Morteza Zadimoghaddam, Online Weighted Matching: Beating the 1/2 Barrier	José Soto, Strong Algorithms for the Ordinal Matroid Secretary Problem	
SIGALAS Build C, Z 2 2nd floor 3x30 min	**On the Tree Augmentation Problem**, *Organizer*: Laura Sanità, session 240 COMB David Adjiashvili, Beating Approximation Factor 2 For Weighted Tree Augmentation With Bounded Costs	Jochen Koenemann, Improved Approximation for Tree Augmentation via Chvatal Gomory Cuts	Rico Zenklusen, Improved Approximation for Tree Augmentation: Saving by Rewiring	
Salle 41 Build C, Z 1 3rd floor 3x30 min	**Scheduling with setup, uncertainty and precedences**, *Organizer*: Monaldo Mastrolilli, session 419 COMB Kim-Manuel Klein, Empowering the Configuration-IP	Nicole Megow, Scheduling under Explorable Uncertainty	Jose Verschae, Min-sum scheduling under precedence constraints	
DURKHEIM Build A, Z 1 3rd floor 3x30 min	**Global Optimization**, *Organizer*: Hassan Hijazi, session 299 CP Adam Ouorou, A class of proximal algorithms based on Chebychev centers for nonsmooth convex o	Kaarthik Sundar, Convex relaxations for Mixed-Integer Multilinear Functions	Tillmann Weisser, Sparse Certificates for Polynomial Optimization	

Optimization under Uncertainty - Monday 3:15 PM – 4:45 PM

Room	Session	Talk 1	Talk 2	Talk 3	Track
Salle 32 Build B, Z 5 Ground Floor 3x30 min	**Scenario discretization techniques in stochastic optimization**, *Organizer*: Fabian Bastin, session 287	Thuy Anh Ta, On a two-stage stochastic optimization problem with stochastic constraints	Julien Keutchayan, Multistage stochastic optimization: discretization of probability distributions	Michel Gendreau, Effective Heuristics for the Short-Term Hydro-Generation Planning Problem	**Stoch**
DENIGES Build C, Z 5 Ground Floor 3x30 min	**Preference robust optimization**, *Organizer*: Erick Delage, session 166	William Haskell, Robust choice with multi-attribute quasi-concave choice functions	Jonathan Li, Optimizing aspirational preferences when the choice of a measure is ambiguous	Erick Delage, Utility-based Shortfall Risk Models when Preference Information is Incomplete	**Robust**
Salle 33 Build B, Z 5 Ground Floor 3x30 min	**Distributionally Robust Optimization - New Theory and Applications**, *Organizer*: Zhichao Zheng, session 356	Yini Gao, Data-Driven Bounded Rationality in Games- A Robust Framework	Cagil Kocyigit, Distributionally Robust Mechanism Design	Zhichao Zheng, Schedule Reliability in Liner Shipping by Distributionally Robust Optimization	**Robust**
Salle 31 Build B, Z 5 Ground Floor 3x30 min	**Approximate dynamic programming**, *Organizer*: David Brown, session 159	Martin Haugh, Information Relaxation Bounds for Partially Observed Markov Decision Processes	Huseyin Topaloglu, Approximate Dynamic Programming for Dynamic Assortment Optimization	David Brown, Approximations to Stochastic Dynamic Programs via Information Relaxation Duality	**Markov**
Salle 30 Build B, Z 5 Ground Floor 3x30 min	**Risk and Energy Markets**, *Chair*: Julio Deride, session 376	Olivier Huber, On solving risk-averse equilibrium problems via reformulations	Henri Gerard, On risk averse competitive equilibrium	Julio Deride, Stochastic General Equilibrium Model with Application to Energy Markets	**Game**

Continuous Optimization - Monday 3:15 PM – 4:45 PM

Room	Session	Talk 1	Talk 2	Talk 3	Track
GINTRAC Build Q, Z 8 Ground Floor 3x30 min	**Polynomial and tensor optimization I**, *Organizer*: Jiawang Nie, session 5	Jean Lasserre, Sparse Polynomial Interpolation: Compressed Sensing, Super-resolution, or Prony?	Stephane Gaubert, Eigenvalues inequalities for nonnegative tensors and their tropical analogues	Harm Derksen, Signal Denoising, Tensors and Singular Values	**NLP**
Salle 05 Build Q, Z 11 1st floor 3x30 min	**Convex regularization and inverse problems**, *Organizer*: Pierre Weiss, session 216	Vincent Duval, T-systems for super-resolution microscopy	Frederic De Gournay, Convex regularisation, sparsity and representation theorem	Jonas Kahn, Bounds on the size of polyedral cones	**NLP**
Salle KC7 Build K, Z 10 Intermediate 2 3x30 min	**Sparse Recovery**, *Chair*: Mustafa C Pinar, session 432	John Chinneck, LP-based Sparse Solutions Revisited	Mustafa Pinar, Sparse Recovery and Convex Quadratic Splines	Olof Troeng, Efficient ℓ_0 Trend Filtering	**NLP**
Salle 8 Build N, Z 12 4th floor 3x30 min	**Nonconvex Optimization: Theory and Methods - Part 1**, *Organizer*: Shoham Sabach, session 184	Jerome Bolte, From error bounds to the complexity of first-order descent methods	Yakov Vaisbourd, Globally Solving the Trust Region Subproblem Using Simple First-Order Methods	Shoham Sabach, Nonconvex Lagrangian-Based Optimization: Schemes and Global Convergence	**NonSmooth**
Salle 9 Build N, Z 12 4th floor 2x30 min	**Adaptivity in non smooth optimization**, *Organizer*: Masaru Ito, session 558	Masaru Ito, An adaptive first order method for weakly smooth and uniformly convex problems	Somayya Komal, A Subgradient Algorithm for solving variational Inequality Problem		**NonSmooth**
Salle 20 Build G, Z 6 1st floor 3x30 min	**Using SDP relaxations and solving them faster**, *Organizer*: Elisabeth Gaar, session 113	Samuel Burer, Exact SDPs for a Class of (Random and Non-Random) Nonconvex QCQPs	Nicolo Gusmeroli, SDP Based Solution Methods for Binary Quadratic Problems	Yuzixuan Zhu, Sieve-SDP: A simple facial reduction algorithm to preprocess SDPs	**SDP**
Salle LC5 Build L, Z 10 Intermediate 1 3x30 min	**Algorithms for nonlinear conic problems**, *Chair*: Takayuki Okuno, session 463	Leonardo Mito, Augmented Lagrangian for nonlinear SDPs applied to the covering problem	Cunlu Zhou, Long-Step Path-Following Algorithm for Nonlinear Symmetric Programming Problems	Takayuki Okuno, A primal-dual path following method for nonlinear semi-infinite SDPs	**SDP**
Salle 06 Build Q, Z 11 1st floor 3x30 min	**Proximal Methods for Structured Problems**, *Organizer*: Ting Kei Pong, session 147	Tianxiang Liu, A successive DC approximation method for nonconvex nonsmooth optimization	Man-Chung Yue, Cubic Regularization Revisited: Faster (Local) Rates under Weaker Assumptions	Ting Kei Pong, Iteratively reweighted l1 algorithms with extrapolation	**Variat**
Salle ARNOZAN Build Q, Z 8 Ground Floor 3x30 min	**Algorithms for optimization and variational problems with possibly nonisolated solutions I**, *Organizer*: Andreas Fischer, session 152	Nico Strasdat, A special complementarity function revisited	Alexey Izmailov, Critical solutions of nonlinear equations: attraction for Newton-type methods	Andreas Fischer, Local attraction of Newton methods to critical solutions of constrained systems	**Variat**
Salle KC6 Build K, Z 10 Intermediate 1 3x30 min	**Coordinate Descent and Randomized Direct Search Methods**, *Organizer*: Martin Takac, session 211	Asu Ozdaglar, When Cyclic Coordinate Descent Outperforms Randomized Coordinate Descent	El houcine Bergou, Random direct search method for unconstrained smooth minimization	Dimitri Papageorgiou, Active Metric Learning for Supervised Classification	**RandomM**
Salle 21 Build G, Z 6 Intermediate 3x30 min	**Mixed-integer derivative-free optimization**, *Chair*: Clément Royer, session 80	Andrew Conn, Underlying algorithms and theory to our approach to MINLP without derivatives	Delphine Sinoquet, Benchmark of a trust region method for solving black-box mixed-integer problems	Ubaldo Garcia Palomares, A unified approach for solving mixed integer Box-Constrained optimization	**DerFree**
Salle AURIAC Build G, Z 6 1st floor 3x30 min	**Theory and Methods for ODE- and PDE-Constrained Optimization 1**, *Chair*: Carl M Greiff, session 331	Behzad Azmi, On the Barzilai-Borwein step-sizes in Hilbert spaces	Benjamin Horn, Shape Optimization with Stress Constraints for Frictional Contact Problems	Carl Greiff, Quadratic programmimg for time-optimal control in differentially flat systems	**Control**

Room	Specific Models, Algorithms, and Software - Monday 3:15 PM – 4:45 PM			
FABRE Build J, Z 8 Ground Floor 3x30 min	**Distributed Optimization**, *Organizer*: Franck Iutzeler, session 325 **Learning**			
	Franck Iutzeler, Distributed Optimization with Sparse Communications and Structure Identification	Guanghui Lan, Random gradient extrapolation for distributed and stochastic optimization	Alexander Gasnikov, Distributed Computation of Wasserstein Barycenters over Networks	
Salle 16 Build I, Z 7 2nd floor 3x30 min	**Decisions and learning from data**, *Chair*: Christopher McCord, session 481 **Learning**			
	Cédric Rommel, Gaussian mixture penalization for trajectory optimization problems	Christopher McCord, Optimization over Continuous Decisions with Observational Data	Oskar Schneider, Combining Machine Learning and Optimization: Learning to emulate an expert	
PITRES Build O, Z 8 Ground Floor 3x30 min	**Facility Layout**, *Chair*: Anders N Gullhav, session 450 **Logistics**			
	Mirko Dahlbeck, Combinatorial Bounds for the (extended) Double Row Facility Layout Problem	Anders Gullhav, A Matheuristic Approach to the Hospital Facility Layout Problem	Hanane Khamlichi, A Multi task robot layout optimization with inventory lot-sizing problem	
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Combinatorial Optimization in Chip Design**, *Organizer*: Stefan Hougardy, session 257 **Scheduling**			
	Ulrich Brenner, Faster Adder Circuits for Inputs with Prescribed Arrival Times	Pascal Cremer, BonnCell: Automatic Cell Layout for 7nm Processors	Siad Daboul, Provably Fast and Near-Optimum Gate Sizing	
Salle DENUCE Build Q, Z 8 Ground Floor 3x30 min	**Progress in Algorithms for Optimal Power Flow Problems I**, *Organizer*: Miguel F Anjos, session 8 **Energy**			
	Manuel Ruiz, Solving an Optimal Power Flow (OPF) problem with preventive security constraints	Miguel Anjos, Tight-and-Cheap Conic Relaxation for the AC Optimal Power Flow Problem	Mostafa Sahraei Ardakani, Coordinated Planning and Operation of M-FACTS and Transmission Switching	
Salle 24 Build G, Z 6 3rd floor 3x30 min	**Topics in power systems**, *Organizer*: Alberto J Lamadrid, session 438 **Energy**			
	Giulia De Zotti, Consumers Flexibility Estimation at the TSO Level for Balancing Services	Joshua Taylor, Decentralized control of DC-segmented power systems	Alberto Lamadrid, Response to Disruptions in Electricity with Stochastic Microgrids	
Salle LA4 Build L, Z 8 Basement 3x30 min	**Portfolio Optimization**, *Chair*: Bernardo K. Pagnoncelli, session 393 **Sciences**			
	Luca Mencarelli, A Multiplicative Weights Update Algorithm for Portfolio Selection Problems	Bernardo Pagnoncelli, Regularized portfolio optimization with risk measures	Sina Yansori, Log-optimal portfolios under random horizon	
Salle 22 Build G, Z 6 2nd floor 2x30 min	**Implementation of interior-point methods for large-scale problems and applications I**, *Organizer*: Jordi Castro, session 353 **Algo**			
	Jose Herskovits, A feasible direction interior point algorithm for linear programming	Stefano Nasini, A specialized interior-point algorithm for very large minimum cost flows in bipa		
Salle 18 Build I, Z 7 1st floor 3x30 min	**Advances in Linear, Non Linear and Mixed-Integer Optimization**, *Chair*: Hiroshige Dan, session 400 **Algo**			
	Erik Mühmer, Computational Experiments with Nested Dantzig-Wolfe Decompositions	Xavier Schepler, Restrict-and-fix: a constructive heuristic for mixed-integer programs	Hiroshige Dan, Automatic Differentiation Software for Indexed Optimization Problems	

Room	Discrete Optimization & Integer Programming - Monday 5:00 PM – 6:30 PM			
Salle 34 Build B, Z 3 1st floor 3x30 min	**Lattice methods in Integer Optimisation**, *Organizer*: Iskander Aliev, session 78 **IPtheory**			
	Gennadiy Averkov, Approximation of corner polyhedra with intersection cuts	Timm Oertel, The Support of Integer Optimal Solutions	Iskander Aliev, Distances to Lattice Points in Knapsack Polyhedra	
Salle 44 Build C, Z 1 3rd floor 4x20 min	**Data Mining**, *Chair*: Marcus V Poggi, session 504 **IPpractice**			
	Takahiro Kan, A weighting local search for huge assignment problems in item recommendation	Atsushi Miyauchi, Exact Clustering via Integer Programming and Maximum Satisfiability	Dennis Kreber, The best subset selection problem in regression	Marcus Poggi, Cut and Column Generation for Process Discovery
Salle 36 Build B, Z 4 Intermediate 4x20 min	**IP Practice II**, *Chair*: Petra M. Bartmeyer, session 508 **IPpractice**			
	Gaël Guillot, Application of the SSSDP method to combinatorial optimisation problems	Yi-Shuai Niu, A Parallel Branch and Bound with DC Algorithm for Mixed Integer Optimization	Quentin Viaud, Two-dimensional bin packing problem with defects on bins	Petra Bartmeyer, A new approach to relax the binary variables on binary quadratic problems
DURKHEIM Build A, Z 1 3rd floor 3x30 min	**Mixed-Integer Conic Optimization**, *Organizer*: Sven Wiese, session 57 **MINLP**			
	Lucas Letocart, Exact methods based on SDP for the k-item quadratic knapsack problem	Tristan Gally, Knapsack Constraints over the Positive Semidefinite Cone	Sven Wiese, The Mixed-integer Conic Optimizer in MOSEK	
Salle 39 Build E, Z 1 3rd floor 3x30 min	**Polynomial optimization in binary variables**, *Organizer*: Elisabeth Rodriguez-Heck, session 58 **MINLP**			
	Arnaud Lazare, Unconstrained 0-1 polynomial optimization through convex quadratic reformulation	Anja Fischer, A study of specially structured polynomial matroid optimization problems	Elisabeth Rodriguez-Heck, Linear and quadratic reformulations of nonlinear 0-1 optimization problems	
Salle 35 Build B, Z 4 Intermediate 3x30 min	**MINLP methods in gas transport optimization (II)**, *Organizer*: Lars Schewe, session 163 **MINLP**			
	Benjamin Hiller, Exploiting acyclic orientations to solve nonlinear potential-based flow problems	Kai Becker, ASTS-Orientations on Undirected Graphs - A tool for optimizing network flows	Johannes Thürauf, Robust Optimal Discrete Arc Sizing for Tree-Shaped Potential Networks	
LEYTEIRE Build E, Z 1 3rd floor 3x30 min	**Scheduling and File Migration**, *Chair*: Asaf Levin, session 345 **APPROX**			
	Liliana Grigoriu, Scheduling on Uniform Nonsimultaneous Parallel Machines	Marcin Bienkowski, On phase-based algorithms for online file migration	Asaf Levin, A unified framework for designing EPTAS's for load balancing on parallel machine	
Salle 43 Build C, Z 1 3rd floor 4x20 min	**Algorithms for matching markets**, *Organizer*: Amin Saberi, session 467 **APPROX**			
	Arash Asadpour, Concise Bidding Through Dependent Randomized Rounding	Balasubraman Sivan, Robust Repeated Auctions under Heterogeneous Buyer Behavior	Vahab Mirrokni, Proportional Allocation: Simple, Distributed, and Diverse Matching w High Entropy	Amin Saberi, Matching in dynamic environments
SIGALAS Build C, Z 2 2nd floor 4x20 min	**Combinatorial optimization and convexity**, *Chair*: Yu Yokoi, session 424 **COMB**			
	Yuni Iwamasa, Discrete convexity in binary VCSPs	Fei Wang, Low matrix completion by a majorized penalty approach	Georg Loho, Abstract tropical linear programming	Yu Yokoi, List Supermodular Coloring
Salle 41 Build C, Z 1 3rd floor 4x20 min	**Practical aspects of network optimization**, *Chair*: Kai Hoppmann, session 427 **COMB**			
	Sonia Vanier, Energy-Efficient in Multi-Hop Wireless Networks Problem	Keisuke Hotta, Optimal division for the multi-member constituency system	Saman Eskandarzadeh, Maintenance Scheduling in a Railway Corridor	Kai Hoppmann, Pushing a Network to its Limits - Finding Maximum Min-Cost-Flows

Room	Optimization under Uncertainty - Monday 5:00 PM – 6:30 PM					
Salle 32 Build B, Z 5 Ground Floor 3x30 min	**Distributionally Robust Stochastic Programming: Theory and Applications**, *Organizer*: Ran Ji, session 250	Yiling Zhang, Ambiguous Chance-constrained Binary Programs Under Mean-covariance Information	Karthyek Murthy, Distributionally Robust Optimization with optimal transport (Wasserstein) costs	Ran Ji, Distributionally Robust Chance-Constrained Optimization with Wasserstein Metric		Stoch
Salle 30 Build B, Z 5 Ground Floor 3x20 min	**Differentiability, convexity, and modeling in stochastic optimization**, *Chair*: Kai A. Spuerkel, session 493	Holger Heitsch, Stochastic optimization with probabilistic/robust (probust) constraints	Pedro Perez-Aros, Subdifferential characterization of probability functions	Kai Spuerkel, Strong Convexity in Stochastic Programming with Deviation Risk Measures		Stoch
DENIGES Build C, Z 5 Ground Floor 3x30 min	**Advances in Adjustable Robust Optimization**, *Organizer*: Do Young Yoon, session 350	Dick den Hertog, Robust optimization for models with uncertain SOC and SDP constraints	Ernst Roos, Approximation of uncertain convex inequalities	Do Young Yoon, Monitoring with Limited Information		Robust
Salle 37 Build B, Z 4 Intermediate 3x20 min	**New models in robust optimization**, *Chair*: Juan S Borrero, session 459	Jaeyoong Lim, On using cardinality constrained uncertainty for objective coefficients	Philip Kolvenbach, Robust optimization of PDE-constrained problems using second-order methods	Juan Borrero, Robust optimization with non-convex uncertainty sets		Robust
Salle 31 Build B, Z 5 Ground Floor 2x30 min	**Learning and dynamic programming**, *Chair*: Boxiao Chen, session 381	Manu Gupta, A unifying computation of Whittle's Index for Markovian bandits	Jose Nino-Mora, A verification theorem for indexability of real-state restless bandits			Markov

Room	Continuous Optimization - Monday 5:00 PM – 6:30 PM					
GINTRAC Build Q, Z 8 Ground Floor 3x30 min	**Gradient Methods for Constrained Optimization Problems**, *Organizer*: Igor Konnov, session 4	Igor Konnov, Simple Adaptive Versions of Iterative Optimization Methods	Alexander Zaslavski, Subgradient Projection Algorithm with Computational Errors	Andrea Cristofari, An active-set framework for minimizing nonconvex functions over the simplex		NLP
Salle 05 Build Q, Z 11 1st floor 4x20 min	**Polynomial and tensor optimization III**, *Organizer*: Jiawang Nie, session 7	Lek-Heng Lim, Higher order cone programming	Ke Ye, Ranks and decompositions of Hankel tensors	Annie Raymond, Symmetric Sums of Squares over k-Subset Hypercubes	Jiawang Nie, Tight relaxations for polynomial optimization and lagrange multiplier expression	NLP
Salle 9 Build N, Z 12 4th floor 3x20 min	**Modeling in NLP**, *Chair*: Laura Balzano, session 433	Laura Balzano, Low Algebraic Dimension Matrix Completion	Mirai Tanaka, DC programming algorithm for fully convex bilevel optimization	Nuttapol Pakkaranang, An inertial proximal point methods for solving minimization problems		NLP
Salle 8 Build N, Z 12 4th floor 3x30 min	**Extending the Reach of First-Order Methods, Part I**, *Organizer*: Haihao Lu, session 285	Benjamin Grimmer, Subgradient Method Convergence Rates without Lipschitz Continuity or Convexity	Yurii Nesterov, Relative smoothness condition and its application to third-order methods.	Haihao Lu, Generalized Stochastic Frank-Wolfe Method		NonSmooth
Salle 20 Build G, Z 6 1st floor 3x30 min	**Solving large scale convex composite programming**, *Organizer*: Kim-Chuan Toh, session 130	Kim-Chuan Toh, A block symmetric Gauss-Seidel decomposition theorem for convex composite QP	Xin Yee Lam, Fast algorithms for large scale generalized distance weighted discrimination	Yancheng Yuan, An Efficient Semismooth Newton Based Algorithm for Convex Clustering		SDP
Salle LC5 Build L, Z 10 Intermediate 1 3x30 min	**Convergence and Approximation in Conic Programming**, *Chair*: Tamás Terlaky, session 465	Nuri Vanli, Convergence Rate of Block Coordinate Ascent for Nonconvex Burer-Monteiro Method	Yuriy Zinchenko, Towards efficient approximation of p-cones	Tamás Terlaky, Quadratic convergence to the optimal solution of second-order conic optimization		SDP
Salle 06 Build Q, Z 11 1st floor 4x20 min	**Nonlinear Optimization and Variational Inequalities VI**, *Organizer*: Cong Sun, session 146	Fengmin Xu, Balance analysis of sparsity and robustness for portfolio adjustment problem	Chao Zhang, Two-stage stochastic program and stochastic variational inequalities	Xiao Wang, Proximal Stochastic Quasi-Newton methods for Nonconvex Composite Optimization	Zhongming Wu, General inertial proximal gradient method for nonconvex nonsmooth optimization	Variat
Salle ARNOZAN Build Q, Z 8 Ground Floor 4x20 min	**Variational Analysis 4**, *Organizer*: Jo A. Brueggemann, session 370	Jo Brueggemann, Path-following method for a class of obstacle problems with integral constraints	Yboon García Ramos, Nonconvex integration using ϵ-subdifferentials	Yakui Huang, A family of two-point stepsize gradient methods	Khoa Nguyen, Proximal alternating direction method of multipliers in the nonconvex setting	Variat
Salle KC6 Build K, Z 10 Intermediate 1 3x20 min	**Complexity of Randomized Algorithms**, *Organizer*: Raghu Pasupathy, session 347	Martin Morin, On the Convergence of SAGA-like Algorithms	Bang Vu, On the linear convergence of the projected stochastic gradient method	Raghu Pasupathy, The Complexity of Adaptive Sampling Accelerated Gradient Dsescent		RandomM
Salle 21 Build G, Z 6 Intermediate 3x30 min	**Advances in DFO I**, *Chair*: Sébastien Le Digabel, session 40	Warren Hare, Calculus Rules of the Simplex Gradient	Miguel Munoz Zuniga, Derivative free global Optimization with categorical-continuous variables	Stefan Wild, A Taxonomy of Constraints for Blackbox-Based Optimization		DerFree
Salle AURIAC Build G, Z 6 1st floor 4x20 min	**Advances in optimization methods for time dependent problems:I**, *Organizer*: Matthias Heinkenschloss, session 223	Mihai Anitescu, Exponentially convergent receding horizon constrained optimal control	Carl Laird, Parallel strategies for DAE optimization with direct Schur-complement decomp.	Johannes Haubner, Shape optimization for unsteady fluid-structure interaction	Matthias Heinkenschloss, A parallel-in-time gradient-type method for optimal control problems	Control

Room	Specific Models, Algorithms, and Software - Monday 5:00 PM – 6:30 PM				
FABRE	**Riemannian geometry in optimization for learning**, *Organizer*: Nicolas Boumal, session 320				**Learning**
Build J, Z 8 Ground Floor 4x20 min	Nicolas Boumal, Global rates of convergence for nonconvex optimization on manifolds	Ronny Bergmann, A parallel Douglas-Rachford algorithm for data on Hadamard manifolds	Paul Breiding, Riemannian optimization for the canonical tensor rank approximation problem	Junyu Zhang, Primal-Dual Optimization Algorithms over Riemannian Manifolds	
Salle DENUCE	**Exploiting structure in constrained optimization**, *Organizer*: Mihai Cucuringu, session 334				**Learning**
Build Q, Z 8 Ground Floor 4x20 min	Hemant Tyagi, Provably robust estimation of modulo 1 samples of a smooth function	Akiko Takeda, Efficient DC Algorithm for constrained sparse optimization problems	Nikitas Rontsis, Distributionally Ambiguous Optimization Techniques for Batch Bayesian Optimizati	Andre Uschmajew, On critical points of quadratic low-rank matrix optimization problems	
Salle 22	**Sparsity, variable selection and efficient algorithms**, *Chair*: Alex Sholokhov, session 475				**Learning**
Build G, Z 6 2nd floor 4x20 min	Sam Tajbakhsh, Distributed algorithms for statistical learning with structured sparsity	Jean Pauphilet, Sparse regression: Scalable algorithms and empirical performance	Alex Sholokhov, Sparsified Huge-Scale Optimization for Regularized Regression Problems	Zixin Shen, Forward stepwise variable selection based on relative weights	
Salle 16	**Packing and Capacity Management**, *Chair*: Eugene Zak, session 452				**Logistics**
Build I, Z 7 2nd floor 3x20 min	Marina Andretta, Solving Irregular Strip Packing Problems with free rotations	Alexandre Le Jean, A 3D-knapsack problem with truncated pyramids and static stability constraint	Eugene Zak, Minimization of sum of inverse sawtooth functions		
Salle 18	**Manufacturing**, *Chair*: Younsoo Lee, session 530				**Scheduling**
Build I, Z 7 1st floor 4x20 min	Sébastien Beraudy, Detailed production planning models for semiconductor manufacturing with profit	Teun Janssen, Scheduling in the Photolithography Bay	Hugo Harry Kramer, Column generation and fix-and-optimize for the lot-sizing with remanufacturing	Younsoo Lee, On the discrete lot-sizing and scheduling problem with sequence-dependent setup	
Salle 23	**Novel data-driven OR techniques for power system operations and planning**, *Organizer*: Juan M. Morales, session 52				**Energy**
Build G, Z 6 3rd floor 3x30 min	Salvador Pineda Morente, Chronological Time-Period Clustering for Optimal Capacity Expansion Planning	Christos Ordoudis, Energy and Reserve Dispatch with Distributionally Robust Joint Chance Constraints	Juan Morales, Predicting the electricity demand response via data-driven inverse optimization		
Salle 24	**Structure and Learning in Power Grid Optimization**, *Organizer*: Deepjyoti Deka, session 135				**Energy**
Build G, Z 6 3rd floor 3x30 min	Gal Dalal, Chance-Constrained Outage Scheduling using a Machine Learning Proxy	Sidhant Misra, Statistical Learning For DC Optimal Power Flow	Apurv Shukla, Non-Stationary Streaming PCA		
Salle LA4	**Structure from evidence**, *Organizer*: Peter Gritzmann, session 386				**Sciences**
Build L, Z 8 Basement 3x30 min	Douglas Gonçalves, Mathematical Programming in Quantum Information and Computation	Jorge Barreras, Detection of Uninformed Experts	Peter Gritzmann, On constrained flow and multi assignment problems for plasma particle tracking		
PITRES	**Implementation of interior-point methods for large-scale problems and applications II**, *Organizer*: Jordi Castro, session 352				**Algo**
Build O, Z 8 Ground Floor 3x30 min	Csaba Meszaros, On the implementation of the crossover algorithm	Aurelio Oliveira, Interior point methods applied to context-free grammar parameter estimation	Jordi Castro, A new specialized interior-point method for support vector machines		

Room	Discrete Optimization & Integer Programming - Tuesday 8:30 AM – 10:30 AM				
Salle 43	**Extended formulations**, *Organizer*: Stefan Weltge, session 219				**IPtheory**
Build C, Z 1 3rd floor 4x30 min	Michele Conforti, Balas formulation for the union of polytopes is optimal	Tony Huynh, Strengthening Convex Relaxations of 0/1-Sets Using Boolean Formulas	Makrand Sinha, Lower Bounds for Approximating the Matching Polytope	Stefan Weltge, Lifting Linear Extension Complexity Bounds to the Mixed-Integer Setting	
Salle 34	**MIP under Uncertainty 1**, *Organizer*: Fatma Kilinc-Karzan, session 231				**IPtheory**
Build B, Z 3 1st floor 3x30 min		Shabbir Ahmed, Distributionally Robust Combinatorial Optimization	Simge Kucukyavuz, Risk-Averse Set Covering Problems	Ruiwei Jiang, Mixed-Integer Recourse via Prioritization	
Salle 35	**Cutting Planes for Integer Programs**, *Chair*: Matthias Köppe, session 512				**IPtheory**
Build B, Z 4 Intermediate 4x30 min	Jiawei Wang, Characterization and Approximation of General Dual-Feasible Functions	Yuan Zhou, All finite group complexity injects	Daniel Porumbel, Projective cutting-planes by projecting interior points onto polytope facets	Matthias Köppe, cutgeneratingfunctionology: Python software for CGFs and superadditive duality	
Salle 44	**Machine Learning for Optimization**, *Organizer*: Bistra Dilkina, session 138				**IPpractice**
Build C, Z 1 3rd floor 4x30 min	Bistra Dilkina, Machine Learning for Branch and Bound	Markus Kruber, Learning when to use a decomposition	Elias Khalil, Learning Combinatorial Optimization Algorithms Over Graphs	Andrea Lodi, Learning Discrete Optimization	
LEYTEIRE	**Streaming**, *Organizer*: Michael Kapralov, session 228				**APPROX**
Build E, Z 1 3rd floor 4x30 min	Eric Price, Counting subgraphs in graph streams	David Woodruff, Sublinear Time Low Rank Approximation of Positive Semidefinite Matrices	Pan Peng, Estimating Graph Parameters from Random Order Streams	Michael Kapralov, $(1+\Omega(1))$-Approximation to MAX-CUT Requires Linear Space	
Salle 36	**Approximation Algorithms for Clustering**, *Organizer*: Chaitanya Swamy, session 256				**APPROX**
Build B, Z 4 Intermediate 4x30 min	Sara Ahmadian, Better Guarantees for k-Means Problem using Primal-Dual Algorithms	Chris Schwiegelshohn, On the Local Structure of Stable Clustering Instances	Benjamin Moseley, Approximation Bounds for Hierarchical Clustering	Chaitanya Swamy, Unifying k-Median and k-Center: Approximation Algorithms for Ordered k-Median	
SIGALAS	**Matching games and beyond**, *Organizer*: Jochen Koenemann, session 241				**COMB**
Build C, Z 2 2nd floor 4x30 min	Zhuan Khye Koh, Stabilizing Weighted Graphs	Justin Toth, Computing the Nucleolus of Weighted Cooperative Matching Games in Poly Time	Jannik Matuschke, New and simple algorithms for stable flow problems	Agnes Cseh, The complexity of cake cutting with unequal shares	
Salle 41	**Equilibrium Computation in Congestion Games**, *Organizer*: Umang Bhaskar, session 242				**COMB**
Build C, Z 1 3rd floor 4x30 min	Ioannis Panageas, Multiplicative Weights Update with Constant Step-Size in Congestion Games	Tobias Harks, Equilibrium Computation in Resource Allocation Games	Guido Schäfer, Computing Efficient Nash Equilibria in Congestion Games	Umang Bhaskar, Equilibrium Computation in Atomic Splittable Routing Games with Convex Costs	
Salle 39	**Exact approaches for problems over lattices and graphs**, *Chair*: Daniele Catanzaro, session 425				**COMB**
Build E, Z 1 3rd floor 4x30 min	Austin Buchanan, Why is maximum clique often easy in practice?	Matteo Cosmi, Scheduling for Last-Mile Food Delivery	Martin Frohn, Optimizing over lattices of unrooted binary trees: Part I - Foundations	Daniele Catanzaro, Optimizing over lattices of unrooted binary trees: Part II - On the BMEP	
DURKHEIM	**Graphical Optimization Model 1**, *Organizer*: Joris Kinable, session 295				**CP**
Build A, Z 1 3rd floor 4x30 min	David Bergman, On the integrated last mile transportation problem	Willem-Jan van Hoeve, Cut Generation for Integer (Non-)Linear Programming via Decision Diagrams	Joris Kinable, Hybrid Optimization Methods for Time-Dependent Sequencing Problems	John Hooker, Compact Representation of Near-Optimal Integer Programming Solutions	

Optimization under Uncertainty - Tuesday 8:30 AM – 10:30 AM

Room				
DENIGES Build C, Z 5 Ground Floor 4x30 min	**Risk-averse stochastic programming**, *Organizer*: Andrzej Ruszczynski, session 252 — **Stoch**			
	Darinka Dentcheva, Asymptotics of stochastic optimization problems with composite risk functionals	Ozlem Cavus, Multi-objective risk-averse two-stage stochastic programming problems	Alexander Shapiro, Distributionally robust stochastic programming	Andrzej Ruszczynski, Risk Disintegration with Application to Partially Observable Systems
Salle 37 Build B, Z 4 Intermediate 3x30 min	**Nonlinear Optimization with Uncertain Constraints**, *Organizer*: Charlie Vanaret, session 110 — **Robust**			
		Andreas Waechter, Nonlinear programming reformulations of chance constraints (Part 2)	Alejandra Pena-Ordieres, Nonlinear programming reformulations of chance constraints (Part 1)	Sven Leyffer, Sequential Linearization for Nonlinear Robust Optimization
Salle 33 Build B, Z 5 Ground Floor 3x30 min	**Robust Optimization and Operations Mangement**, *Organizer*: Chaithanya Bandi, session 410 — **Robust**			
		Nikos Trichakis, Robustness of Static Pricing Policies in the Face of Strategic Customers	Omar Besbes, Prior-Independent Optimal Auctions	Chaithanya Bandi, Design and Control of Multi-class Queueing Networks via Robust Optimization
Salle 31 Build B, Z 5 Ground Floor 4x30 min	**Algorithms for stochastic games : new approaches**, *Organizer*: Hugo Gimbert, session 137 — **Markov**			
	Marcin Jurdzinski, Quasi-polynomial algorithms for solving parity games	Antonin Kucera, One-Counter Stochastic Games with Zero-Reachability Objectives	Marcello Mamino, Around tropically convex constraint satisfaction problems.	Mateusz Skomra, The condition number of stochastic mean payoff games
Salle 30 Build B, Z 5 Ground Floor 4x30 min	**Algorithmic Game Theory I**, *Organizer*: Luce Brotcorne, session 311 — **Game**			
	Victor Bucarey, Solving Strong Stackelberg Equilibrium in Stochastic Games	Fränk Plein, Models for the single-minded bundle pricing problem	Concepcion Dominguez, Branch-and-cut algorithm for the Rank Pricing problem	Yury Kochetov, A matheuristic for the bilevel 0-1 public-private partnership problem

Continuous Optimization - Tuesday 8:30 AM – 10:30 AM

Room				
GINTRAC Build Q, Z 8 Ground Floor 4x30 min	**Stochastic and Nonlinear Optimization I**, *Organizer*: Jorge Nocedal, session 47 — **NLP**			
	Raghu Bollapragada, A Progressive Batching L-BFGS Method for Machine Learning	Leon Bottou, Convexity "à la carte"	Philip Thompson, On variance reduction for stochastic optimization with multiplicative noise	Frank Curtis, Characterizing Worst-Case Complexity of Algorithms for Nonconvex Optimization
Salle 05 Build Q, Z 11 1st floor 4x30 min	**Machine learning and sparse optimisation** , *Organizer*: Coralia Cartis, session 109 — **NLP**			
	Martin Lotz, Condition numbers and weak average-case complexity in optimization	Armin Eftekhari, A Long (Random) Walk Solves All Your (Linear) Problems	Florentin Goyens, Manifold lifting: problems and methods	Jared Tanner, Sparse non-negative super-resolution: simplified and stabilized
Salle KC7 Build K, Z 10 Intermediate 2 4x30 min	**Unconstrained Optimization**, *Chair*: Ekkehard Sachs, session 401 — **NLP**			
	Andrea Caliciotti, SYMMBK algorithm applied to Newton-Krylov methods for unconstrained optimization	Elisa Riccietti, Regularizing trust-region methods for ill-posed nonlinear least-squares problems	Massimo Roma, Approximate Inverse Preconditioning for Newton-Krylov methods	Ekkehard Sachs, Second Order Adjoints
Salle LC4 Build L, Z 9 Intermediate 1 4x30 min	**Advances in Bundle Methods for Convex Optimization**, *Organizer*: Christoph Helmberg, session 93 — **NonSmooth**			
	Frank Fischer, An Asynchronous Parallel Bundle Method Based on Inexact Oracles	Antonio Frangioni, Fully Incremental Bundle Methods: (Un)cooperative (Un)faithful Oracles and Upper	Elisabeth Gaar, The Bundle Method for Getting an Improved SDP Relaxation of the Stability Number	Christoph Helmberg, A Dynamic Scaling Approach for Bundle Methods in Convex Optimization
Salle 8 Build N, Z 12 4th floor 4x30 min	**Addressing problems with complex geometries**, *Organizer*: Edouard Pauwels, session 229 — **NonSmooth**			
	Jerome Malick, Sensitivity analysis for mirror-stratifiable convex functions	Courtney Paquette, An accelerated proximal method for minimizing compositions of convex functions	Antoine Hochart, How to perturb semi-algebraic problems to ensure constraint qualification?	Edouard Pauwels, The multiproximal linearization method for convex composite problems
Salle 20 Build G, Z 6 1st floor 4x30 min	**Algebraic and geometric aspects of semidefinite programming**, *Organizer*: Hamza Fawzi, session 85 — **SDP**			
	James Saunderson, Certificates of polynomial nonnegativity via hyperbolic optimization	Xavier Allamigeon, Log-barrier interior point methods are not strongly polynomial	Amy Wiebe, Slack ideals of polytopes	Dogyoon Song, Measuring Optimality Gap in Conic Programming Approximations with Gaussian Width
Salle LC5 Build L, Z 10 Intermediate 1 4x30 min	**Theory and algorithms in conic linear programming 1**, *Organizer*: Gabor Pataki, session 88 — **SDP**			
	Henry Wolkowicz, Low-Rank Matrix Completion (LRMC) using Nuclear Norm (NN) with Facial Reduction	Negar Soheili, Solving conic systems via projection and rescaling	Henrik Friberg, Projection and presolve in MOSEK: exponential and power cones	Levent Tuncel, TOTAL DUAL INTEGRALITY FOR CONVEX, SEMIDEFINITE, AND EXTENDED FORMULATIONS
Salle 06 Build Q, Z 11 1st floor 4x30 min	**Nonlinear Optimization and Variational Inequalities V**, *Organizer*: Xin Liu, session 145 — **Variat**			
	Yaohua Hu, Lower-order regularization method for group sparse optimization with application	Tingting Wu, Solving Constrained TV2L1-L2 MRI Signal Reconstruction via an Efficient ADMM	Oleg Burdakov, On solving saddle-point problems and non-linear monotone equations	Javad Feizollahi, A first-order method for semidefinite stochastic variational inequality problems
Salle ARNOZAN Build Q, Z 8 Ground Floor 4x30 min	**Optmization Algorithms and Variational Inequalites I**, *Organizer*: Bo Jiang, session 148 — **Variat**			
	Yu-Hong Dai, Smoothing quadratic regularization method for the hemivariational inequalities	Deren Han, ADMM for Optimization Problems Involving Nonconvex Functions	Xingju Cai, ADMM-based methods for monotone inverse variational inequalities	Bo Jiang, Vector Transport-Free SVRG with General Retraction for Riemannian Optimization
Salle KC6 Build K, Z 10 Intermediate 1 4x30 min	**Larges Scale and Distributed Optimization**, *Organizer*: Ermin Wei, session 214 — **RandomM**			
	Pontus Giselsson, On Linear Convergence for Douglas-Rachford splitting and ADMM	Jonathan Eckstein, Block-Iterative and Asynchronous Projective Splitting for Monotone Operators	Gesualdo Scutari, Achieving Geometric Convergence for Distributed Asynchronous Optimization	Ermin Wei, Asynchronous Distributed Network Newton Method
Salle 21 Build G, Z 6 Intermediate 4x30 min	**Bayesian and Randomized Optimization II**, *Chair*: Youssef Diouane, session 79 — **DerFree**			
	Nathalie Bartoli, Adaptive modeling strategy for high-dimensional constrained global optimization	Robert Gramacy, Modeling an Augmented Lagrangian for Blackbox Constrained Optimization	Victor Picheny, Bayesian optimization under mixed constraints	Zi Wang, Bayesian Optimization Guided by Max-values
Salle AURIAC Build G, Z 6 1st floor 4x30 min	**Optimization Methods for PDE Constrained Problems** , *Organizer*: Michael Ulbrich, session 221 — **Control**			
	Anton Schiela, An affine covariant composite step method with inexact step computations	Sebastian Garreis, Optimal Control under Uncertainty: Adaptive Solution with Low-rank Tensors	Carlos Rautenberg, On the optimal control of quasi-variational inequalities	Michael Ulbrich, Inexact bundle methods for nonconvex problems in Hilbert space with applications

Specific Models, Algorithms, and Software - Tuesday 8:30 AM – 10:30 AM

Room	Session
FABRE Build J, Z 8 Ground Floor 4x30 min	**Optimization in Statistical Learning**, *Organizer*: Quentin Berthet, session 326 — Learning Jonathan Weed, Near-linear time approximation algorithms for optimal transport Andreas Elsener, Sharp Oracle Inequalities for nonconvex regularized M-estimators Alexandre d Aspremont, Sharpness, Restart and Compressed Sensing Performance Fan Yang, Towards a deeper understanding of generalization for kernel learning
Salle DENUCE Build Q, Z 8 Ground Floor 4x30 min	**Statistics meets optimization: going beyond convexity**, *Organizer*: John Duchi, session 337 — Learning Mahdi Soltanolkotabi, Learning ReLUs and over-parameterized neural networks via gradient descent Ju Sun, When are nonconvex optimization problems not scary? John Duchi, Solving composite optimization problems, with applications to phase retrieval an Rina Barber, Optimal iterative thresholding algorithms for sparse optimization
Salle 22 Build G, Z 6 2nd floor 4x30 min	**Pricing**, *Chair*: Anastasiya Ivanova, session 478 — Learning Anastasiya Ivanova, Distributed price adjustment for the resource allocation problem Yesmine Rouis, Price forecasting with machine learning algorithms for recommerce activities Sara Calleja, Volume forecasting with machine learning algorithms for recommerce activities Spyros Zoumpoulis, Optimal Pricing and Introduction Timing of New Virtual Machines
Salle 18 Build I, Z 7 1st floor 4x30 min	**Path and tree problems**, *Chair*: Arthur J Delarue, session 360 — Network Andreas Karrenbauer, Approximate Shortest Paths and Transshipment in Distributed and Streaming Models Dmytro Matsypura, Exact IP-based approaches for the longest induced path problem. Kiyoshi Sawada, Adding Edges of Short Lengths Incident with the Root to Complete K-ary Tree Arthur Delarue, Travel Time Estimation in the Age of Big Data
Salle 16 Build I, Z 7 2nd floor 3x30 min	**Facility Location**, *Chair*: Ivan Contreras, session 414 — Logistics Ivan Contreras, Exact solution of single source quadratic capacitated location problems Blas Pelegrin, Optimal multi-facility location for competing firms under quantity competition Daniel Santos, A new formulation for the Hamiltonian p-median problem
Salle 23 Build G, Z 6 3rd floor 4x30 min	**Electric Vehicles and Decarbonization**, *Chair*: Martim Joyce-Moniz, session 519 — Energy Paolo Pisciella, A techno-economic analysis of the impact of decarbonization Francisco Munoz, Equilibrium Analysis of a Carbon Tax With Pass-through Restrictions Daniel Olivares, Management of EV Charging Stations under Advance Reservations Schemes Martim Joyce-Moniz, Increasing electric vehicle adoption via strategic siting of charging stations
Salle 24 Build G, Z 6 3rd floor 4x30 min	**Risk Models for Electricity Markets**, *Chair*: Michael C Ferris, session 521 — Energy Daniel Ralph, Risky Capacity Equilibrium Models for risk averse investment equilibria Ryan Cory-Wright, Payment mechanisms, efficiency savings and risk-aversion in electricity markets Fabio Moret, Risk and Information Sharing in Peer-to-Peer Electricity Markets Michael Ferris, Dynamic Risked Equilibrium for Energy Planning
Salle LA4 Build L, Z 8 Basement 4x30 min	**Interval Global Optimization**, *Organizer*: Frederic Messine, session 339 — Sciences Tibor Csendes, Nonlinear Symbolic Transformations for Simplifying Functions – Interval Methods Bertrand Neveu, An Interval Branch and Bound Algorithm for Parameter Estimation Dominique Monnet, Interval Branch-and-Bound Algorithm for semi-infinite programming Frederic Messine, Reliable convex relaxation techniques for interval global optimization codes
PITRES Build O, Z 8 Ground Floor 4x30 min	**LP, Mixed Integer Convex Programming and Decomposition**, *Organizer*: Thorsten Koch, session 236 — Algo Miten Mistry, Optimising over Gradient-Boosted Regression Trees with Convex Penalty Functions Nikolaos Ploskas, An advanced initialization procedure for the simplex algorithm Stephen Maher, Experiments with a general Benders' decomposition framework for SCIP Christian Puchert, Progress in the Branch-Price-and-Cut Solver GCG

Invited Talks - Tuesday 11:00 AM – 12:00 AM

Room	Session
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**Adaptive Robust Optimization with Scenario-wise Ambiguity Sets**, *Organizer*: Daniel Kuhn, session 551 — SEMI Melvyn Sim, Adaptive Robust Optimization with Scenario-wise Ambiguity Sets
DENIGES Build C, Z 5 Ground Floor 1x60 min	**Asymptotic Lagrangian duality for nonsmooth optimization**, *Organizer*: Xiaojun Chen, session 541 — KEYNOTE Regina Burachik, Asymptotic Lagrangian duality for nonsmooth optimization
BROCA Build W, Z 0 3rd floor 1x60 min	**Lower bounds on the size of linear programs**, *Organizer*: Volker Kaibel, session 545 — KEYNOTE Thomas Rothvoss, Lower Bounds on the Size of Linear Programs

Invited Talks - Tuesday 1:30 PM – 2:30 PM

Room	Session
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**The Resurgence of Proximal Methods in Optimization**, *Organizer*: Claudia Sagastizabal, session 555 — PLENARY Marc Teboulle, The resurgence of proximal methods in optimization

Discrete Optimization & Integer Programming - Tuesday 3:15 PM – 4:45 PM

Room	Session	Talk 1	Talk 2	Talk 3	Track
Salle 43 Build C, Z 1 3rd floor 3x30 min	**MIP under Uncertainty 2**, *Organizer*: Simge Kucukyavuz, session 232	Manish Bansal, Two-stage stochastic p-order conic mixed integer programs	Ward Romeijnders, Inexact cutting plane techniques for two-stage stochastic mixed-integer programs	Andrew Schaefer, Solving Stochastic and Bilevel Mixed-Integer Programs via a Generalized Value F.	**IPtheory**
Salle 44 Build C, Z 1 3rd floor 3x30 min	**Symmetry Handling in Integer Programs**, *Organizer*: Christopher Hojny, session 129	Cecile Rottner, Breaking full-orbitopal symmetries and sub-symmetries	Domenico Salvagnin, Symmetry Breaking Inequalities from the Schreier-Sims table	Christopher Hojny, Symmetry Breaking Polytopes: A Framework for Symmetry Handling in Binary Program	**IPpractice**
DURKHEIM Build A, Z 1 3rd floor 3x30 min	**Applications in Mixed-Integer Quadratic Programming**, *Organizer*: Boshi Yang, session 107	Boshi Yang, Improved Representations of the Quadratic Linear Ordering Problem	Areesh Mittal, Robust QCQPs Under Mixed Integer Uncertainty	Chiara Liti, Machine Learning and Optimization for Neuroscience	**MINLP**
Salle 34 Build B, Z 3 1st floor 3x30 min	**Convex relaxations in MINLP**, *Organizer*: Adam N Letchford, session 278	Borzou Rostami, A convex reformulation and an outer approximation for a class of BQP	Felipe Serrano, Separating over the convex hull of MINL constraints	Adam Letchford, Bi-Perspective Cuts for Mixed-Integer Fractional Programs	**MINLP**
Salle 35 Build B, Z 4 Intermediate 3x30 min	**Applications of MINLP**, *Organizer*: Dolores Romero Morales, session 281	Claudia López, Packing problem as mixed integer non-linear model using formulation space search	Steffen Rebennack, Piecewise Linear Function Fitting via Mixed-Integer Linear Programming	Dolores Romero Morales, Feature Selection for Benchmarking	**MINLP**
LEYTEIRE Build E, Z 1 3rd floor 3x30 min	**Algorithms in the Sharing Economy**, *Organizer*: David Shmoys, session 22	Anthony Kim, Minimizing Latency in Online Ride and Delivery Services	Alice Paul, Broken Bike Docks and the Prize-Collecting Traveling Salesman Problem	David Shmoys, Allocating capacity in bike-sharing systems	**APPROX**
Salle 36 Build B, Z 4 Intermediate 3x30 min	**Local Search and Facility Location**, *Organizer*: Felix Willamowski, session 342	Neelima Gupta, Local Search based Approximation Algorithms for Capacitated k median problems.	Krzysztof Sornat, Proportional Approval Voting, Harmonic k-median, and Negative Association	Felix Willamowski, Hard Instances for Local Search via Mixed Integer Programming	**APPROX**
Salle 41 Build C, Z 1 3rd floor 3x30 min	**New developments in prophet inequalities and related settings**, *Organizer*: Ruben Hoeksma, session 258	Ashish Chiplunkar, Prophet Inequality and Prophet Secretary	Brendan Lucier, Prophets, Secretaries, and Prices	Tim Oosterwijk, Posted Prices and Threshold Strategies for Random Arrivals	**COMB**
Salle 39 Build E, Z 1 3rd floor 3x30 min	**Submodular optimization and beyond**, *Chair*: Satoru Iwata, session 418	Martin Nägele, Submodular Minimization Under Congruency Constraints	Kenjiro Takazawa, The *b*-bibranching Problem: TDI System, Packing, and Discrete Convexity	Satoru Iwata, Index Reduction via Unimodular Transformations	**COMB**

Optimization under Uncertainty - Tuesday 3:15 PM – 4:45 PM

Room	Session	Talk 1	Talk 2	Talk 3	Track
Salle 32 Build B, Z 5 Ground Floor 3x30 min	**Distributionally Robust and Stochastic Optimization: A Sampling/Scenario Perspective**, *Organizer*: Guzin Bayraksan, session 249	Alexander Zolan, Optimizing the Design of a Latin Hypercube Sampling Estimator for SAA	Jun-ya Gotoh, Out-of-sample analysis of distributionally robust optimization	Guzin Bayraksan, Effective Scenarios in Multistage Distributionally Robust Stochastic Programs	**Stoch**
Salle 33 Build B, Z 5 Ground Floor 3x30 min	**Recent Advances in Robust Optimization I**, *Organizer*: Phebe Vayanos, session 442	Vishal Gupta, Optimization in the Small-Data, Large-Scale Regime	Velibor Misic, Interpretable Optimal Stopping	Phebe Vayanos, Fair, Efficient, and Interpretable Policies for Allocating Scarce Resources	**Robust**
DENIGES Build C, Z 5 Ground Floor 3x30 min	**Recent Advances in Robust Optimization II**, *Organizer*: Wolfram Wiesemann, session 445	Jianzhe Zhen, A Robust Optimization Perspective on Bilinear Programming	Huajie Qian, Calibrating Optimization under Uncertainty	Wolfram Wiesemann, The Distributionally Robust Chance Constrained Vehicle Routing Problem	**Robust**
Salle 31 Build B, Z 5 Ground Floor 3x30 min	**Market places and dynamic programming**, *Chair*: Dan A Iancu, session 380	Gonzalo Romero, Revenue Management with Repeated Customer Interactions	Boxiao Chen, Dynamic Inventory Control with Stockout Substitution and Demand Learning	Dan Iancu, Revenue Losses From Income Guarantees in Centralized Allocation Systems	**Markov**
Salle 30 Build B, Z 5 Ground Floor 3x30 min	**Game Theory and Energy Markets**, *Chair*: Didier Aussel, session 375	Anton Svensson, Constraint quali cations for parametrized optimization problems and applications	Léonard vonNiederhäusern, TrEMa: A Trilevel Energy Market Model	Didier Aussel, Electricity market model with elastic demand	**Game**

Continuous Optimization - Tuesday 3:15 PM – 4:45 PM

Room	Session	Talk 1	Talk 2	Talk 3	Track
GINTRAC Build Q, Z 8 Ground Floor 3x30 min	**Sum-of-squares and moment problems: methods and applications**, *Organizer*: Etienne De Klerk, session 2	Amir Ali Ahmadi, LP, SOCP, and Optimization-Free Approaches to Polynomial Optimization	Krzysztof Postek, Distributionally robust optimization with SOS polynomial density functions and m	Georgina Hall, Nonnegative polynomials, and applications to learning	NLP
Salle KC7 Build K, Z 10 Intermediate 2 3x30 min	**Bridging NLP and Theoretical Computer Science**, *Organizer*: Aleksander Madry, session 51	Aleksander Madry, Improved Max Flow and Bipartite Matching Algorithms via Interior Point Method	Lorenzo Orecchia, First-order methods: from dynamical systems to discrete optimization	Yin Tat Lee, A homotopy method for lp regression provably beyond self-concordance	NLP
Salle 05 Build Q, Z 11 1st floor 2x30 min	**Interior Point Methods in Engineering Applications II**, *Organizer*: Jacek Gondzio, session 61	Michal Kocvara, A multigrid interior point method for large scale topology optimization	Jacek Gondzio, Solving large-scale truss layout optimization problems by a primal-dual IPM		NLP
Salle 9 Build N, Z 12 4th floor 3x30 min	**Linear Optimization III**, *Chair*: Rodrigo Mendoza Smith, session 439	Rodrigo Mendoza Smith, Neural constraint selection in Linear Programming	Chu Nguyen, New station cone algorithm variant for linear programming and computing experiment	Khalid El Yassini, A predictor-corrector algorithm for lp problems using the mixed penalty approach	NLP
Salle 8 Build N, Z 12 4th floor 3x30 min	**Nonconvex Optimization: Theory and Methods - Part 2**, *Organizer*: Russell Luke, session 186	Guoyin Li, Splitting methods for nonconvex feasibility problems	Patrick Johnstone, Projective Splitting with Forward Steps	Russell Luke, Convergence Analysis for Nonconvex Optimization Made Easy	NonSmooth
Salle 20 Build G, Z 6 1st floor 3x30 min	**Recent Advances in Conic Programming I**, *Organizer*: Makoto Yamashita, session 82	Bissan Ghaddar, Strong and Cheap SDP and SOCP Hierarchies for Polynomial Optimization	Sunyoung Kim, BP: a Matlab package based on the Bisection and Projection method for POPs	David Papp, Sum-of-squares optimization with and without semidefinite programming	SDP
Salle LC5 Build L, Z 10 Intermediate 1 3x30 min	**Relative Entropy Optimization II**, *Organizer*: Venkat Chandrasekaran, session 112	Venkat Chandrasekaran, Newton Polytopes and Relative Entropy Optimization	Timo de Wolff, Optimization over the Hypercube via Sums of Nonnegative Circuit Polynomials	Orcun Karaca, The REPOP Toolbox: Polynomial Optimization Using Relative Entropy Relaxations	SDP
Salle 06 Build Q, Z 11 1st floor 3x30 min	**Nonlinear Optimization and Variational Inequalities III**, *Organizer*: Xin Liu, session 143	Xinwei Liu, A primal-dual IPM with rapid detection on infeasibility for nonlinear programs	Wei Bian, Some discussion on nonsmooth convex regression with cardinality penalty	Bo Wen, Proximal Algorithms with Extrapolation for Nonconvex Nonsmooth Problems	Variat
Salle KC6 Build K, Z 10 Intermediate 1 3x30 min	**Recent Advances in Stochastic and Non-convex Optimization II**, *Organizer*: Mingyi Hong, session 304	Tianbao Yang, First-order Stochastic Algorithms for Escaping From Saddle Points	John Birge, Markov chain Monte Carlo methods for Dynamic Stochastic Optimization	Jong-Shi Pang, Composite Difference-Max Programs for Modern Statistical Estimation Problems	RandomM
Salle 21 Build G, Z 6 Intermediate 3x30 min	**Advances in DFO II**, *Chair*: Warren Hare, session 37	Yves Lucet, Variable-fidelity derivative-free algorithms for road design	Matt Menickelly, Derivative-Free Robust Optimization by Outer Approximations	Sébastien Le Digabel, The Mesh Adaptive Direct Search algorithm for granular and discrete variables	DerFree
Salle AURIAC Build G, Z 6 1st floor 3x30 min	**Optimal Control and PDE Constrained Optimization**, *Organizer*: Hasnaa Zidani, session 233	Damien Allonsius, Control of semi discretized (in space) systems of parabolic equations.	Francesca Chittaro, Strong local optimality for generalised L^1 optimal control problems	Zheng Chen, Shortest Dubins Paths through Three Points	Control

Specific Models, Algorithms, and Software - Tuesday 3:15 PM – 4:45 PM

Room	Session	Talk 1	Talk 2	Talk 3	Track
Salle 16 Build I, Z 7 2nd floor 3x30 min	**Distributed and Asynchronous Learning**, *Organizer*: Ion Necoara, session 323	Aditya Devarakonda, Avoiding communication in first-order methods for convex optimization	Marten van Dijk, On the Expected Convergence of SGD with Large Stepsizes	Puya Latafat, Asynchronous primal-dual proximal algorithms for large-scale optimization	Learning
FABRE Build J, Z 8 Ground Floor 3x30 min	**Advances in large-scale machine learning**, *Organizer*: Mark Schmidt, session 327	Francis Bach, Exponential convergence of testing error for stochastic gradient methods.	Volkan Cevher, Mirrored Langevin Dynamics	Zaid Harchaoui, Catalyst Acceleration for Gradient-based Optimization of Structured Models	Learning
Salle 22 Build G, Z 6 2nd floor 2x30 min	**Learning for mixed integer optimization**, *Chair*: Hari Bandi, session 482	Hari Bandi, Learning a Mixture of Gaussians via Mixed Integer Optimization	Takanori Maehara, Learning for Tuning Parameters of NUOPT MILP Solver		Learning
PITRES Build O, Z 8 Ground Floor 3x30 min	**Pricing Methods**, *Organizer*: Rafael Martinelli, session 182	Teobaldo Bulhões Júnior, A branch-and-price algorithm for the Minimum Latency Problem	Jacques Desrosiers, Pricing, cycles, and pivots	Ruslan Sadykov, Branch-Cut-and-Price Solver for Vehicle Routing Problems	Logistics
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Supply Chain and Lot Sizing**, *Chair*: Simon Thevenin, session 534	Sixiang Zhao, Decision Rule-based Method for Flexible Multi-Facility Capacity Planning Problem	Kerem Akartunali, Two-Period Relaxations for Big-Bucket Lot-Sizing: Polyhedra and Algorithms	Simon Thevenin, Scenario based stochastic optimization for the multi-echelon lot-sizing problem	Scheduling
Salle DENUCE Build Q, Z 8 Ground Floor 3x30 min	**Equilibrium Modelling in Energy**, *Organizer*: Thomas Kallabis, session 290	Mirjam Ambrosius, Optimal Price Zones and Investment Incentives in Electricity Markets	Thomas Kallabis, Strategic generation investment using a stochastic rollinghorizon MPEC approach	Christoph Weber, Coordination Problems in the Coupling of Gas and Electricity Markets	Energy
Salle 24 Build G, Z 6 3rd floor 3x30 min	**Optimization Models for Renewable Energy Integration 2**, *Chair*: Michel Denault, session 523	Cristina Corchero, A MIP formulation of a Hybrid AC-DC offshore wind power plant topology	Kristina Janzen, Optimal Design of a Decentralized Energy Network including Renewable Energies	Michel Denault, Approximate dynamic programming for hydropower optimization	Energy
Salle LA4 Build L, Z 8 Basement 3x30 min	**Optimization in Medicine**, *Organizer*: Sebastian Sager, session 394	Manuel Tetschke, Optimizing the individual treatment of patients with polycythemia vera	Nelson Maculan, Combinatorial Problems and Models to Help Prevention and Combat Arboviruses	Sebastian Sager, Towards optimized consolidation (chemo)therapy for acute myeloid leukemia	Sciences
Salle 18 Build I, Z 7 1st floor 3x30 min	**Optimization software and applications**, *Chair*: Bartolomeo Stellato, session 399	Bartolomeo Stellato, OSQP: An Operator Splitting Solver for Quadratic Programs	Navjot Kukreja, High-level abstractions for checkpointing in PDE-constrained optimisation	Ivet Galabova, A quadratic penalty algorithm for linear programming	Algo

Room	Invited Talks - Tuesday 3:15 PM – 4:45 PM			
SIGALAS Build C, Z 2 2nd floor	**A.W. Tucker Prize Session**, *Chair*: Simge Kucukyavuz, session 559 — INTERFACE			

Room	Discrete Optimization & Integer Programming - Wednesday 8:30 AM – 10:30 AM			
Salle 43 Build C, Z 1 3rd floor 4x30 min	**Determinantal structures of IPs**, *Organizer*: Martin Henk, session 131 — IPtheory			
	Stephan Artmann, Width in congruency-constrained TU-systems.	Friedrich Eisenbrand, Faster algorithms for Integer Programming using the Steinitz Lemma	Christoph Glanzer, On the number of distinct rows of a matrix with bounded subdeterminants	Robert Weismantel, Distances between LPs, IPs and MIPs
Salle 35 Build B, Z 4 Intermediate 4x30 min	**Advances in Integer Programming**, *Organizer*: Santanu S Dey, session 230 — IPtheory			
	Sanjeeb Dash, A generalization of Gomory-Chvatal cuts	Burak Kocuk, Integer Programming Techniques for Optimal Transmission Switching Problems	Alejandro Toriello, Time-indexed Relaxations for the Online Bipartite Matching Problem	Laurence Wolsey, Constant Capacity Flow Cover Inequalities on a Path or a Variant of Lot-Sizing
Salle 42 Build C, Z 1 3rd floor 4x30 min	**Primal Algorithms for Integer Programming Problems**, *Organizer*: Daniel Aloise, session 338 — IPtheory			
	Adil Tahir, Integral Column Generation Algorithm for Set Partitioning Type Problems	Omar Foutlane, Distributed Integral Simplex Using Decomposition for Set Partitioning Problems	Ilyas Himmich, A Polyhedral Study of the Shortest Path Problem with Resource Constraints	Daniel Aloise, A scalable algorithm for the solution of large clustering problems
Salle 44 Build C, Z 1 3rd floor 4x30 min	**Benders Decomposition for Combinatorial and Bilevel Optimization**, *Organizer*: Fabio Furini, session 171 — IPpractice			
	Arthur Mahéo, A Framework for Benders with Integer Sub-Problem	Paolo Paronuzzi, New ILP formulations for the k-Vertex Cut Problem	Ivana Ljubic, Decomposition Approaches to Covering Location Problems	Fabio Furini, The Maximum Clique Interdiction Game
Salle 34 Build B, Z 3 1st floor 3x30 min	**MINLP (I)**, *Organizer*: Daniel Bienstock, session 65 — MINLP			
		Bachir El Khadir, Time-Varying Semidefinite Programs	Kurt Anstreicher, Strengthened Relaxations for Quadratic Optimization with Switching Variables	James Renegar, A Simple Nearly-Optimal Restart Scheme For Speeding-Up First Order Methods
LEYTEIRE Build E, Z 1 3rd floor 4x30 min	**Approximation Algorithms for the Traveling Salesman Problem**, *Organizer*: Anke van Zuylen, session 23 — APPROX			
	Stephan Held, Vehicle Routing with Subtours	Kent Quanrud, Fast Approximations for Metric TSP	Jens Vygen, The *s*-*t*-path TSP: past, present, and future	Anke van Zuylen, The Salesman's Paths: Layered Christofides' Trees, Deletion and Matroids
Salle 36 Build B, Z 4 Intermediate 4x30 min	**Approximation Algorithms for Scheduling Problems**, *Organizer*: Nicole Megow, session 72 — APPROX			
	Ruben Hoeksma, The general scheduling problem with uniform release dates is not APX-hard	Clifford Stein, Minimizing Maximum Flow Time on Related Machines via Dynamic Pricing	Sven Jäger, Generalizing the Kawaguchi-Kyan Bound to Stochastic Parallel Machine Scheduling	Julian Mestre, Precedence-Constrained Min Sum Set Cover
Salle 41 Build C, Z 1 3rd floor 4x30 min	**Discrete Convex Analysis**, *Organizer*: Akiyoshi Shioura, session 243 — COMB			
	Akiyoshi Shioura, M-convex Function Minimization under L1-distance Constraint	Eric Balkanski, On the Construction of Substitutes	Fabio Tardella, Discrete Midpoint Convexity	Satoko Moriguchi, Scaling, proximity, and optimization of integrally convex functions
Salle 39 Build E, Z 1 3rd floor 4x30 min	**Optimization under uncertainty**, *Organizer*: Marco Molinaro, session 261 — COMB			
	William Umboh, Online Probabilistic Metric Embedding and its Applications	Ravishankar Krishnaswamy, Online and Dynamic Algorithms for Set Cover	Sahil Singla, Algorithms and Adaptivity Gaps for Stochastic Probing	Marco Molinaro, Online and Random-order Load Balancing Simultaneously
DURKHEIM Build A, Z 1 3rd floor 4x30 min	**Learning in CP**, *Organizer*: Arnaud Lallouet, session 301 — CP			
	Nadjib Lazaar, Constraint acquisition	Arnaud Lallouet, Reasoning with Learned Constraints	Arnaud Gotlieb, Boundary Estimation: Learning Boundaries for Constraint Optimization Problems	Michela Milano, Empirical Model Learning: boosting optimization through machine learning

Room	Optimization under Uncertainty - Wednesday 8:30 AM – 10:30 AM			
DENIGES Build C, Z 5 Ground Floor 4x30 min	**Chance Constraint and Its Applications**, *Organizer*: Jianqiang Cheng, session 253 — Stoch			
	Abdel Lisser, Joint chance constrained general sum games	Jia Liu, Distributionally robust geometric programs with chance constraints	Francesca Maggioni, Bounds for probabilistic constrained problems	Jianqiang Cheng, Partial Sample Average Approximation Method for Chance Constrained Problems
Salle 32 Build B, Z 5 Ground Floor 3x30 min	**Sampling and stability in stochastic optimization**, *Chair*: Harsha Honnappa, session 488 — Stoch			
		Edward Anderson, Distributional Robustness and Sample Average Approximation	Matthias Claus, On stability of stochastic bilevel programs with risk aversion	Gerard Cornuejols, From Estimation to Optimization via Shrinkage
Salle 37 Build B, Z 4 Intermediate 4x30 min	**Interfaces of Applied Probability and Optimization**, *Organizer*: Omar El Housni, session 409 — Robust			
	Julien Grand Clement, Robust Markov Decision Process: Beyond (and back to) Rectangularity	Omar El Housni, Beyond Worst-case: A Probabilistic Analysis of Affine Policies	Omid Nohadani, Sustainable Inventory With Robust Periodic-affine Policies and Med. Supply Chains	Karthik Natarajan, Distributionally Robust Markovian Traffic Equilibrium
Salle 33 Build B, Z 5 Ground Floor 4x30 min	**Robust combinatorial optimization IV**, *Chair*: Arie Koster, session 449 — Robust			
	Pedro Munari, The vehicle routing problem under uncertainty via robust optimization	Marina Leal, A time-dependent version of the robust TSP and SPP.	Arie Koster, Scheduling Jobs under Uncertainty: A Customer-oriented Approach	Roberto Wolfler Calvo, Optimizing the electricity production planning with stochastic outage durations
Salle 30 Build B, Z 5 Ground Floor 4x30 min	**Risk and Financial Markets**, *Chair*: Markku J Kallio, session 377 — Game			
	Stefano Nasini, Bilevel programming approach for investment strategies under intermediation	Yang Zhan, A smooth path-following method for computing equilibria in incomplete markets	Markku Kallio, Cooperative Mitigation of Contagion in Financial Networks	Zhenyu Hu, Stable Risk Sharing and Its Monotonicity

Room	Continuous Optimization - Wednesday 8:30 AM – 10:30 AM			
GINTRAC Build Q, Z 8 Ground Floor 4x30 min	**Stochastic and Nonlinear Optimization III**, *Organizer*: Jorge Nocedal, session 31 — NLP			
	Fred Roosta, Efficient Newton-type methods for non-convex machine learning problems	Jorge Nocedal, Optimization Methods for Training Neural Networks	Stephen Wright, A Newton-CG Method with Complexity Guarantees	Uday Shanbhag, Smoothed Variable Sample-size Acc. Prox. Methods for Stoch. Convex Optimization
Salle 05 Build Q, Z 11 1st floor 4x30 min	**Optimality conditions in NLP and conic problems**, *Organizer*: Roberto Andreani, session 43 — NLP			
	Roberto Andreani, A SEQUENTIAL OPTIMALITY CONDITION RELATED TO THE QUASINORMALITY CQ	Gabriel Haeser, An extension of Yuan's Lemma and its applications in optimization	Luis Felipe Bueno, Optimality Conditions for Generalized Nash Equilibrium Problems	Tatiana Tchemisova, On Optimality Conditions for Linear Copositive Programming
Salle KC7 Build K, Z 10 Intermediate 2 4x30 min	**Computational advances in NLP**, *Chair*: Jeffrey CH Pang, session 434 — NLP			
	Alfonso Lobos Ruiz, Optimal Bidding, Allocation, and Budget Spending for a Demand-Side Platform.	Jeffrey Pang, Distributed deterministic asynchronous optimization using Dykstra's splitting	Zhening Li, Decompositions and optimizations of symmetric conjugate complex forms	Max Goncalves, An inexact Newton-like conditional gradient method for constrained systems
Salle 9 Build N, Z 12 4th floor 4x30 min	**Fixed Point Approaches**, *Chair*: Poom Kumam, session 435 — NLP			
	Konrawut Khammahawong, Convergence analysis of S-iteration process for discontinuous operators	Poom Kumam, A new lgorithms for split feasibility problems involving paramonotone equilibria	Khanitin Muangchoo-in, Fixed point and convergence theorems for monotone (α,β)-nonexpansive	Wudthichai Onsod, Monotone generalized almost contraction on weighted graph
Salle LC4 Build L, Z 9 Intermediate 1 4x30 min	**Recent advances in first-order algorithms for non-smooth optimization**, *Organizer*: Thomas Pock, session 198 — NonSmooth			
	Peter Ochs, Non-smooth Non-convex Bregman Minimization: Unification and new Algorithms	Yura Malitsky, Primal-dual algorithm for linearly constrained optimization problem	Matthias Ehrhardt, Stochastic PDHG with Arbitrary Sampling and Applications to Medical Imaging	Stanislav Mazurenko, Acceleration and global convergence of the NL-PDHGM
Salle 8 Build N, Z 12 4th floor 4x30 min	**Dynamical Systems and Optimization**, *Organizer*: Hedy Attouch, session 351 — NonSmooth			
	Radu Ioan Bot, The continuous proximal-gradient approach in the nonconvex setting	Alexandre Cabot, Accelerated Forward-Backward Algorithms	Juan Peypouquet, Inertial proximal algorithms for maximally monotone operators	Silvia Villa, A dual diagonal iterative regularization method
Salle AURIAC Build G, Z 6 1st floor 4x30 min	**Recent Advances in Conic Programming II**, *Organizer*: Sena Safarina, session 83 — SDP			
	Rujun Jiang, Convex Relaxations for Nonconvex Quadratically Constrained Quadratic Program	Sena Safarina, Cone Decomposition Method for Mixed-Integer SOCP arising from tree breeding	Goran Banjac, Infeasibility detection in ADMM for convex optimization	Marta Cavaleiro, A Simplex-like algorithm for the infimum point w.r.t. the second order cone
Salle 20 Build G, Z 6 1st floor 4x30 min	**Theory and algorithms in conic linear programming 2**, *Organizer*: Gabor Pataki, session 89 — SDP			
	Masakazu Muramatsu, An extension of Chubanov's algorithm to symmetric cone programming	Joachim Dahl, Extending MOSEK with exponential cones	Stefan Sremac, Primal Facial Reduction in Semidefinite Programming and Matrix Completions	Bruno Lourenco, Amenable cones: bridging error bounds and facial reduction
Salle LC5 Build L, Z 10 Intermediate 1 4x30 min	**New trends II**, *Chair*: Frank Permenter, session 500 — SDP			
	Claudia Adams, An L^2-approach to Copositivity	Faizan Ahmed, On algorithms to optimize homogeneous polynomial over the simplex and the sphere	John Mitchell, Complementarity formulations of rank minimization problems	Frank Permenter, Interior-point methods via the exponential map
Salle 06 Build Q, Z 11 1st floor 2x30 min	**Stochastic Optimization and Variational Inequalities II**, *Organizer*: Alejandro R. Jofre, session 156 — Variat			
			Yueyue Fan, How does uncertainty of demand propagate to flows under network equilibrium	Alejandro Jofre, Variance-based stochastic extragradient methods with linear search for Stoch. VI
Salle ARNOZAN Build Q, Z 8 Ground Floor 4x30 min	**Variational Analysis 1**, *Organizer*: Samir Adly, session 364 — Variat			
	Alexandra Schwartz, Second Order Optimality Conditions for Cardinality Constrained Problems	Helmut Gfrerer, Stability Analysis for Parameterized Equilibria with Conic Constraints	Michel Thera, Stability and Sensitivity Analysis of Parametrized Optimization Problems	Samir Adly, Sensitivity analysis of parameterized nonlinear variational inequalities.
Salle KC6 Build K, Z 10 Intermediate 1 4x30 min	**First Order Methods for Non-Smooth Constrained Optimization**, *Organizer*: Qihang Lin, session 305 — RandomM			
	Shiqian Ma, On the Non-Ergodic Convergence Rate of an Inexact Augmented Lagrangian Framework	Selvaprabu Nadarajah, A level-set method for stochastic optimization with expectation constraints	Peng Zheng, Fast method for non-smooth non-convex minimization	DaoLi Zhu, Stochastic Primal-Dual Coordinate Method for Nonlinear Convex Cone Programs
Salle 21 Build G, Z 6 Intermediate 4x30 min	**New derivative-free algorithms**, *Chair*: Margherita Porcelli, session 34 — DerFree			
	Margherita Porcelli, Gray-box optimization of structured problems and other new developments in BFO	Francesco Rinaldi, Model-based derivative-free methods for nonsmooth black-box functions	Lindon Roberts, A flexible, robust and efficient derivative-free solver for least squares	Ana Custodio, MultiGLODS: Clever Multistart in Multiobjective Directional Direct Search

Room	Specific Models, Algorithms, and Software - Wednesday 8:30 AM – 10:30 AM			
Salle 16 Build I, Z 7 2nd floor 3x30 min	**First-Order Methods for Machine Learning**, *Organizer*: Fabian Pedregosa, session 319 — Learning			
		Nicolas Flammarion, Stochastic Composite Least-Squares Regression with convergence rate O(1/n)	Fabian Pedregosa, Adaptive Three Operator Splitting	Sebastian Stich, Approximate Composite Minimization: Convergence Rates and Examples
FABRE Build J, Z 8 Ground Floor 4x30 min	**Structured Optimization for Machine Learning and Signal Processing**, *Organizer*: Lin Xiao, session 330 — Learning			
	Donald Goldfarb, Training neural networks using ADMM for multiaffine constrai	Xinhua Zhang, Generalized Conditional Gradient for Structured Sparsity and Convex Deep Network	Lieven Vandenberghe, Proximal methods for optimization over nonnegative trigonometric polynomials	Mikael Johansson, Fast convex optimization for eigenproblems and beyond
Salle 18 Build I, Z 7 1st floor 4x30 min	**Robust network optimization**, *Organizer*: Dimitri Papadimitriou, session 357 — Network			
	Joe Naoum-Sawaya, Decomposition Approach for Robust Network Interdiction	Varun Reddy, Robust network slice design under correlated demand uncertainties	Xudong Hu, Equilibria for Robust Routing of Atomic Players	Dimitri Papadimitriou, Reliable Multilevel Facility Location Problem (MFLP)
Salle DENUCE Build Q, Z 8 Ground Floor 4x30 min	**Decomposition Techniques to Solve Large-Scale Optimization Problems for Electricity and Natural Gas Systems**, *Organizer*: Ramteen Sioshansi, session 136 — Energy			
	Jean-Paul Watson, Toward Scalable Stochastic Economic Dispatch on an Industrial-Scale Model	David Pozo, Distributionally Robust Transmission Expansion Planning	Gerrit Slevogt, Structures and algorithms for nomination validation in steady-state gas networks	Giorgia Oggioni, A bilevel model for the waste-to-energy supply chain in a circular economy
Salle 23 Build G, Z 6 3rd floor 4x30 min	**Energy-aware planning and scheduling 1**, *Organizer*: Sandra U. Ngueveu, session 177 — Energy			
	Sophie Demassey, Robust optimisation of storage in a power generation expansion planning problem	Peter Pflaum, Microgrid Energy Flexibility Optimization – 3 use cases	Paolo Gianessi, ILP models for the job-shop scheduling problem with energy consideration	Sandra U. Ngueveu, Decomposition method in a scheduling problem with energy storage and costs
Salle 24 Build G, Z 6 3rd floor 4x30 min	**Distribution and Demand Flexibility**, *Chair*: Golbon Zakeri, session 510 — Energy			
	Alejandro Angulo, A Data–Driven Robust Power Management in Active Distribution Systems	Anja Hähle, Exploiting Flexibility in Loads for Balancing Power in Electrical Grids	Paulin Jacquot, Analysis of a Routing Game Model for Demand Side Management	Golbon Zakeri, Demand response in electricity markets
Salle LA4 Build L, Z 8 Basement 3x30 min	**Energy markets**, *Organizer*: Martine Labbé, session 50 — Sciences			
		Bernard Fortz, Unit Commitment under Market Equilibrium Constraints	Martin Schmidt, The Impact of Physics on Market Equilibria in Energy Networks	Martine Labbé, Dynamic programming approach for bidding problems on day-ahead markets
PITRES Build O, Z 8 Ground Floor 3x30 min	**Progress in MIP Solvers I**, *Organizer*: Michael Winkler, session 235 — Algo			
		Imre Polik, New features and improvements in the SAS/OR optimization package	Thorsten Koch, MIPLIB 2017+1	Hans Mittelmann, Benchmarks of commercial and noncommercial optimization software
Salle 22 Build G, Z 6 2nd floor 4x30 min	**Numerically Efficient Methods for Piecewise Algorithmic Differentiation I**, *Organizer*: Torsten F Bosse, session 269 — Algo			
	Sri Hari Narayanan, Study of the numerical efficiency of structured abs-normal forms	Torsten Bosse, (Almost) Matrix-free solver for piecewise linear functions in Abs-Normal form	Andreas Griewank, An active signature method for piecewise differentiable/linear optimization.	Angel Rojas, Solving l_1 regularized minimax problems by successive piecewise linearization

Room	Invited Talks - Wednesday 8:30 AM – 10:30 AM			
SIGALAS Build C, Z 2 2nd floor 4x30 min	**Stochastic optimization**, *Chair*: Alexei A. Gaivoronski, session 314 — INTERFACE			
	Bernardo Costa, Using disjunctive programming to represent Risk Aversion policies	Anthony Downward, SDDP with stagewise-dependent objective coefficient uncertainty	Alexei Gaivoronski, Stochastic optimization of simulation models: management of	Kazem Abbaszadeh, Demand Response To Electricity Prices In Flexible Manufacturing

Room	Invited Talks - Wednesday 11:00 AM – 12:00 AM			
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**Insights via volumetric comparison of polyhedral relaxations**, *Organizer*: Andrea Lodi, session 548 — SEMI			
	Jon Lee, Insights via volumetric comparison of polyhedral relaxations			
BROCA Build W, Z 0 3rd floor 1x60 min	**Monotone Operator Theory in Convex Optimization**, *Organizer*: Samir Adly, session 537 — KEYNOTE			
	Patrick Combettes, Monotone Operator Theory in Convex Optimization			
DENIGES Build C, Z 5 Ground Floor 1x60 min	**Online Competitive Algorithms for Resource Allocation**, *Organizer*: Frank E. Curtis, session 539 — KEYNOTE			
	Maryam Fazel, Online Competitive Algorithms for Resource Allocation			
LEYTEIRE Build E, Z 1 3rd floor 1x60 min	**Model-Based Methods, Sampling Models, and A New Second-Order Model-Based Method**, *Organizer*: Stefan M Wild, session 546 — KEYNOTE			
	Luis Nunes Vicente, Model-Based Methods, Sampling Models, and A New Second-Order Model-Based Method			

Room	Invited Talks - Wednesday 1:30 PM – 2:30 PM			
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**Relaxations and Approximations of Chance Constraints**, *Organizer*: Simge Kucukyavuz, session 525 — PLENARY			
	Shabbir Ahmed, Relaxations and Approximations of Chance Constraints			

Discrete Optimization & Integer Programming - Wednesday 3:15 PM – 4:45 PM

Room				
Salle 44 Build C, Z 1 3rd floor 3x30 min	**Knapsack Problems**, *Organizer*: Enrico Malaguti, session 185			**IPpractice**
	Ashwin Arulselvan, Algorithms for bilevel knapsack problem	Orlando Rivera-Letelier, Cutting Planes for the Multi-Modal Precedence Constrained Problem	Enrico Malaguti, The Fractional Knapsack Problem with Penalties	
Salle 36 Build B, Z 4 Intermediate 3x30 min	**Decomposition I**, *Chair*: Dieter Weninger, session 486			**IPpractice**
	Kerem Bulbul, Benders Decomposition and Column-and-Row Generation for LPs w/Column-Dependent Rows	Paul Stursberg, Improved Cut Selection for Benders Decomposition	Dieter Weninger, A Penalty Alternating Direction Decomposition Framework for MIPs	
DURKHEIM Build A, Z 1 3rd floor 3x30 min	**Decomposition methods for MINLP**, *Organizer*: Ivo Nowak, session 55			**MINLP**
	Ivo Nowak, Decomposition-based Successive Approximation Methods for MINLP	Pavlo Muts, Decogo - A new decomposition-based MINLP solver	Eligius Hendrix, On simplicial monotonicity and dimension reduction in MINLP	
Salle 34 Build B, Z 3 1st floor 3x30 min	**MINLP (II)**, *Organizer*: Daniel Bienstock, session 66			**MINLP**
	Akshay Gupte, Polyhedral relaxations for nonconvex quadratic functions	Mohit Tawarmalani, Product convexification: A new relaxation framework for nonconvex programs	Javad Lavaei, Sparse conic optimization: low-rank solutions and near-linear time algorithms	
Salle 35 Build B, Z 4 Intermediate 3x30 min	**MINLP for Data Science**, *Organizer*: Vanesa Guerrero, session 108			**MINLP**
	Sandra Benítez-Peña, Cost-sensitive SVM	Cristina Molero-Río, Optimizing classification trees via non-linear continuous programming	Vanesa Guerrero, MINLP to visualize dynamic proximities and frequencies	
LEYTEIRE Build E, Z 1 3rd floor 3x30 min	**Clustering**, *Organizer*: Mohammad R Salavatipour, session 30			**APPROX**
	Aravindan Vijayaraghavan, Clustering Mixtures of Well-Separated Gaussians	Konstantin Makarychev, Correlation Clustering	Melanie Schmidt, Analysis of Ward's method	
Salle 43 Build C, Z 1 3rd floor 3x30 min	**Network Design and Routing**, *Chair*: Yuko Kuroki, session 346			**APPROX**
	Yusa Matsuda, A 4-approximation algorithm for k-prize collecting Steiner tree problems	Yuko Kuroki, Approximation algorithm for star-star hub-and-spoke network design problems	Jeremy Omer, Time-dependent shortest path with discounted waiting	
Salle 41 Build C, Z 1 3rd floor 3x30 min	**Variants of the Assignment problem**, *Organizer*: Kavitha Telikepalli, session 266			**COMB**
	Tobias Mömke, Approximating Airports and Railways	Ami Paz, A (2+eps)-Approximation for Maximum Weight Matching in the Semi-Streaming Model	Kavitha Telikepalli, Popularity, Mixed Matchings, and Self-duality	
Salle 39 Build E, Z 1 3rd floor 3x30 min	**Polyhedral aspects of combinatorial optimization problems**, *Chair*: Guillerme Duvillié, session 404			**COMB**
	Shungo Koichi, A polyhedral insight into covering a 2/3 supermodular function by a graph	Sergei Chubanov, Alternating contractions and their combinatorial applications	Guillerme Duvillié, Comparison of some symmetry breaking techniques for graph coloring problem	

Optimization under Uncertainty - Wednesday 3:15 PM – 4:45 PM

Room				
Salle 32 Build B, Z 5 Ground Floor 3x30 min	**Learning and Stochastic Programming**, *Organizer*: Matthias Poloczek, session 254			**Stoch**
	Junyi Liu, Asymptotic Results For Two-stage Stochastic Quadratic Programming	Haoxiang Yang, Optimizing Crashing Decisions in a Project Management Problem with Disruptions	Matthias Poloczek, Bayesian Optimization of Combinatorial Structures	
DENIGES Build C, Z 5 Ground Floor 3x30 min	**Dynamic Optimization: Theory and Algorithms**, *Organizer*: Vineet Goyal, session 100			**Robust**
	Shimrit Shtern, A Scalable Algorithm for Two-Stage Adaptive Linear Optimization	Bradley Sturt, Data-Driven Multi-Stage Adaptive Optimization	Vineet Goyal, Optimal Approximation via Affine Policies for Two-stage Robust Optimization	
Salle 37 Build B, Z 4 Intermediate 3x30 min	**Cursing the Dimensionality: Two-Stage and Multi-Stage Robust Optimization**, *Organizer*: Angelos Tsoukalas, session 443			**Robust**
	Chin Pang Ho, Efficient Algorithms for Robust MDPs with State Rectangularity	Frans de Ruiter, Dual approach for two-stage robust nonlinear optimization models	Angelos Tsoukalas, Robust Dual Dynamic Programming	
Salle 31 Build B, Z 5 Ground Floor 2x30 min	**Dynamic programming applications**, *Chair*: Susanne Hoffmeister, session 379			**Markov**
	Susanne Hoffmeister, Markov Decision Processes for Sport Strategy Optimization	Paolo Serafini, A Model to evaluate the cost-effectiveness trade-off for urologic treatments		
Salle 30 Build B, Z 5 Ground Floor 3x30 min	**Nonconvex and Complex Problems in Multiobjective Optimization**, *Chair*: Gabriele Eichfelder, session 268			**Game**
	Gabriele Eichfelder, A Trust Region Method for Heterogeneous Multiobjective Optimization	Elizabeth Karas, Multiobjective programming via bundle methods	Tommaso Levato, Sparse multiobjective optimization via concave approximations	

Room	Continuous Optimization - Wednesday 3:15 PM – 4:45 PM				
GINTRAC Build Q, Z 8 Ground Floor 3x30 min	**The power and limits of the Lasserre hierarchy**, *Organizer*: Markus Schweighofer, session 9				NLP
	Standa Zivny, The power and limits of convex relaxations for general-valued CSPs	Adam Kurpisz, On the convergence of the Lasserre/SoS hierarchy for 0/1 optimization problems.	Monaldo Mastrolilli, High Degree SOS Proofs, Bienstock-Zuckerberg hierarchy and Chvatal-Gomory cuts		
Salle 05 Build Q, Z 11 1st floor 3x30 min	**Subspace methods in NLP I**, *Organizer*: Michal Kocvara, session 45				NLP
	Zaikun Zhang, A Space Transformation Framework for Nonlinear Optimization: Part I	Serge Gratton, A Space Transformation Framework for Nonlinear Optimization: Part II	Francisco Sobral, Quasi-Newton and the Unreduced Matrix in Interior Point Methods		
Salle 9 Build N, Z 12 4th floor 3x30 min	**Quadratic Optimization**, *Chair*: Anders Forsgren, session 417				NLP
	David Ek, On limited-memory quasi-Newton methods for minimizing a quadratic function	Anders Forsgren, On degeneracy in active-set methods for linear and convex quadratic programming	Fernanda Raupp, An algorithm for projecting a point onto a level set of a quadratic function		
Salle 8 Build N, Z 12 4th floor 3x30 min	**Adaptivity in non-smooth optimization**, *Organizer*: Volkan Cevher, session 187				NonSmooth
	Olivier Fercoq, Adaptive Double Loop Smoothing Algorithms	Kfir Levy, Universal Acceleration through Learning Rate Adaptation	Stephen Becker, ADMM vs gradient methods for ill-conditioned imaging problems		
Salle 20 Build G, Z 6 1st floor 3x30 min	**SDP approaches to combinatorial and global optimization problems**, *Organizer*: Etienne De Klerk, session 15				SDP
	Samuel Gutekunst, Semidefinite Programming Relaxations of the Traveling Salesman Problem	Hao Hu, On Solving the Quadratic Shortest Path Problem.	Ahmadreza Marandi, SDP relaxations of polynomial optimization problems with chordal structure		
Salle LC5 Build L, Z 10 Intermediate 1 3x30 min	**Reformulation-based solution methods for quadratic programming**, *Organizer*: Dominique Quadri, session 215				SDP
	Eric Soutil, Non-convex Quadratic Integer Programming : a piecewise linearization	Hadrien Godard, Solving Alternative Current Optimal Power Flow to global optimality	Sourour Elloumi, Preprocessing and reformulation for the Quadratic Assignment Problem		
Salle 06 Build Q, Z 11 1st floor 3x30 min	**Optimization Algorithms and Variational Inequalities II**, *Organizer*: Xiaoqi Yang, session 150				Variat
	Xiaoqi Yang, On Error Bound Moduli for Locally Lipschitz and Regular Functions	Min Li, Inexact primal-dual hybrid gradient methods for saddle-point problems	Kuang Bai, On directional pseudo/quasi-normality and directional enhanced KKT conditions		
Salle ARNOZAN Build Q, Z 8 Ground Floor 3x30 min	**Nash equilibrium and games 1**, *Organizer*: Lorenzo Lampariello, session 365				Variat
	Anna Thünen, Solving Multi-Leader-Follower Games	Jacqueline Morgan, Nash equilibrium: uniqueness and approximation via continuous optimization	Mauro Passacantando, Fixed point and extragradient algorithms for quasi-equilibria		
Salle KC6 Build K, Z 10 Intermediate 1 3x30 min	**Fast Converging Stochastic Optimization Algorithms**, *Organizer*: Francis Bach, session 213				RandomM
	Aymeric Dieuleveut, Bridging the Gap between Constant Step Size SGD and Markov Chains	Aude Genevay, Stochastic Optimization for Large Scale Optimal Transport	Robert Gower, Variance Reduced Methods via Sketching		
Salle 21 Build G, Z 6 Intermediate 3x30 min	**Surrogate-based algorithms for constrained derivative-free problems**, *Chair*: Phillipe R. Sampaio, session 126				DerFree
	Manuel Ramos-Castillo, Optimal agricultural scheduling through MINLP surrogate-based optimization	Phillipe Sampaio, A global optimization algorithm for derivative-free constrained problems	Geovani Grapiglia, Derivative-Free Trust-Region Algorithms for L1, Minimax and Bi-Objective Optimiz		
Salle AURIAC Build G, Z 6 1st floor 3x30 min	**Risk-Averse PDE-Constrained Optimization–Methods and Applications**, *Organizer*: Harbir Antil, session 222				Control
	Ruediger Schultz, Stochastic Dominance in Elastic Shape Optimization	Harbir Antil, Weighted Sobolev Spaces with Application to Image Processing	Drew Kouri, Smoothing Techniques for Risk-Averse PDE-Constrained Optimization		

Room	Specific Models, Algorithms, and Software - Wednesday 3:15 PM – 4:45 PM			
Salle DENUCE Build Q, Z 8 Ground Floor 3x30 min	**Second order methods for training ML models**, *Chair*: Julien Mairal, session 474			**Learning**
	Amir Abdessamad, Newton method with an adjusted generalized Hessian matrix for SVMs	Julien Mairal, A Variable Metric Inexact Proximal Point Algorithm for Quasi-Newton Acceleration	Robert Mohr, An Adaptive Sample Size Trust-Region Method for Empirical Risk Minimization	
FABRE Build J, Z 8 Ground Floor 3x30 min	**Convex optimization, distances and constraints**, *Chair*: Pablo A Parrilo, session 476			**Learning**
	Pavel Dvurechensky, Computational Optimal Transport: Accelerated Gradient Descent vs Sinkhorn	Pablo Parrilo, Geodesic distance maximization	Adil Salim, A Splitting Algorithm for Minimization under Stochastic Linear Constraints	
Salle 16 Build I, Z 7 2nd floor 3x30 min	**Rail and Maritime Transportation**, *Chair*: Kazuhiro Kobayashi, session 454			**Logistics**
	Kazuhiro Kobayashi, Accelerated column generation for a ship routing problem with speed optimization	Stanley Schade, Column Generation in Railway Optimization	Tatsuki Yamauchi, Optimizing Train Stopping Patterns for Congestion Management	
Salle 18 Build I, Z 7 1st floor 3x30 min	**Scheduling in Networks**, *Chair*: Hamish Waterer, session 532			**Scheduling**
	Gratien Bonvin, Global optimization for the pump scheduling problem in drinking water networks	Amadeu Coco, Addressing a scheduling problem for planned disruptions on urban road networks	Hamish Waterer, Scheduling of maintenance windows in a mining supply chain railway network	
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Conic Optimization and Power Systems**, *Organizer*: Jakub Marecek, session 68			**Energy**
	Arvind Raghunathan, Degeneracy in Chordal Decomposition of Semidefinite Programs	Jakub Marecek, When to switch from a convex relaxation to Newton's method on the non-convex POP	Konstantin Turitsyn, Convex restrictions of power flow feasibility sets	
Salle 24 Build G, Z 6 3rd floor 2x30 min	**Emerging Energy Markets**, *Organizer*: Dennice F. Gayme, session 291			**Energy**
	Maryam Kamgarpour, Designing coalition-proof mechanisms - the case of electricity markets	Sean Meyn, Irrational Agents and the Power Grid		
Salle LA4 Build L, Z 8 Basement 3x30 min	**Air Transportation and Air Traffic Management**, *Organizer*: Sonia Cafieri, session 315			**Sciences**
	Ahmed Khassiba, A two-stage stochastic model for scheduling aircraft arrivals under uncertainty	Fernando Dias, Aircraft conflict resolution and heading recovery with mixed-integer programming	Sonia Cafieri, MINLP for aircraft conflict avoidance via speed and heading angle deviations	
PITRES Build O, Z 8 Ground Floor 3x30 min	**Progress in Conic and MIP Solvers**, *Organizer*: Imre Polik, session 237			**Algo**
	Jean-Hubert Hours, Artelys Knitro 11.0, a new conic solver and other novelties	Erling Andersen, MOSEK version 9	Franz Wesselmann, Recent enhancements in MATLAB Optimization Toolbox solvers for LP and MILP	
Salle 22 Build G, Z 6 2nd floor 3x30 min	**Structure Detection in Integer Programming**, *Organizer*: Taghi Khaniyev, session 272			**Algo**
	Taghi Khaniyev, Automatic structure detection in mixed integer programs	Michael Bastubbe, Modular Detection of Model Structure in Integer Programming	Jonas Witt, A Computational Investigation on Generic Cutting Planes in Branch-Price-and-Cut	

Room	Invited Talks - Wednesday 3:15 PM – 4:45 PM			
SIGALAS Build C, Z 2 2nd floor 3x30 min	**Logistics**, *Chair*: Frieder Smolny, session 388			**INTERFACE**
	Kaj Holmberg, Using OpenStreetMap data for route optimization: extraction and reduction	Gwénaël Rault, Modeling the Periodic Vehicle Routing Problem in an industrial context	Frieder Smolny, Multiscale optimization of logistics networks	

Room	Discrete Optimization & Integer Programming - Wednesday 5:00 PM – 6:30 PM			
Salle 43 Build C, Z 1 3rd floor 2x30 min	**IP-Formulations**, *Chair*: Temitayo Ajayi, session 516			**IPtheory**
	Wolfgang Riedl, The quadratic assignment problem: a comparison of two linearizations	Temitayo Ajayi, Assessing Parametrized Linear Programming Relaxations With Superadditive Duality		
Salle 44 Build C, Z 1 3rd floor 3x30 min	**Exact Approaches for Vehicle Routing and Variants**, *Organizer*: Ricardo Fukasawa, session 288			**IPpractice**
	Ricardo Fukasawa, The Capacitated Vehicle Routing Problem with Stochastic Demands	Claudio Contardo, Efficient metaheuristic pricing in vehicle routing	Rafael Martinelli, Exact Solution of a Class of Vehicle Scheduling Problems	
DURKHEIM Build A, Z 1 3rd floor 3x30 min	**MINLP (III)**, *Organizer*: Daniel Bienstock, session 67			**MINLP**
	Alberto Del Pia, Cardinality-constrained linear regression with sparse matrices	Guanyi Wang, Computational evaluation of new dual bounding techniques for sparse PCA	Jeff Linderoth, Cutting Planes for Linear Programs with Complementarity Constraints	
Salle 34 Build B, Z 3 1st floor 3x30 min	**Robust Approaches for Challenging Uncertain Optimization Problems**, *Organizer*: Frauke Liers, session 124			**MINLP**
	Timo Gersing, A New Approach for Extending Cover Inequalities for the Robust Knapsack Polytope	Andreas Schmitt, An Interdiction Approach for the Design of High-Rise Water Supply Systems	Sebastian Tschuppik, Robust optimization with selected scenarios	
Salle 35 Build B, Z 4 Intermediate 3x30 min	**Advances in MINLP**, *Organizer*: Laura Palagi, session 165			**MINLP**
	Marianna De Santis, An Active Set Algorithm for Robust Combinatorial Optimization	Veronica Piccialli, Membrane System Design Optimization	Emiliano Traversi, Dantzig Wolfe Decomposition for Binary Quadratic Programming	
LEYTEIRE Build E, Z 1 3rd floor 3x30 min	**Approximation Algorithms for Geometric Packing Problems**, *Organizer*: Fabrizio Grandoni, session 28			**APPROX**
	Fabrizio Grandoni, Approximating Geometric Knapsack via L-Packings	Andreas Wiese, Parameterized (1+eps)-approximation algorithms for packing problems	Klaus Jansen, Closing the gap for pseudo-polynomial strip packing	
Salle 36 Build B, Z 4 Intermediate 3x30 min	**Online Optimization**, *Organizer*: Kevin Schewior, session 35			**APPROX**
	Victor Verdugo, How large is your graph?	Andreas Tönnis, Submodular Secretary Problems: Cardinality, Matching, and Linear Constraints	Kevin Schewior, Tight Competitive Analysis for Online TSP on the Line	
Salle 41 Build C, Z 1 3rd floor 4x20 min	**Connectivity problems and Steiner trees**, *Chair*: Andreas E Feldmann, session 421			**COMB**
	Marcus Brazil, Computing minimum 2-connected Steiner networks in the Euclidean plane	Yasuko Matsui, Enumerating All Spanning Subgraphs with Edge-Connectivity at Least k	Mark Turner, The variable-cost node-weighted Steiner tree problem in the Euclidean plane.	Andreas Feldmann, Parameterized Approximation Algorithms for Bidirected Steiner Network Problems
Salle 39 Build E, Z 1 3rd floor 4x20 min	**Shortest paths and cutting stock**, *Chair*: Arnaud Vandaele, session 426			**COMB**
	Pedro de las Casas, Cost Projection Methods for the Shortest Path Problem with Crossing Costs	Adam Schienle, Solving the Time-Dependent Shortest Path Problem using Super-Optimal Wind	Miriam Schlöter, Earliest Arrival Transshipments in Networks With Multiple Sinks	Arnaud Vandaele, One-dimensional cutting stock instances for which few patterns are needed

Room	Optimization under Uncertainty - Wednesday 5:00 PM – 6:30 PM			
DENIGES Build C, Z 5 Ground Floor 3x30 min	**Stochastic Programming and Distributionally Robust Optimization Models with Endogenous Uncertainty**, *Organizer*: Miguel Lejeune, session 248 (Stoch)			
	Nilay Noyan, Distributionally Robust Optimization with Decision-Dependent Ambiguity Set	Kartikey Sharma, Optimization Under Decision-dependent Uncertainty	Miguel Lejeune, Chance-Constrained Optimization Models with Endogenous and Exogenous Uncertainty	
Salle 32 Build B, Z 5 Ground Floor 4x20 min	**Stochastic optimization models and applications**, *Chair*: F.-Javier Heredia, session 495 (Stoch)			
	Geoffrey Oxberry, Design optimization under uncertainty	Gislaine Pericaro, Optimal non-anticipative scenarios for nonlinear hydrothermal power systems	Alexander Vinel, A Generalized Risk Parity Model with Application for Hazmat Transportation	F.-Javier Heredia, A multistage stochastic programming model for the optimal bid of a wind producer
Salle 37 Build B, Z 4 Intermediate 2x30 min	**Robust Adaptive Control and Learning**, *Organizer*: Siqian Shen, session 97 (Robust)			
	Siqian Shen, Distributionally Robust Adaptive Control under Nonstationary Uncertainty	Lauren Steimle, Leveraging stochastic programming to design robust policies for Markov decision		
Salle 33 Build B, Z 5 Ground Floor 4x20 min	**Robust combinatorial optimization III**, *Organizer*: Moritz Mühlenthaler, session 255 (Robust)			
	Moritz Mühlenthaler, Robust Matching Augmentation	Viktor Bindewald, Solving Bulk-Robust Assignment Problems to Optimality	Felix Hommelsheim, Assignment Problems with few Failure Resources	Jaehyeon Ryu, Distributionally Robust Chance-Constrained Binary Knapsack Problem
Salle 30 Build B, Z 5 Ground Floor 3x30 min	**Aspects of Multiobjective Combinatorial Optimization**, *Organizer*: Matthias Ehrgott, session 87 (Game)			
	Serpil Sayin, Generating Representative Sets for Multiobjective Discrete Optimization Problems	Kim Andersen, A multi-objective approach to sensitivity analysis of MILP	Fritz Bökler, Approximating the Multi-objective Shortest Path Problem in Practice	

Room	Continuous Optimization - Wednesday 5:00 PM – 6:30 PM			
GINTRAC Build Q, Z 8 Ground Floor 3x30 min	**Software for Nonlinear Optimization**, *Organizer*: Sven Leyffer, session 133 (NLP)			
	Charlie Vanaret, Argonot: An Open-Source Software Framework for Nonlinear Optimization	Philip Gill, A Primal-Dual Shifted Barrier Method for Nonlinear Optimization	Elizabeth Wong, L-RH-B: Software for Large-Scale Bound-Constrained Optimization	
Salle 05 Build Q, Z 11 1st floor 3x30 min	**Conjugate Gradient Methods**, *Chair*: Giovanni Fasano, session 362 (NLP)			
	Mehiddin Al-Baali, A New Diagonalizable Conjugate Gradient Method for Unconstrained Optimization	Giovanni Fasano, Conjugate Direction Methods and Polarity for Quadratic Hypersurfaces	Luis Lucambio Perez, Non-linear conjugate gradient for vector optimization on Riemannian manifolds	
Salle 9 Build N, Z 12 4th floor 3x30 min	**Linear Optimization II**, *Chair*: Julian Hall, session 416 (NLP)			
	Julian Hall, Starting the dual revised simplex method from an advanced basis	Masaya Tano, On the number of simplex iterations of the steepest-edge for a nondegenerate LP	Marina Epelman, New Results on the Simplex Method for Minimum Cost Flows in Infinite Networks	
Salle ARNOZAN Build Q, Z 8 Ground Floor 3x30 min	**Interior Point Methods in LP and NLP**, *Chair*: Andre L Tits, session 430 (NLP)			
	Andre Tits, Constraint-Reduced MPC for CQP, with a Modified Active Set Identification Scheme	Thiane Coliboro, An IPM approach for a time dependent large-scale assortment allocation problem	Ngoc Nguyen Tran, Local analysis of a primal-dual method for NLP without constraint qualification	
Salle 8 Build N, Z 12 4th floor 3x30 min	**Methods and Analysis for Nonsmooth Optimization**, *Organizer*: Michael L Overton, session 86 (NonSmooth)			
	Michael Overton, Partial Smoothness of the Numerical Radius	Adrian Lewis, Partial smoothness and active sets: a fresh approach	Dmitriy Drusvyatskiy, Subgradient methods for sharp weakly convex problems	
Salle 20 Build G, Z 6 1st floor 3x30 min	**Noncommutative polynomial optimization: semidefinite relaxations, free convexity and applications to quantum information I**, *Organizer*: Monique Laurent, session 20 (SDP)			
	Markus Schweighofer, Inclusion of spectrahedra, free spectrahedra and coin tossing	Tom-Lukas Kriel, Matrix convex sets and matrix extreme points	Janez Povh, Extracting optimisers by non-commutative GNS construction is robust	
Salle LC5 Build L, Z 10 Intermediate 1 4x20 min	**Completely Positive Cones and Applications**, *Chair*: Patrick Groetzner, session 464 (SDP)			
	Muhammad Iqbal, Approximation Hierarchies for Copositive and Completely Positive Tensor Cones	Mina Saee Bostanabad, Inner approximating the completely positive cone via the cone of SDD matrices	Ellen Fukuda, Solving nonlinear conic programming problems with a new DC approach	Patrick Groetzner, A method to compute factorizations for completely positive matrices
Salle 06 Build Q, Z 11 1st floor 3x30 min	**Complementarity Problems**, *Organizer*: Samir K. Neogy, session 173 (Variat)			
	Muddappa Gowda, Weakly homogeneous variational inequalities	Samir Neogy, On testing matrices with nonnegative principal minors	Dipti Dubey, Total Dual Integrality and Integral Solutions of Linear Complementarity Problem	
Salle KC6 Build K, Z 10 Intermediate 1 4x20 min	**Non-Convex and Second-order Methods in Machine Learning**, *Organizer*: Martin Takac, session 33 (RandomM)			
	Aurelien Lucchi, Escaping Saddles with Stochastic Algorithms	Reza Babanezhad, Convergence Rate of Expectation-Maximization	Francesco Orabona, Parameter-free nonsmooth convex stochastic optimization through coin betting	Martin Takac, SGD and Hogwild! Convergence Without the Bounded Gradients Assumption
Salle 21 Build G, Z 6 Intermediate 3x30 min	**Progress in methods and theory of derivative-free optimization**, *Chair*: Serge Gratton, session 42 (DerFree)			
	Charles Audet, Mesh-based Nelder-Mead algorithm for inequality constrained optimization	Jeffrey Larson, Manifold Sampling for Nonconvex Optimization of Piecewise Linear Compositions	Morteza Kimiaei, Competitive derivative-free optimization with optimal complexity	
Salle AURIAC Build G, Z 6 1st floor 4x20 min	**Advances in optimization methods for time dependent problems II**, *Organizer*: Denis Ridzal, session 225 (Control)			
	Stefan Ulbrich, Preconditioners for unsteady PDE-constrained optimization and parallel variants	Sebastian Goetschel, Parallel-in-time PDE-constrained optimization using PFASST	Andreas Potschka, Direct Multiple Shooting for parabolic PDE constrained optimization	Denis Ridzal, Multigrid-in-time methods for optimization with nonlinear PDE/DAE constraints

Room	Specific Models, Algorithms, and Software - Wednesday 5:00 PM – 6:30 PM			
FABRE Build J, Z 8 Ground Floor 3x30 min	**Problems in the intersection of machine learning and optimization**, *Chair*: Ross M Anderson, session 328			**Learning**
	Brandon Amos, OptNet: End-to-End Differentiable Constrained Optimization	Ross Anderson, Solving argmax for a neural network with MIP, and related optimization problems	Vinod Nair, Learning Fast Optimizers for Contextual Stochastic Integer Programs	
Salle 22 Build G, Z 6 2nd floor 2x20 min	**Large-scale convex optimization**, *Chair*: Alexander V. Rogozin, session 479			**Learning**
	Alexander Rogozin, Optimal distributed convex optimization on slowly time-varying graphs	Tommaso Colombo, Leverage data structure to improve Stochastic Gradient Descent algorithm		
Salle 24 Build G, Z 6 3rd floor 4x20 min	**Location and Routing**, *Chair*: Mustapha Oudani, session 451			**Logistics**
	Imen Ben Mohamed, Stochastic Two-echelon Location-Routing	Rasul Esmaeilbeigi, Benders decomposition for a hierarchical facility location problem	Nicolas Kämmerling, Benders Decomposition for Uncertain Hub Location with Variable Allocation	Mustapha Oudani, The Incomplete Hub Location and Routing Problem
Salle 16 Build I, Z 7 2nd floor 3x20 min	**Production-Routing**, *Chair*: Feng Gao, session 456			**Logistics**
	Feng Gao, Models and Algorithms for Robust Production Routing Under Demand Uncertainty	Saranthorn Phusingha, Meta-Heuristics for Multi-Period Sales Districting Problem	Yuzhuo Qiu, Models and Algorithms for Stochastic and Robust Production Routing with Time Win	
Salle 18 Build I, Z 7 1st floor 3x20 min	**Machine Scheduling 2**, *Chair*: Guopeng Song, session 529			**Scheduling**
	Cristiane Ferreira, Human-Robot Scheduling in Collaborative Environments	Margaux Nattaf, Parallel machine scheduling with time constraints on machine qualifications	Guopeng Song, The robust machine availability problem	
Salle DENUCE Build Q, Z 8 Ground Floor 4x20 min	**Optimization and modeling of integrated energy systems**, *Organizer*: Jalal Kazempour, session 71			**Energy**
	Stefanos Delikaraoglou, Market-based valuation of natural gas network flexibility	Ibrahim Abada, Unintended consequences: The snowball effect of energy communities	Lesia Mitridati, Coordination of Heat and Electricity Systems via Market-Based Mechanisms	Anna Schwele, Virtual bidders and self-schedulers in electricity and natural gas markets
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Energy Market Models**, *Chair*: Sauleh A Siddiqui, session 522			**Energy**
	Thomas Kleinert, Global Optimization of Multilevel Electricity Market Models	Emre Celebi, Co-optimization Models with Market-Clearing Equilibrium: A Robust Approach	Sauleh Siddiqui, Solving Problems with Equilibrium Constraints Applied to Energy Markets	
Salle LA4 Build L, Z 8 Basement 3x30 min	**Resource-constrained assignment and scheduling**, *Organizer*: Fabian Bastin, session 398			**Sciences**
	Giorgio Sartor, A novel formulation for job-shop scheduling in traffic management	Vipin Vijayalakshmi, Improving local search for distributed resource allocation and equilibrium.	Fabian Bastin, A learning-based approach for multi-skill staffing optimization in call centers	
PITRES Build O, Z 8 Ground Floor 3x30 min	**Progress in MIP Solvers II**, *Organizer*: Hans Mittelmann, session 234			**Algo**
	Andrea Tramontani, Benders Decomposition in IBM CPLEX	Michael Winkler, Gurobi 8.0 - What's new	Michael Perregaard, Recent Progress in the Xpress Solvers	

Room	Invited Talks - Wednesday 5:00 PM – 6:30 PM			
SIGALAS Build C, Z 2 2nd floor 4x20 min	**Solvers and softwares**, *Chair*: François Clautiaux, session 390			**INTERFACE**
	Julien Darlay, Solving packing, routing and scheduling problems using LocalSolver	Pawel Lichocki, Applied mixed integer programming: The why and how	Robert Luce, Solving MIPs with Gurobi Instant Cloud	Johannes Müller, Creating an optimization web app with FICO Xpress

Room	Discrete Optimization & Integer Programming - Thursday 8:30 AM – 10:30 AM			
Salle 34 Build B, Z 3 1st floor 4x30 min	**Integer linear programming, convex geometry, and lattices** , *Organizer*: Sinai Robins, session 142 **IPtheory**			
	Achill Schürmann, Exploiting Linear Symmetries in Integer Convex Optimization	Matthias Schymura, On the reverse isodiametric problem	Kevin Woods, The Complexity of Presburger Arithmetic in Fixed Dimension	Sinai Robins, Fourier transforms of polytopes, solid angle sums, and discrete volumes
Salle 35 Build B, Z 4 Intermediate 4x30 min	**Convexity and Polytopes**, *Chair*: David Warme, session 518 **IPtheory**			
	Emiliano Lancini, Box-Total Dual Integrality and k-Edge-Connectivity	Tamon Stephen, On the Circuit Diameter Conjecture	Filipe Cabral, The role of extreme points for convex hull operations.	David Warme, Metrics for Strength of Inequalities with Respect to a Polytope
Salle 44 Build C, Z 1 3rd floor 4x30 min	**Advanced Linear(ized) MIP Formulations for Zero-One Programs**, *Organizer*: Sven Mallach, session 127 **IPpractice**			
	Leon Eifler, Mixed-Integer Programming for Clustering in Non-reversible Markov Processes	Adalat Jabrayilov, A new ILP for the Steiner Tree Problem with Revenues, Budget and Hop Constraints	Daniel Schmidt, An extended formulation for the Steiner Forest Problem	Sven Mallach, Compact Linearization for Zero-One Quadratic Programs
LEYTEIRE Build E, Z 1 3rd floor 4x30 min	**Submodular Maximization**, *Organizer*: Moran Feldman, session 29 **APPROX**			
	Moran Feldman, Deterministic and Combinatorial Algorithms for Submodular Maximization	Baruch Schieber, Constrained Submodular Maximization via Greedy Local Search	Simon Bruggmann, Submodular Maximization through the Lens of Linear Programming	Niv Buchbinder, Constrained Submodular Maximization via a Non-symmetric Technique
Salle 43 Build C, Z 1 3rd floor 4x30 min	**Cycles and Trees**, *Organizer*: Tobias Mömke, session 90 **APPROX**			
	Alantha Newman, Coloring and Dominating Set on Digraphs with Bounded Independence Number	Antonios Antoniadis, A PTAS for TSP with Hyperplane Neighborhoods	László Kozma, Maximum Scatter TSP in doubling metrics	Ralf Klasing, Approximabilty of Hub Allocation Problems
Salle 36 Build B, Z 4 Intermediate 4x30 min	**Bin Packing**, *Chair*: Frits CR Spieksma, session 344 **APPROX**			
	Nadia Brauner, Automatically computed bounds for the online bin stretching problem	Leah Epstein, Batched bin packing	Shlomo Karhi, Online Packing of Arbitrary Size Items into Designated and Multipurpose Bins	Frits Spieksma, Partitioning Vectors into Quadruples
Salle 41 Build C, Z 1 3rd floor 4x30 min	**Graphs and clutters**, *Organizer*: Gerard Cornuejols, session 263 **COMB**			
	Guoli Ding, Packing cycles in a tournament	Sharat Ibrahimpur, Min-Max Theorems for Packing and Covering Odd (u,v)-trails	Ahmad Abdi, Cuboids, a class of clutters	Dabeen Lee, Deltas, extended odd holes and their blockers
Salle 39 Build E, Z 1 3rd floor 4x30 min	**Graph theory**, *Chair*: Thomas Bellitto, session 422 **COMB**			
	Isabel Beckenbach, A Tight Cut Decomposition for Hypergraphs with Perfect Matchings	Xujin Chen, Densities, Matchings, and Fractional Edge-Colorings	Yutaro Yamaguchi, Making Bipartite Graphs DM-irreducible	Thomas Bellitto, Optimal weighting to minimize the independence ratio of a graph
DURKHEIM Build A, Z 1 3rd floor 4x30 min	**Parallel Computing and Sustainability**, *Organizer*: Bistra Dilkina, session 296 **CP**			
	Fei Fang, Designing the game to play in security and sustainability domains	Nahid Jafari, A Robust Optimization Model for an Invasive Species Management Problem	Salvador Abreu, Parallel HYbridization for Simple Heuristics	Ciaran McCreesh, Parallel Search, Ordering, Reproducibility, and Scalability
Salle 47 Build A, Z 1 3rd floor 4x30 min	**Performance Analysis**, *Organizer*: Charlotte Truchet, session 298 **CP**			
	Lars Kotthoff, The Shapley Value and the Temporal Shapley Value for Algorithm Analysis	Guilhem Semerjian, Phase transitions in random constraint satisfaction problems	Charlotte Truchet, A probabilistic study of the propagation of the AllDifferent constraint	Alexander Tesch, Improving Energetic Propagations for Cumulative Scheduling

Room	Optimization under Uncertainty - Thursday 8:30 AM – 10:30 AM			
DENIGES Build C, Z 5 Ground Floor 4x30 min	**New results in chance-constrained optimization**, *Chair*: Bismark Singh, session 489 **Stoch**			
	Abebe Geletu, Smoothing Methods for Chance Constrained Optimization of Elliptic PDE Systems	René Henrion, Dynamic chance constraints under random distributiond	Armin Hoffmann, Differentiabilty of joint chance constraints under weakened LICQ	Bismark Singh, Approximating Chance Constrained Programs using Classical Inequalities
Salle 32 Build B, Z 5 Ground Floor 4x30 min	**Topics in multistage and integer stochastic optimization**, *Organizer*: Jim Luedtke, session 490 **Stoch**			
	Ozge Safak, Three-Stage Stochastic Airline Scheduling Problem	Mehdi Karimi-Nasab, State space analysis of a stochastic DP to deal with curse of dimensionality	Cong Han Lim, Partitioned Subgradient Methods for Stochastic Mixed Integer Program duals	Jim Luedtke, Lagrangian dual decision rules for multistage stochastic integer programs
Salle 37 Build B, Z 4 Intermediate 4x30 min	**K-adaptability**, *Organizer*: Anirudh Subramanyam, session 1 **Robust**			
	Jannis Kurtz, Min-max-min Robust Optimization for the Capacitated Vehicle Routing Problem	Michael Poss, Min-Max-Min Robustness for Combinatorial Problems with Budgeted Uncertainty	Jonas Pruente, K-Adaptibility in Stochastic Programming	Anirudh Subramanyam, K-Adaptability in Two-Stage Mixed-Integer Robust Optimization
Salle 33 Build B, Z 5 Ground Floor 3x30 min	**New applications of robust optimizations**, *Chair*: Mirjam Duer, session 461 **Robust**			
		Jorge Vera, Condition and geometric measures for consistency in intertemporal optimization	Alec Koppel, Compositional Stochastic Optimization with Kernels for Robust Online Learning	Mirjam Duer, Robust Approach for Stratified Sampling Allocation Problems
Salle 30 Build B, Z 5 Ground Floor 4x30 min	**Stackelberg Games**, *Chair*: Stefano Coniglio, session 374 **Game**			
	Jean-Bernard Eytard, Tropical geometry applied to bilevel programming	Stefan Waldherr, Bilevel Programming for Combinatorial Exchanges with Budget Constraints	Stefano Coniglio, Computing Pessimistic Leader-Follower Equilibria with Multiple Followers	Francesco Caruso, A learning approach for selection of subgame perfect Nash equilibria

Room	Continuous Optimization - Thursday 8:30 AM – 10:30 AM			
Salle ARNOZAN Build Q, Z 8 Ground Floor 4x30 min	**First-order methods: advances and applications**, *Organizer*: Immanuel M. Bomze, session 3			NLP
	Axel Boehm, Incremental mirror descent with random sweeping and a proximal step	Immanuel Bomze, Active-set identification in Frank-Wolfe variants on the standard simplex	Michael Kahr, Robust StQP, first-order methods, and applications in social network analysis	Mathias Staudigl, On the convergence of projection free Hessian Barrier-Gradient Algorithms
GINTRAC Build Q, Z 8 Ground Floor 4x30 min	**Recent advances in interior point methods and NLP**, *Organizer*: Michael Todd, session 77			NLP
	Michael Todd, The ellipsoid method redux	E. Alper Yildirim, MILP Formulations for Globally Solving Nonconvex Standard Quadratic Programs	Yinyu Ye, A One-phase Interior Point Method For Nonconvex Optimization	Oliver Hinder, A polynomial time interior point method for problems with nonconvex constraints
Salle 05 Build Q, Z 11 1st floor 4x30 min	**Machine learning for optimisation**, *Organizer*: Coralia Cartis, session 176			NLP
	Adilet Otemissov, Dimensionality reduction for global optimisation: adaptive random embeddings	Coralia Cartis, Stochastic trust-region with global rate to second-order criticality	Radu Baltean-Lugojan, Online generation via offline selection of strong linear cuts from QP SDP relax.	Boris Houska, Global optimization in Hilbert Space
Salle KC7 Build K, Z 10 Intermediate 2 4x30 min	**First Order Methods I**, *Chair*: Sandra A. Santos, session 436			NLP
	Sandra Santos, Accelerating block coordinate descent methods with identification strategies	Francesco Locatello, On Matching Pursuit and Coordinate Descent	Tianyi Lin, A Unified Scheme to Accelerate Adaptive Cubic Regularization and Gradient Method	Felix Lieder, Performance Estimation for Fixed Point Iterations
Salle LC4 Build L, Z 9 Intermediate 1 4x30 min	**Universal methods in non-smooth analysis**, *Organizer*: Alexander Gasnikov, session 53			NonSmooth
	Alexander Tyurin, Universal Nesterov's gradient method in general model conception	Sergey Guminov, Dual universal conjugate gradient type methods.	Alexander Tytov, Universal Proximal Method for Variational Inequalities	Dmitry Kamzolov, Universal Intermediate Gradient Method for Convex Problems with Inexact Oracle
Salle 8 Build N, Z 12 4th floor 4x30 min	**First-order methods for nonconvex and pathological convex problems**, *Organizer*: Wotao Yin, session 183			NonSmooth
	Mila Nikolova, Alternating structure-adapted proximal gradient descent for nonconvex problems	Wenbo Gao, ADMM for Multiaffine Constrained Optimization	Ernest Ryu, Douglas-Rachford Splitting for Pathological Convex Optimization	Wotao Yin, Polynomial-Time Run-and-Inspect Method for Certain Nonconvex Optimization
Salle 9 Build N, Z 12 4th floor 4x30 min	**Non smooth optimization for lage scale poblems**, *Organizer*: Yu Du, session 556			NonSmooth
	Yu Du, Selective Linearization for Multi-block Statistical Learning Problems	Dmitry Grishchenko, Randomized Proximal Algorithm with Automatic Dimension Reduction.	Shummin Nakayama, Inexact proximal memoryless spectral-scaling MBFGS method	Min Tao, Decomposition methods for computing d-stationary solutions for nonconvex problem
Salle 20 Build G, Z 6 1st floor 4x30 min	**Computer-assisted analyses of optimization algorithms I**, *Organizer*: Adrien Taylor, session 19			SDP
	Yoel Drori, Efficient First-order Methods for Convex Minimization: A Constructive Approach	Donghwan Kim, Optimized first-order method for decreasing gradient of smooth convex functions	Bryan Van Scoy, The Fastest Known First-Order Method for Smooth Strongly Convex Minimization	Laurent Lessard, Analysis of First-Order Algorithms for Distributed Optimization
Salle LC5 Build L, Z 10 Intermediate 1 4x30 min	**Geometry and duality in convex optimization**, *Organizer*: Javier F Pena, session 160			SDP
	David Gutman, Condition Numbers for Convex Functions with Polytope Domains	Javier Pena, Conditioning of conic systems via the Grassmannian manifold	Jourdain Lamperski, Solving linear inequalities via non-convex optimization	Gabor Pataki, On positive duality gaps in semidefinite programming
Salle 06 Build Q, Z 11 1st floor 4x30 min	**Nonlinear Optimization and Variational Inequalities I**, *Organizer*: Xin Liu, session 140			Variat
	Yaxiang Yuan, Theory and Applicaiton of p-regularized subproblem with $p > 2$	Jinyan Fan, A semidefinite relaxation algorithm for polynomial equations	Cong Sun, On a special robust optimization problem	Liang Zhao, Limited memory algorithms with cubic regularization
Salle KC6 Build K, Z 10 Intermediate 1 4x30 min	**Recent Advances on Stochastic Algorithms and Machine Learning**, *Organizer*: Shiqian Ma, session 202			RandomM
	Qihang Lin, Level-Set Methods for Finite-Sum Constrained Convex Optimization	Xudong Li, Estimation of Markov Chain via Rank-constrained Likelihood	Guanghui Lan, Random gradient extrapolation for distributed and stochastic optimization	Renbo Zhao, An Accelerated Algorithm for Stochastic Three-composite Optimization
Salle 21 Build G, Z 6 Intermediate 4x30 min	**Bayesian and Randomized Optimization I**, *Chair*: Stefan M Wild, session 39			DerFree
	Mickael Binois, Improving Bayesian optimization via random embeddings	Saul Toscano-Palmerin, Bayesian Optimization of Expensive Integrands	Clément Royer, Using Models in Allocate and Partition Algorithms	Youssef Diouane, A Rigorous Framework for Efficient Global Optimization
Salle AURIAC Build G, Z 6 1st floor 4x30 min	**Optimal Control of Variational Inequalities and Complementarity Systems**, *Chair*: Alexandre Vieira, session 336			Control
	Alexandre Vieira, Optimal control of Linear Complementarity Systems	Anne-Therese Rauls, Computing a Subgradient for the Solution Operator of the Obstacle Problem	Ailyn Stötzner, Optimal Control of Thermoviscoplasticity	Anna Walter, Optimal Control of Elastoplasticity Problems with Finite Deformations

Room	Specific Models, Algorithms, and Software - Thursday 8:30 AM – 10:30 AM			
FABRE Build J, Z 8 Ground Floor 4x30 min	**First-order methods for large-scale convex problems**, *Organizer*: Stephen A Vavasis, session 316 — **Learning**			
	Stephen Vavasis, A single potential governing convergence of CG, AG and Geometric Descent	Mert Gurbuzbalaban, Robust Accelerated Gradient Method	Peter Richtarik, Randomized methods for convex feasibility problems and applications to ML	Yaoliang Yu, Bregman Divergence for Stochastic Variance Reduction
Salle DENUCE Build Q, Z 8 Ground Floor 4x30 min	**Large-scale learning**, *Organizer*: Lorenzo Rosasco, session 335 — **Learning**			
	Mikhail Belkin, The power of interpolation: on the effectiveness of SGD in modern learning	Chris Re, Precision on the Brain: Low-Precision to High-Precision for Machine Learning	Gergely Neu, Iterate averaging as regularization for stochastic gradient descent	Lorenzo Rosasco, Convergence vs stability: a regularization view on accelerated methods
Salle 16 Build I, Z 7 2nd floor 4x30 min	**Dynamical systems, control and optimization**, *Chair*: Benjamin Recht, session 470 — **Learning**			
	Fredrik Bagge Carlson, Tangent Space Regularization for Neural-Networks Models of Dynamical Systems	Benjamin Recht, The sample complexity of iteratively learning to control	Nikolai Matni, Optimization-based adaptive control using a system level approach.	Ashia Wilson, Lyapunov arguments in optimization
Salle LA4 Build L, Z 8 Basement 4x30 min	**Multi-commodity flows**, *Organizer*: Ralf Borndörfer, session 358 — **Network**			
	Daniel Granot, Monotonicity and conformality in multicommodity network-flow problems	Eduardo Moreno, An exact method based on adaptive partitions for the Stochastic Fixed-Charge MCF	Stefano Gualandi, Approximate Wasserstein Distances of order 1 between images	Ralf Borndörfer, Metric Inequalities for Routings on Direct Connections in Line Planning
PITRES Build O, Z 8 Ground Floor 3x30 min	**Vehicle Routing I**, *Chair*: Guy Desaulniers, session 411 — **Logistics**			
		Guy Desaulniers, The vehicle routing problem with stochastic and correlated travel times	Bolor Jargalsaikhan, An exact formulation for pickup and delivery problem with divisible split-ups	Mathias Klapp, Branch-and-Price for Probabilistic Vehicle Routing
Salle 23 Build G, Z 6 3rd floor 4x30 min	**Unit Commitment Problem and Applications**, *Organizer*: Tiziano Parriani, session 94 — **Energy**			
	Allegra De Filippo, Off-line/on-line optimization under uncertainty on energy management	Dimitri Thomopulos, A Constrained Shortest Path formulation for the Hydro Unit Commitment Problem	Rafael Lobato, Stochastic Hydrothermal Unit Commitment via Multi-level Scenario Trees	Tiziano Parriani, CHP Systems Optimization in Presence of Time Binding Constraints
Salle 24 Build G, Z 6 3rd floor 4x30 min	**Mining Applications**, *Organizer*: Alexandra M Newman, session 172 — **Energy**			
	Marcos Goycoolea, Lane's Algorithm Revisited	Peter Malkin, A MILP-based approach for loader assignment in open pit scheduling	Levente Sipeki, Optimal Selection of Support Pillars in an Underground Mine	Alexandra Newman, Mathematical Methods for Complex Underground Design and Scheduling Problems
Salle 22 Build G, Z 6 2nd floor 4x30 min	**Numerically Efficient Methods for Piecewise Algorithmic Differentiation II**, *Organizer*: Torsten F Bosse, session 270 — **Algo**			
	Laurent Hascoet, Pushing the Algorithmic Differentiation tool Tapenade towards new languages	Peter Stechlinski, Generalized Sensitivity Analysis of Nonlinear Programs	Kamil Khan, Evaluating generalized derivatives efficiently for nonsmooth composite functions	Lisa Hegerhorst, Optimality Conditions for Nonsmooth Constrained Optimization Problems
Salle 18 Build I, Z 7 1st floor 3x30 min	**High-Performance Computing in Optimization I**, *Organizer*: Kibaek Kim, session 271 — **Algo**			
		Ted Ralphs, Performance Assessment for Parallel MILP Solvers	Yuji Shinano, Ubiquity Generator Framework to parallelize state-of-the-art B and B based solvers	Kibaek Kim, Branching Strategies on Decomposition Methods for Mixed-Integer Programming

Room	Invited Talks - Thursday 8:30 AM – 10:30 AM			
SIGALAS Build C, Z 2 2nd floor 4x30 min	**Energy**, *Chair*: Kazem Abbaszadeh, session 387 — **INTERFACE**			
	Rishi Adiga, Optimization Models for Geothermal Energy	Rodolphe Griset, Static robustness for EDF nuclear long term production planning	Gabriela Maschietto, Optimization of district heating production operations	Mahbubeh Habibian, Demand and reserve co-optimization for a price-making consumer of electricity

Room	Invited Talks - Thursday 11:00 AM – 12:00 AM			
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**The BARON software for MINLP**, *Organizer*: Claudia D Ambrosio, session 547 — **SEMI**			
	Nikolaos Sahinidis, The BARON software for MINLP			
BROCA Build W, Z 0 3rd floor 1x60 min	**Cutting Planes in the Extended Space**, *Organizer*: Adam N Letchford, session 543 — **KEYNOTE**			
	Oktay Gunluk, Cutting Planes in the Extended Space			
DENIGES Build C, Z 5 Ground Floor 1x60 min	**Effective Scenarios and Scenario Reduction for Risk-Averse Stochastic Programs**, *Organizer*: Jim Luedtke, session 544 — **KEYNOTE**			
	Tito Homem-de-Mello, Effective Scenarios and Scenario Reduction for Risk-Averse Stochastic Programs			

Room	Invited Talks - Thursday 1:30 PM – 2:30 PM			
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**Randomness, risk and electricity prices**, *Organizer*: Michael C Ferris, session 554 — **PLENARY**			
	Andy Philpott, Randomness, risk and electricity prices			

Discrete Optimization & Integer Programming - Thursday 3:15 PM – 4:45 PM

Room	Session				Track
Salle 42 Build C, Z 1 3rd floor 3x30 min	**Non-Standard IP Methods**, *Chair*: Ulf Friedrich, session 513 Tri-Dung Nguyen, Algebraic Geometry and Integer Programmings in Cooperative Game Theory	Wolfgang Keller, A hierarchy of cutting plane operators based on lineality spaces	Ulf Friedrich, A power series algorithm for non-negative IP		IPtheory
Salle 43 Build C, Z 1 3rd floor 3x30 min	**Polynomial Time Solvable Problems and Complete Descriptions**, *Chair*: Andreas Bärmann, session 520 A-E Falq, Extreme points for scheduling around a common due date	Lars Rohwedder, On Integer Programming and Convolution	Andreas Bärmann, The Clique Problem with Multiple-Choice Constraints and Two Polynomial Subcases		IPtheory
Salle 44 Build C, Z 1 3rd floor 3x30 min	**Computational Issues in Integer Programming**, *Organizer*: Ricardo Fukasawa, session 289 Laurent Poirrier, Implementation and performance of the simplex method	Giulia Zarpellon, Learning MILP resolution outcomes before reaching time-limit	Aleksandr Kazachkov, Computational Results with V-Polyhedral Cuts and Strengthening Approaches		IPpractice
Salle 39 Build E, Z 1 3rd floor 3x30 min	**Convexification and more (I)**, *Organizer*: Jon Lee, session 62 Marcia Fampa, Treating indefinite quadratic and bilinear forms in MINLP	Amélie Lambert, Valid inequalities for QCQPs	Luze Xu, More Virtuous Smoothing		MINLP
Salle 34 Build B, Z 3 1st floor 3x30 min	**Heuristics in MINLP**, *Chair*: Bertrand Travacca, session 276 João Lauro Faco', MINLP solutions using a Generalized-GRASP solver	Christoph Neumann, Feasible rounding ideas for mixed-integer optimization problems	Bertrand Travacca, Dual Hopfield Models for Large Scale Mixed Integer Programming		MINLP
Salle 35 Build B, Z 4 Intermediate 3x30 min	**MINLP with quadratic terms**, *Chair*: Enrico Bettiol, session 282 Fabricio Oliveira, The p-Lagrangian method for MIQCQPs	Etienne Leclercq, A dedicated version of BiqCrunch for solving the Max-Stable Set problem exactly	Enrico Bettiol, Simplicial Decomposition for quadratic convex 0-1 problems		MINLP
LEYTEIRE Build E, Z 1 3rd floor 3x30 min	**Approximation Algorithms for Clustering.**, *Organizer*: Deeparnab Chakrabarty, session 32 Jaroslaw Byrka, Constant-Factor Approximation for Ordered k-Median	Amit Jayant Deshpande, Sampling-based algorithms and clustering with outliers	Deeparnab Chakrabarty, Generalized Center Problems with Outliers		APPROX
Salle 36 Build B, Z 4 Intermediate 3x30 min	**Routing and Inventory**, *Organizer*: Dorit Hochbaum, session 343 Alexander Birx, Improved upper bound for online Dial-a-Ride on the line	Jan Marcinkowski, A 4/5 - Approximation Algorithm for the Maximum Traveling Salesman Problem	Dorit Hochbaum, The gap between the continuous and discrete Replenishment Schedule problem		APPROX
SIGALAS Build C, Z 2 2nd floor 3x30 min	**Algorithms for TSP**, *Organizer*: Ola Svensson, session 239 Vera Traub, Approaching 3/2 for the s-t-path TSP	Ramamoorthi Ravi, Cut-Covering Decompositions for Connectivity Problems	Ola Svensson, A Constant-factor Approximation Algorithm for the Asymmetric Traveling Salesman		COMB
DURKHEIM Build A, Z 1 3rd floor 3x30 min	**Applications of CP**, *Organizer*: Louis-Martin Rousseau, session 284 Olivier Bachollet, A Constraint Programming approach to a meal delivery problem	Florian Grenouilleau, A Decomposition Approach for the Home Health Care Routing and Scheduling Problem	Louis-Martin Rousseau, A CP Approach to the Traveling Salesman Problem in the Postal Services		CP

Optimization under Uncertainty - Thursday 3:15 PM – 4:45 PM

Room	Session				Track
Salle 32 Build B, Z 5 Ground Floor 3x30 min	**Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 1**, *Organizer*: Vincent Leclère, session 246 David Wozabal, Computing parameter sensitivities for discrete time Markov decision processes	Nils Löhndorf, Modeling time-dependent randomness in stochastic dual dynamic programming	Benoît Legat, Computing ellipsoidal controlled invariant sets for stochastic programming		Stoch
DENIGES Build C, Z 5 Ground Floor 3x30 min	**Distributionally Robust Optimization With Marginals and Cones**, *Organizer*: Divya Padmanabhan, session 354 Louis Chen, Distributionally Robust Linear and Discrete Optimization with Marginals	Guanglin Xu, A Copositive Approach for Decision Rule Approximations of Multi-Stage RO	Divya Padmanabhan, Tractable Solutions to Distributionally Robust Optimisation		Robust
Salle 37 Build B, Z 4 Intermediate 3x30 min	**Non-linear robust optimization**, *Chair*: Laurent Alfandari, session 460 Daniel de Roux, Graph learning with the Wasserstein metric	Laurent Alfandari, Robust optimization for non-linear impact of data variation	Suh-Wen Chiou, A mathematical program for signal control with equilibrium constraints		Robust
Salle 30 Build B, Z 5 Ground Floor 3x30 min	**Generation and Representation Algorithms in Multiobjective Optimization**, *Organizer*: Michael Stiglmayr, session 267 Britta Schulze, On a Polynomial Bound in Multiobjective Unconstrained Combinatorial Optimization	Kathrin Klamroth, Efficient Representation of the Search Region and Generic Algorithms in MOCO	Michael Stiglmayr, Representation of the non-dominated set of multiobjective optimization problems		Game

Room	Continuous Optimization - Thursday 3:15 PM – 4:45 PM			
Salle 05 Build Q, Z 11 1st floor 3x30 min	**Methods of Optimization in Riemannian Manifolds**, *Organizer*: Orizon P Ferreira, session 21			**NLP**
	Paulo Oliveira, A two-phase proximal-like algorithm in domains of positivity	Glaydston Bento, Proximal point method in multiobjective optimization on Hadamard manifolds	Orizon Ferreira, Newton's Method for Locally Lipschitz vector Fields on Riemannian Manifolds	
Salle 8 Build N, Z 12 4th floor 3x30 min	**Extending the Reach of First-Order Methods, Part II**, *Organizer*: Robert M. Freund, session 286			**NonSmooth**
	Matus Telgarsky, Risk and parameter convergence of logistic regression	Alp Yurtsever, A conditional gradient framework for composite convex minimization	Robert Freund, Accelerating Greedy Coordinate Descent Methods	
Salle LC5 Build L, Z 10 Intermediate 1 3x30 min	**Noncommutative polynomial optimization: semidefinite relaxations, free convexity and applications to quantum information II**, *Organizer*: Monique Laurent, session 18			**SDP**
	Sander Gribling, Quantifying entanglement of a quantum correlation using polynomial optimization	Antonios Varvitsiotis, Graph isomorphism: conic relaxations and physical interpretation	Farid Alizadeh, Optimization over univariate polynomials: Algorithms and applications	
Salle 06 Build Q, Z 11 1st floor 3x30 min	**Nonlinear Optimization and Variational Inequalities II**, *Organizer*: Cong Sun, session 141			**Variat**
	Xin Liu, On the Lojasiewicz Exponent of Quadratic Minimization with Sphere Constraint	Bin Gao, A Parallelizable Algorithm for Orthogonally Constrained Optimization Problems	Yanfei Wang, A Joint Matrix Minimization Approach for Seismic Wavefield Recovery	
Salle KC6 Build K, Z 10 Intermediate 1 3x30 min	**Asynchronous Parallel and Distributed Optimization**, *Organizer*: Wotao Yin, session 200			**RandomM**
	Rémi Leblond, Improved asynchronous parallel optimization analysis for incremental methods	Robert Hannah, Why Asynchronous Algorithms may Drastically Outperform Traditional Ones	Renato Monteiro, Complexity of a quadratic penalty accelerated inexact proximal point method	
Salle AURIAC Build G, Z 6 1st floor 2x30 min	**Theory and Methods for ODE- and PDE-Constrained Optimization 2**, *Chair*: Johann Schmitt, session 333			**Control**
	Johann Schmitt, Optimal boundary control of hyperbolic balance laws with state constraints	Paloma Schäfer Aguilar, Numerical approximation of optimal control problems for conservation laws		

Room	Specific Models, Algorithms, and Software - Thursday 3:15 PM – 4:45 PM			
FABRE Build J, Z 8 Ground Floor 3x30 min	**Accelerating Learning**, *Organizer*: Martin Takac, session 322			**Learning**
	Damien Scieur, Nonlinear Acceleration of Stochastic Algorithms	Sai Praneeth Karimireddy, Accelerated First Order Methods with Approximate Subproblems	Angelia Nedich, Optimal Algorithms for Distributed Optimization	
Salle 16 Build I, Z 7 2nd floor 3x30 min	**Robust first order methods**, *Organizer*: Fatma Kilinc-Karzan, session 332			**Learning**
	Dimitris Papailiopoulos, Robust distributed learning in the face of adversity	Suriya Gunasekar, Characterizing implicit bias of optimization and its role in generalization	Nam Ho-Nguyen, First-order Framework for Robust Convex Optimization	
PITRES Build O, Z 8 Ground Floor 2x30 min	**Path Problems**, *Chair*: Yanchao Liu, session 453			**Logistics**
	Edward He, Dynamic Discretization Discovery Algorithms for Time-Dependent Path Problems	Yanchao Liu, Drone Path Planning and Aerial Traffic Flow		
Salle 18 Build I, Z 7 1st floor 3x30 min	**Production Planning**, *Chair*: Michel Siemon, session 531			**Scheduling**
	Tobias Hofmann, ISO-PESP - A PESP Variant for Minimizing the Cycle Time of Production Lines	Julia Lange, A matheuristic for the blocking job shop problem with a tardiness objective	Michel Siemon, Value-based End-to-End Production Planning in Non-Ferrous Metal Industry	
Salle DENUCE Build Q, Z 8 Ground Floor 3x30 min	**Optimization Models for Renewable Energy Integration 1**, *Organizer*: Luis F Zuluaga, session 120			**Energy**
	Panagiotis Andrianesis, Optimal Grid Operation and DER Dispatch in Active Distribution Networks	Galina Orlinskaya, Bilevel Optimization for Flexible Electricity Supply Tariff Design	Luis Zuluaga, Competitive equilibrium and revenue adequate prices for robust energy markets	
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Progress in Algorithms for Optimal Power Flow Problems II**, *Chair*: Miguel F Anjos, session 509			**Energy**
	Alvaro Lorca, Robust Optimization for the Alternating Current Optimal Power Flow Problem	Ksenia Bestuzheva, Global Optimization for Alternating Current Optimal Power Flow	Andreas Grothey, Optimal Power Flow solver based on HELM	
Salle 24 Build G, Z 6 3rd floor 3x30 min	**Electricity Generation Scheduling and Dispatch**, *Chair*: Christophe Duhamel, session 511			**Energy**
	Beste Basciftci, Data-Driven Generator Maintenance and Operations Scheduling under Uncertainty	Diego Jimenez, A Network Flow–Based MILP Formulation for the Thermal Unit Commitment Problem	Christophe Duhamel, solving the Short-term Hydrothermal Scheduling problem with linearizations	
Salle LA4 Build L, Z 8 Basement 3x30 min	**Inverse Problems in Physics**, *Chair*: Leo Liberti, session 391			**Sciences**
	Andreas Alpers, On the reconstruction of lattices from diffraction data	Fabian Klemm, Grain map reconstruction by means of generalized Voronoi Diagrams	Leo Liberti, Scientific applications of distance geometry	
Salle 22 Build G, Z 6 2nd floor 3x30 min	**High-Performance Computing in Optimization II**, *Chair*: Joaquim Dias Garcia, session 466			**Algo**
	Timotej Hrga, High-Performance Solver for Binary Quadratic Problems	Brian Dandurand, Bilevel optimization approaches for power system security	Joaquim Dias Garcia, Genesys: Simulating Power Systems by Solving Millions of MIPs	

Room	Discrete Optimization & Integer Programming - Thursday 5:00 PM – 6:30 PM			
Salle 43	**Advances in Integer Programming**, *Organizer*: Robert Hildebrand, session 227			**IPtheory**
Build C, Z 1 3rd floor 4x20 min	Laura Sanità, On the diameter of the fractional matching polytope	Gonzalo Muñoz, Treewidth-based Extension Complexity Lower Bounds	Igor Malinovic, On valid inequalities for knapsack polytopes	Robert Hildebrand, Polynomial Integer Programming in Fixed Dimension and Applications in FPT
Salle 42	**Cutting Planes for Special Problems**, *Chair*: Eleazar Madriz, session 517			**IPtheory**
Build C, Z 1 3rd floor 3x30 min	Ruslan Simanchev, Separation problem for 2-partition inequalities	Markó Horváth, Polyhedral results for position based scheduling of chains on a single machine	Eleazar Madriz, A Benders procedure for the b-complementary multisemigroup dual program.	
Salle 36	**Matching Problems**, *Organizer*: Sergio García Quiles, session 175			**IPpractice**
Build B, Z 4 Intermediate 4x20 min	Thanh Nguyen, Stable Matching with Proportionality Constraints	Maxence Delorme, Mathematical models for stable marriage problems with ties	William Pettersson, Improvements in Kidney Exchange Programme Models for Large-Scale Programmes	Peter Biro, Stable project allocation under distributional constraints
Salle 44	**Cutting Planes**, *Chair*: Fabrizio Marinelli, session 485			**IPpractice**
Build C, Z 1 3rd floor 4x20 min	Edvin ABlad, A tighter ILP model and an improved branching for a load-balancing problem	Sávio Dias, A Branch-and-Cut Approach for the Car Renter Salesman Problem	Georgia Souli, On Lifted Cover Inequalities: A New Lifting Procedure with Unusual Properties	Fabrizio Marinelli, Exploiting star inequalities for the maximum quasi-clique problem
DURKHEIM	**Convexification and more (II)**, *Organizer*: Akshay Gupte, session 106			**MINLP**
Build A, Z 1 3rd floor 3x30 min	Christoph Buchheim, Binary Programming with Semilinear Elliptic PDE-constraints	Christopher Coey, Using algebraic structure to accelerate polyhedral approximation	Andres Gomez, Quadratic optimization with M-matrices and semi-continuous variables	
Salle 34	**Relaxations in MINLP**, *Chair*: Jan Kronqvist, session 280			**MINLP**
Build B, Z 3 1st floor 3x30 min	Ralf Lenz, Tight Convex Relaxations for Expansion Planning of Potential Driven Networks	Jan Kronqvist, Using Regularization and Second Order Derivatives with Outer Approximation	Andreas Lundell, The Supporting Hyperplane Optimization Toolkit for Convex MINLP	
Salle 35	**Applications in MINLP**, *Chair*: Justo Puerto, session 283			**MINLP**
Build B, Z 4 Intermediate 3x30 min	Do Duc Le, Modeling and optimization of traffic at traffic-light controlled intersections	Maximilian Merkert, Flow-based extended formulations for feasible traffic light controls	Justo Puerto, MINLP for pricing transaction costs in different models of portfolio selection	
LEYTEIRE	**Approximation Algorithms for Optimization under Uncertainty**, *Organizer*: Marc Uetz, session 95			**APPROX**
Build E, Z 1 3rd floor 3x30 min	Thomas Kesselheim, Prophet Inequalities Made Easy: Stochastic Opt. by Pricing Non-Stochastic Inputs	Max Klimm, Hiring Secretaries over Time: The Benefit of Concurrent Employment	Marc Uetz, Greed is Good - Online Algorithms for Stochastic Unrelated Machine Scheduling	
Salle 41	**Approximation algorithms for combinatorial optimization problems**, *Organizer*: Thomas Rothvoss, session 265			**COMB**
Build C, Z 1 3rd floor 3x30 min	Mohit Singh, Approximation Algorithms for Diverse Subset Selection Problems	Roy Schwartz, Local Guarantees in Graph Cuts and Clustering	Anupam Gupta, Scheduling Stochastic Jobs on Unrelated Machines	
Salle 39	**Heuristics for combinatorial optimization problems**, *Chair*: Evren Guney, session 428			**COMB**
Build E, Z 1 3rd floor 4x20 min	Cid de Souza, A Matheuristic to the Firefighter Problem on Graphs	Shinsaku Sakaue, Accelerated Best-first Search for Monotone Submodular Function Maximization	Kazuya Fukuoka, A statistical stopping criterion for simulated annealing	Evren Guney, A Lagrangean Relaxation Based Heuristic For Efficient Influence Maximization

Room	Optimization under Uncertainty - Thursday 5:00 PM – 6:30 PM			
Salle 32	**Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 2**, *Organizer*: Vincent Leclère, session 247			**Stoch**
Build B, Z 5 Ground Floor 4x20 min	Oscar Dowson, The practitioners guide to SDDP: lessons from SDDP.jl	François Pacaud, Decomposing Dynamic Programming equations: from global to nodal value functions	Vitor de Matos, Energy portfolio optimization for Brazilian distribution companies: a multistage	Luiz Carlos da Costa Junior, Stochastic programming framework for risk aversion representation with SDDP
Salle 30	**Topics in multistage stochastic optimization**, *Chair*: Felipe Beltrán, session 492			**Stoch**
Build B, Z 5 Ground Floor 3x20 min	Min Zhang, Risk Minimization, Regret Minimization and the Progressive Hedging Algorithm	David Hemmi, Recursive Evaluate and Cut for combinatorial Multistage Programs	Felipe Beltrán, Stochastic dual dynamic programming with Chebyshev centers	
DENIGES	**Robust Optimization under Data Uncertainty**, *Organizer*: Omid Nohadani, session 98			**Robust**
Build C, Z 5 Ground Floor 3x30 min	Matthias Ehrgott, Uncertain Data Envelopment Analysis	Soroosh Shafieezadeh, Wasserstein Distributionally Robust Kalman Filtering	Zhenzhen Yan, Appointment Scheduling Under Time-Dependent Patient No-Show Behavior	
Salle 37	**Combinatorial robust optimization I**, *Organizer*: Marc Goerigk, session 167			**Robust**
Build B, Z 4 Intermediate 4x20 min	Artur Pessoa, Solving the Robust Capacitated Vehicle Routing Problem Under Demand Uncertainty	Marc Goerigk, Approximating combinatorial optimization problems with the OWA criterion	Oyku Naz Attila, Reformulations for Robust Lot-Sizing Problem with Remanufacturing	Christoph Hansknecht, ast robust shortest path computations
Salle 31	**Approximation in dynamic programming**, *Chair*: Philip C Placek, session 382			**Markov**
Build B, Z 5 Ground Floor 3x30 min	Wolf Kohn, Dynamic Programming via a State Abstract Machine and Implementation	Philip Placek, An Incremental Probability Model for Dynamic Systems	Benoît Tran, A Stochastic Min-plus Algorithm for Deterministic Optimal Control	

Room	Continuous Optimization - Thursday 5:00 PM – 6:30 PM			
Salle 05	**Polynomial and tensor optimization II**, *Organizer*: Jiawang Nie, session 6			**NLP**
Build Q, Z 11 1st floor 4x20 min	Didier Henrion, Computing invariant measures with the Lasserre hierarchy	Anwa Zhou, Completely positive tensor recovery with minimal nuclear value	João Gouveia, Phaseless rank of a matrix	Xinzhen Zhang, A Complete Semidefinite Algorithm for Detecting Copositive Matrices and Tensors
Salle KC7	**First Order Methods II**, *Chair*: Guillaume Berger, session 437			**NLP**
Build K, Z 10 Intermediate 2 3x20 min	Guillaume Berger, Hölder-continuous gradient and first-order approximation accuracy	Andersen Ang, Accelerating Nonnegative Matrix Factorization Algorithms using Extrapolation	Lei Zhao, First-Order Primal-Dual Method for Nonlinear Convex Cone Programs	
Salle 20	**Global Optimization 3**, *Chair*: Jean-Baptist Hiriart-Urruty, session 503			**Global**
Build G, Z 6 1st floor 4x20 min	Jaromil Najman, Tighter McCormick relaxations through subgradient propagation in a BaB framework	Simon Boulmier, Nonlinear branch-and-bound improvements for global optimization	Mester Abigél, JAVA implementation of a modular, population based global optimizer package	Tiago Montanher, A rigorous MINLP solver using interval unions
Salle LC4	**Efficient Semismooth Newton Methods for Large Scale Statistical Optimization Problems**, *Organizer*: Defeng Sun, session 123			**NonSmooth**
Build L, Z 9 Intermediate 1 3x30 min	Meixia Lin, Efficient sparse Hessian based algorithms for the clustered lasso problem	Yangjing Zhang, An efficient algorithm for solving large scale sparse group Lasso problems	Defeng Sun, On the efficient computation of the projector over the Birkhoff polytope	
Salle 8	**Different faces of nonsmoothness in optimization**, *Organizer*: Tim Hoheisel, session 212			**NonSmooth**
Build N, Z 12 4th floor 3x30 min	Oliver Stein, Global optimization of GSIPs using disjunctive programming	Abraham Engle, Superlinear Convergence of QN Methods for PLQ Convex-Composite Optimization	Tim Hoheisel, Applications of the generalized matrix-fractional function	
Salle AURIAC	**Recent Advances in Conic Programming III**, *Organizer*: Masakazu Muramatsu, session 84			**SDP**
Build G, Z 6 1st floor 4x20 min	Makoto Yamashita, A path-following method for semidefinite programming without Slater condition	Tang Peipei, A Majorized Newton-CG ALM for Linearly Constrained Convex Programming	Yoshio Ebihara, Analysis of Positive Systems by Semidefinite and Copositive Programming	Yuzhu Wang, Acceleration of the Lagrangian-DNN method for a class of QOPs
Salle LC5	**Using coning programming in problems solving**, *Chair*: Kurt Majewski, session 497			**SDP**
Build L, Z 10 Intermediate 1 4x20 min	Vilmar Jefte De Sousa, Linear Relaxation of Maximum k-Cut with Semidefinite-Based Constraints	Anja Kuttich, Feedback Controller and Topology Design for uncertain mechanical systems	Julie Sliwak, Stabilization of the moment-based approach to prove global optimality for ACOPF	Kurt Majewski, Maximum Volume Inscribed Ellipsoids for Specific Absorption Rate Bounds in MRI
Salle 06	**VU-decomposition techniques for nonsmooth optimization**, *Organizer*: Claudia Sagastizabal, session 158			**Variat**
Build Q, Z 11 1st floor 3x30 min	Shuai Liu, An epsilon-VU algorithm with superlinear convergence	Claudia Sagastizabal, A derivative-free $\mathcal{VU}$-algorithm for convex finite-max problems	Lucas Simões, A Fast Gradient Sampling-like Method for Solving Nonsmooth Optimization Problems	
Salle ARNOZAN	**Variational Analysis 5**, *Organizer*: David Sossa, session 371			**Variat**
Build Q, Z 8 Ground Floor 4x20 min	Francisco Jara-Moroni, A global-local approach for stochastic programs with complementarity constraints	Miguel Sama, Conical Regularization of Multiobjective Optimization Problems	David Sossa, Complementarity problems with respect to Loewnerian cones	Chee Khian Sim, Relaxed Peaceman-Rachford Splitting Method: Convergence Study
Salle KC6	**Recent Progress on Second-order Type Optimization Methods**, *Organizer*: Andre Milzarek, session 302			**RandomM**
Build K, Z 10 Intermediate 1 3x20 min	Ching-pei Lee, Inexact Successive Quadratic Approximation for Regularized Optimization	Jiang Hu, Structured Quasi-Newton method For Optimization with Orthogonality Constraints	Andre Milzarek, A stochastic semismooth Newton method for nonsmooth nonconvex optimization	
Salle 21	**Advances in DFO III**, *Chair*: Juan C Meza, session 496			**DerFree**
Build G, Z 6 Intermediate 3x30 min	Jan Feiling, Utilizing Non-Commutative Maps in Derivative-Free Optimization	Richard Carter, Generalization of DIRECT algorithm supporting interactive problem redefinition	Juan Meza, Pattern Search Methods With Surrogates for Surface Structure Determination	

Room	Specific Models, Algorithms, and Software - Thursday 5:00 PM – 6:30 PM			
FABRE Build J, Z 8 Ground Floor 4x20 min	**First-order methods for large-scale convex problems II**, *Organizer*: Stephen A Vavasis, session 318 — **Learning**			
	MADELEINE UDELL, Convex Low Rank Semidefinite Optimization	SIMON LACOSTE-JULIEN, Frank-Wolfe Splitting via Augmented Lagrangian Method	FRANCOIS GLINEUR, Extending performance estimation beyond exact convex fixed-step methods	XUAN VINH DOAN, Low-Storage Conditional Gradient Method for Low-Rank and Sparse Optimization
Salle 16 Build I, Z 7 2nd floor 4x20 min	**Advances in Reinforcement Learning Algorithms**, *Organizer*: Lin Xiao, session 329 — **Learning**			
	MENGDI WANG, Compressive Learning for Sequential Decision Process	SHIPRA AGRAWAL, Posterior sampling for reinforcement learning	LIHONG LI, SBEED learning: Convergent control with nonlinear function approximation	ADITHYA M DEVRAJ, Zap Q-Learning: Fastest Convergent Q-learning
Salle 22 Build G, Z 6 2nd floor 4x20 min	**Ranking and recommendation**, *Chair*: Aleksandra Burashnikova, session 472 — **Learning**			
	ALEKSANDRA BURASHNIKOVA, Learning Online Ranking Models with a Sequential Optimization Algorithm	IBRAHIM MUTER, Integrating Individual and Aggregate Diversity in Top-N Recommendation	ENGIN TAS, A stochastic gradient descent algorithm for learning to rank	JOSE DULA, The Recommender Problem with Convex Hulls
Salle 24 Build G, Z 6 3rd floor 3x20 min	**Vehicle Routing III**, *Chair*: Raquel Bernardino, session 413 — **Logistics**			
	RAQUEL BERNARDINO, A hybrid algorithm for the family traveling salesman problem	ROGHAYEH HAJIZADEH, Snow removal: Modeling and bounds by relaxation, heuristic and branch-and-bound	VITOR NESELLO, Column Generation Based Local Search for Pickup-and-Delivery problems	
Salle 18 Build I, Z 7 1st floor 4x20 min	**Supply Chain**, *Chair*: Daniel Ramón-Lumbierres, session 533 — **Scheduling**			
	WEI HUANG, Using SAP Integrated Business Planning to Optimize Supply Chain	FLORIAN FONTAN, Complexity of processing-time dependent profit maximization scheduling problems	ABDESSAMAD OUZIDAN, Modelization and optimization of inventory management for palletization	DANIEL RAMÓN-LUMBIERRES, A multistage stochastic programming model for the strategic supply chain design
Salle DENUCE Build Q, Z 8 Ground Floor 3x30 min	**Equilibrium and Optimization in Energy Markets**, *Organizer*: Asgeir Tomasgard, session 151 — **Energy**			
	STEVEN GABRIEL, Bilevel Linear Programming Investment Problems Lower-Level Primal and Dual Variables	ENDRE BJORNDAL, The Flow-Based Market Coupling Model and the Bidding Zone Configuration	ASGEIR TOMASGARD, A European power market model with short- and long-term uncertainty	
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Gas Network and Market Optimization**, *Organizer*: Jonas Schweiger, session 293 — **Energy**			
	JONAS SCHWEIGER, Foresighted decision support for gas network operation	FELIX HENNINGS, Controlling complex network elements by target values	JULIA GRÜBEL, Nonconvex Equilibrium Models for Gas Market Analysis	
Salle LA4 Build L, Z 8 Basement 4x20 min	**Medicine and Metabolic engineering**, *Chair*: Mahdi Doostmohammadi, session 396 — **Sciences**			
	MICHELLE BOECK, Model Predictive Control and Robust Optimization in Adaptive Radiation Therapy	BJÖRN MORÉN, Improving a Dose-Volume Model for HDR Brachytherapy to Reduce Tumour Cold Spots	AMANDA SMITH, New bilevel formulations for optimizing flux bounds in metabolic engineering	MAHDI DOOSTMOHAMMADI, MOMO - Multi-Objective Mixed integer Optimisation for metabolic engineering
Salle 9 Build N, Z 12 4th floor 4x20 min	**Large-scale combinatorial optimization implementations**, *Organizer*: Aaron Archer, session 96 — **Algo**			
	ANDREW GOLDBERG, Lost in Translation: Production Code Efficiency	KEVIN AYDIN, Distributed Balanced Partitioning via Linear Embedding	CHRISTIAN SCHULZ, High Quality Graph and Hypergraph Partitioning	HOSSEIN BATENI, Solving Coverage Problems on Massive Data
PITRES Build O, Z 8 Ground Floor 3x30 min	**Computational OR in Julia/JuMP**, *Organizer*: Miles Lubin, session 238 — **Algo**			
	MILES LUBIN, JuMP 0.19 and MathOptInterface: new abstractions for mathematical optimization	SEBASTIEN MARTIN, Optimizing Public Policy: School Transportation and Start Times in Boston.	JARRETT REVELS, Capstan: Next-Generation Automatic Differentiation for Julia	

Room	Invited Talks - Thursday 5:00 PM – 6:30 PM			
SIGALAS Build C, Z 2 2nd floor 4x20 min	**Planning**, *Chair*: Jeanjean Antoine, session 389 — **INTERFACE**			
	JEANJEAN ANTOINE, Planning model for recommerce activities	BORIS GRIMM, A Propagation Approach for Railway Rolling Stock Optimization	ERIC BOURREAU, Real Size Exam Timetabling at Montpellier University (France)	MOHAMED BENKIRANE, An Hypergraph Model for the Rolling Stock Rotation Planning and Train Selection

Discrete Optimization & Integer Programming - Friday 8:30 AM – 10:30 AM

Room				
Salle 43 Build C, Z 1 3rd floor 4x30 min	**Recent advances in Integer Optimization**, *Organizer*: Alberto Del Pia, session 218 **IPtheory**			
	Jean-Philipp Richard, Computational evaluation of new MIP models for tree ensembles optimization	Diego Moran, Strong duality for conic mixed-integer programs	Gustavo Angulo, An affine bounding method for two-stage stochastic integer programs	Merve Bodur, Aggregation-based cutting-planes for packing and covering integer programs
Salle 35 Build B, Z 4 Intermediate 4x30 min	**Mixed Integer Programming Representability**, *Organizer*: Juan Pablo Vielma, session 275 **IPtheory**			
	Chris Ryan, Mixed-integer linear representability, disjunctions, and Chvátal functions	Joey Huchette, A mixed-integer branching approach for very small formulations	Marc Pfetsch, On the Size of Integer Programs with Sparse Constraints or Bounded Coefficients	Juan Pablo Vielma, Mixed-integer convex representability
Salle 44 Build C, Z 1 3rd floor 4x30 min	**Integer Programming and Crew Scheduling**, *Organizer*: Francois Soumis, session 292 **IPpractice**			
	Francois Soumis, Dynamic Constraints Aggregation for Crew Scheduling Problem	Vahid Zeighami, Integrated Crew Pairing and Personalized Crew Assignment Problems	Frédéric Quesnel, Considering preferences and language skills in the airline crew pairings problem	Mohammed Saddoune, Alternate Lagrangian Decomposition for Integrated Crew Scheduling Problem
Salle 34 Build B, Z 3 1st floor 3x30 min	**Optimal Control Problems with Discrete Switches**, *Organizer*: Christian Kirches, session 102 **MINLP**			
		Adrian Bürger, An Algorithm for Model-Predictive Control of Switched Nonlinear Dynamic Systems	Felix Bestehorn, Approximation algorithms for MIOCPs with discontinuous switch costs	Matthias Schloeder, Numerical Modeling of Switched Systems with Jumps in Optimal Control Problems
LEYTEIRE Build E, Z 1 3rd floor 4x30 min	**Data-Driven Revenue Management with Customer Choice**, *Organizer*: Jacob Feldman, session 81 **APPROX**			
	Antoine Desir, Constrained Assortment Optimization under the Markov Chain based Choice Model	Danny Segev, Near-Optimal Approximations for Dynamic Assortment Planning under the MNL Model	Ali Aouad, Near-Optimal Approximations for Display Optimization Under MNL Preferences	Jacob Feldman, New Results for Assortment Optimization under the Exponomial Choice Model
Salle 36 Build B, Z 4 Intermediate 4x30 min	**Clustering.**, *Organizer*: Zac Friggstad, session 155 **APPROX**			
	Arnaud de Mesmay, A Near-Linear Approximation Scheme for Multicuts of Embedded Graphs	Vincent Cohen-Addad, On local search for clustering	Zac Friggstad, Approximation Schemes for Clustering With Outliers	Ashkan Norouzi Fard, Dynamic Facility Location via Exponential Clocks
SIGALAS Build C, Z 2 2nd floor 4x30 min	**Matching and scheduling**, *Organizer*: Seffi Naor, session 54 **COMB**			
	David Wajc, Online Matching in Regular Graphs (and Beyond)	Samir Khuller, Coflow Scheduling and beyond	Guy Even, Best of Two Local Models: Centralized local and Distributed local Algorithms	Seffi Naor, Competitive Algorithms for Online Multi-level Aggregation
Salle 41 Build C, Z 1 3rd floor 4x30 min	**Recent progress in graph cut problems**, *Organizer*: Karthekeyan Chandrasekaran, session 244 **COMB**			
	Tamás Király, Approximation of Linear 3-Cut and related problems	Euiwoong Lee, An FPT Algorithm Beating 2-Approximation for *k*-Cut	Yury Makarychev, An Integrality Gap for the Călinescu–Karloff–Rabani Relaxation for Multiway Cut	Karthekeyan Chandrasekaran, Hypergraph k-cut in randomized polynomial time
Salle 39 Build E, Z 1 3rd floor 4x30 min	**Algorithmic aspects of connectivity in network design**, *Organizer*: Neil Olver, session 264 **COMB**			
	Bundit Laekhanukit, Beyond Metric Embedding: Approximating Group Steiner on Bounded Treewidth Graphs	Mateusz Lewandowski, Approximating Node-Weighted k-MST on Planar Graphs	Andre Linhares, Improved Algorithms for MST and Metric-TSP Interdiction	Kanstantsin Pashkovich, On the Integrality Gap of the Prize-Collecting Steiner Forest LP
DURKHEIM Build A, Z 1 3rd floor 4x30 min	**Graphical Optimization Model 2**, *Organizer*: Maria I. Restrepo, session 297 **CP**			
	Simon de Givry, Recent algorithmic advances for combinatorial optimization in graphical models	Thomas Schiex, Learning and using Graphical models to design new molecules	Maria Restrepo, Integrated staffing and scheduling for home healthcare	Daniel Kowalczyk, Solving parallel machine scheduling problems with B and P and decision diagrams

Optimization under Uncertainty - Friday 8:30 AM – 10:30 AM

Room				
DENIGES Build C, Z 5 Ground Floor 4x30 min	**Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 3**, *Organizer*: Vincent Leclère, session 245 **Stoch**			
	David Morton, Distributionally Robust Dual Dynamic Programming	Andy Sun, Stochastic dual dynamic integer programming	Regan Baucke, A deterministic algorithm for solving stochastic minimax dynamic programmes	Vincent Leclère, Exact converging bounds for Stochastic Dual Dynamic Programming
Salle 32 Build B, Z 5 Ground Floor 4x30 min	**New methods for stochastic optimization and variational inequalities**, *Chair*: Yunxiao Deng, session 491 **Stoch**			
	Alfredo Iusem, Extragradient method for pseudomonotone stochastic variational inequalities	Eduard Gorbunov, An Accelerated Randomized Method for Smooth Stochastic Convex Optimization	Mihai Anitescu, Stochastic Analogues to Deterministic Optimization Methods	Yunxiao Deng, Convex Stochastic Decomposition and Applications to Machine Learning
Salle 33 Build B, Z 5 Ground Floor 3x30 min	**New Horizons in Robust Optimization**, *Organizer*: Angelos Georghiou, session 447 **Robust**			
		Zhi Chen, Data-driven Chance Constrained Programs over Wasserstein Balls	Kilian Schindler, Cardinality-Constrained Clustering and Outlier Detection via Conic Optimization	Angelos Georghiou, A robust optimization prospective to decentralized decision making
Salle 31 Build B, Z 5 Ground Floor 4x30 min	**Advances in theory of dynamic programming**, *Chair*: Stephane L Gaubert, session 385 **Markov**			
	Mauricio Junca, On controllability of Markov chains: A Markov Decision Processes approach	Angeliki Kamoutsi, Stochastic Convex Optimization and Regret Bounds for Apprenticeship Learning	Nabil Kahale, Randomized Dimension Reduction for Monte Carlo Simulations	Nikolas Stott, Dynamic programming over noncommutative spaces applied to switched systems
Salle 30 Build B, Z 5 Ground Floor 4x30 min	**Algorithmic Game Theory II**, *Chair*: Margarida Carvalho, session 372 **Game**			
	Anja Huber, Efficient Black-Box Reductions for Separable Cost Sharing	Marton Benedek, Finding and verifying the nucleolus of cooperative games	Chuangyin Dang, Perfect d-Proper Equilibrium and Its Determination	Margarida Carvalho, Kidney Exchange Game

Room	Continuous Optimization - Friday 8:30 AM – 10:30 AM			
Salle 05 Build Q, Z 11 1st floor 4x30 min	**First order methods**, *Organizer*: Gerardo Toraldo, session 27 — NLP			
	Simone Rebegoldi, Variable metric techniques for the inexact inertial forward-backward algorithm	Daniela di Serafino, Combining IRN and gradient methods for TV-based Poisson image restoration	William Hager, An Active Set Algorithm for Polyhedral Constrained Optimization	Ignace Loris, A line-search based proximal gradient method for (non-)convex optimization
GINTRAC Build Q, Z 8 Ground Floor 4x30 min	**Stochastic and Nonlinear Optimization II**, *Organizer*: Jorge Nocedal, session 48 — NLP			
	Mark Schmidt, "Active-set complexity" of proximal-gradient: How long does it take to find the	Daniel Robinson, A Positive Outlook on Negative Curvature	Albert Berahas, Derivative-Free Optimization of Noisy Functions via Quasi-Newton Methods	Lin Xiao, Randomized Primal-Dual Algorithms for Asynchronous Distributed Optimization
Salle KC7 Build K, Z 10 Intermediate 2 4x30 min	**Regularization and Iterative Methods in Large-Scale Optimization**, *Organizer*: Jacek Gondzio, session 59 — NLP			
	Paul Armand, Local analysis of a regularized primal-dual algorithm for NLP without SOSC	Dominique Orban, Implementing a smooth exact penalty function for nonlinear optimization	Spyridon Pougkakiotis, Dynamic primal-dual regularization in interior point methods	Michael Saunders, Stabilized Optimization via an NCL Algorithm
Salle 9 Build N, Z 12 4th floor 4x30 min	**Decomposition Methods**, *Chair*: Roger Behling, session 431 — NLP			
	Roger Behling, Circumcentering the Douglas–Rachford method	Luiz-Rafael Santos, On the linear convergence of the circumcentered–reflection method	Yuan Shen, Alternating Direction Method of Multipliers for k-means Clustering	Leonardo Galli, A Nonomonotone Decomposition Framework: convergence analysis and applications
Salle LC4 Build L, Z 9 Intermediate 1 4x30 min	**Geometry in complexity analysis of non-smooth optimization methods**, *Organizer*: Jalal Fadili, session 199 — NonSmooth			
	Charles Dossal, An ODE associated to the Nesterov acceleration scheme	Guillaume Garrigos, Structured sparsity in inverse problems and support recovery	Anthony So, Error Bound-Based Convergence Rate Analysis of Newton-Type Methods	Jalal Fadili, Finite Activity Identification: Geometry and Algorithms
Salle 8 Build N, Z 12 4th floor 4x30 min	**Convergence analysis for non smooth optimization**, *Organizer*: Robert Csetnek, session 557 — NonSmooth			
	Robert Csetnek, ADMM for monotone operators: convergence analysis and rates	Mattias Fält, Optimal Convergence Rates for Generalized Alternating Projections	Alain Zemkoho, Newton method for bilevel optimization: Theory+extensive numerical experiments	Dennis Meier, Inducing strong convergence into the asymptotic behaviour of proximal splitting
Salle 20 Build G, Z 6 1st floor 4x30 min	**Copositive and completely positive optimization**, *Organizer*: Olga Kuryatnikova, session 24 — SDP			
	Peter Dickinson, A New Certificate For Copositivity	Markus Gabl, Copositive Approach to adjustable robust optimization	Juan Vera, Using Binary Programming to solve Copositive Optimization Problems	Olga Kuryatnikova, Copositive certificates of non-negativity for polynomials on unbounded sets
Salle LC5 Build L, Z 10 Intermediate 1 4x30 min	**Stability and scaling in conic programming**, *Chair*: Diego Cifuentes, session 498 — SDP			
	Roland Hildebrand, Scaling points and reach for non-self-scaled barriers	Hector Ramirez, Stability Analysis for Parameterized Conic Programs	Wei Zhang, An improved projection and rescaling algorithm for conic feasible problems	Diego Cifuentes, On the local stability of semidefinite relaxations
Salle 06 Build Q, Z 11 1st floor 4x30 min	**Stochastic Optimization and Variational Inequalites**, *Organizer*: Hailin Sun, session 149 — Variat			
	Huifu Xu, Behavioural Function Equilibria and Approximation Schemes in Bayesian Games	Shu Lu, Inference of two stage stochastic programs using SVI techniques	Xiaojun Chen, Theory and algorithms for two-stage stochastic variational inequalities	Hailin Sun, Sample average approximation of two-stage stochastic generalized equation
Salle ARNOZAN Build Q, Z 8 Ground Floor 4x30 min	**Variational Analysis 3**, *Organizer*: Johanna Burtscheidt, session 369 — Variat			
	Johanna Burtscheidt, Stability and Small Application of a Risk Averse CP under Uncertainty	Hongbo Dong, Variable selection with heredity principles by nonconvex optimization	Goran Lesaja, Adaptive Full Newton-step Infeasible Interior-Point Method for Sufficient HLCP	Henri Bonnel, Application of Optimization over the Pareto set in Machine Learning
Salle KC6 Build K, Z 10 Intermediate 1 3x30 min	**Recent Advances in Coordinate Descent and Constrained Problems**, *Organizer*: Ion Necoara, session 208 — RandomM			
		Nicolas Loizou, Convergence Analysis of Inexact Randomized Iterative Methods	Konstantin Mishchenko, A Stochastic Penalty Model for Optimization with Many Convex Constraints	Ion Necoara, Random coordinate descent methods for linearly constrained convex optimization
Salle 21 Build G, Z 6 Intermediate 4x30 min	**Challenging applications in DFO**, *Chair*: Francesco Rinaldi, session 38 — DerFree			
	A Ismael Vaz, Global Direct Search and an application to Additive Manufacturing (3D Printing)	Stefano Lucidi, Derivative-free methods for complex black-box problems	Steven Gardner, Parallel Hybrid Multi-objective Derivative-Free Optimization for Machine Learning	Lukas Adam, Robust multi-objective optimization: Application to the recycling of plastics
Salle AURIAC Build G, Z 6 1st floor 3x30 min	**Optimal Control in Engineering Applications**, *Chair*: Maxime Grangereau, session 310 — Control			
		Masoumeh Mohammadi, A Priori Error Estimates for a Linearized Fracture Control Problem	Maxime Grangereau, Stochastic optimal control of a battery : resolution with McKean-FBSDE	Johanna Biehl, Adaptive Multilevel Optimization of Fluid-Structure Interaction

Specific Models, Algorithms, and Software - Friday 8:30 AM – 10:30 AM

Room				
FABRE Build J, Z 8 Ground Floor 3x30 min	**Dimensionality reduction tools for learning: A sketchy session**, *Organizer*: Robert M Gower, session 313 — Learning			
		Nicolas Keriven, Sketched Learning with Random Feature Moments	Arthur Mensch, Stochastic Subsampling for Factorizing Huge Matrices	Alessandro Rudi, Optimal kernel methods for large scale machine learning
Salle 16 Build I, Z 7 2nd floor 4x30 min	**Dealing with non-convexity**, *Chair*: Damek Davis, session 473 — Learning			
	Leonard Berrada, Smoothing Piecewise Linear Loss Functions for Deep Learning	Damek Davis, Convergence rates of stochastic methods for nonsmooth nonconvex problems	Cong Ma, Implicit Regularization in Nonconvex Statistical Estimation	Naoki Marumo, Provable Convex Minimization under Non-convex Submodular-structured Sparsity
Salle 18 Build I, Z 7 1st floor 4x30 min	**Telecommunications**, *Organizer*: Edoardo Amaldi, session 361 — Network			
	Michal Pioro, An Optimization Model for Quadratic Flow Thinning	Matthias Rost, Approximating the Virtual Network Embedding Problem: Theory and Practice	Chafiq Titouna, DDRA: Distributed Detection and Recovery Algorithm for Wireless Sensor Networks	Edoardo Amaldi, On the Virtual Network Embedding problem with substrate network expansion
PITRES Build O, Z 8 Ground Floor 4x30 min	**Hybrid Algorithms and Matheuristics for VRP**, *Organizer*: Thibaut Vidal, session 181 — Logistics			
	Thibaut Vidal, Heuristics for vehicle routing problems: Sequence or set optimization?	Dominique Feillet, Single Liner Service Design with Speed Optimization	Jean Bertran Gauthier, Heuristic pricing for the shortest path problem with resource constraints	Pedro Diniz, Garbage Collection Routing With Heterogeneous Fleet
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Scheduling Applications**, *Chair*: Mauricio C. de Souza, session 526 — Scheduling			
		Atsuko Ikegami, Generating many optimal solutions in nurse scheduling	Davaatseren Baatar, Mixed Integer Programming Based Merge Search for Open Pit Block Scheduling	Mauricio de Souza, Surgical scheduling under uncertainty by approximate dynamic programming
Salle 24 Build G, Z 6 3rd floor 3x30 min	**Power Systems Models with Discrete Decision Variables**, *Organizer*: Adolfo R Escobedo, session 26 — Energy			
		Kai Pan, Co-optimizing Energy and Ancillary Services	Harsha Gangammanavar, Stochastic Framework for Coordinated Operation of Multiple Microgrids	Adolfo Escobedo, Generation of Angular Valid Inequalities for Transmission Expansion Planning
Salle DENUCE Build Q, Z 8 Ground Floor 4x30 min	**Machine Learning in State Estimation and Situational Awareness in Power Grids**, *Organizer*: Deepjyoti Deka, session 134 — Energy			
	Deepjyoti Deka, Learning with end-users in distribution grids:Topology and parameter estimation	Marc Vuffray, Online Learning of Power Transmission Dynamics	Mauro Escobar, Machine learning with PMU signals	Dongchan Lee, Convex polytope machine approach for transient stability assessment
Salle LA4 Build L, Z 8 Basement 3x30 min	**Finance and Portfolio Optimization**, *Organizer*: Asaf Shupo, session 395 — Sciences			
		Benjamin Heymann, Auction under ROI constraints	Gabriela Kovacova, Time Consistency of the Mean-Risk Problem	Asaf Shupo, Building Optimal Strategies Using Multi-Objective Optimization
Salle 22 Build G, Z 6 2nd floor 4x30 min	**New Developments in Optimization Modeling Software**, *Organizer*: Robert Fourer, session 101 — Algo			
	Steven Dirkse, Enhanced Model Deployment and Solution in GAMS	David Gay, Adding Functions to AMPL	Paul Kerr-Delworth, Optimization Modeling in MATLAB	Youngdae Kim, Efficient model generation for decomposition methods in modeling languages

Invited Talks - Friday 11:00 AM – 12:00 AM

Room				
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**Tseng Memorial Lectureship in Continuous Optimization**, *Organizer*: Yaxiang Yuan, session 549 — SEMI			
LEYTEIRE Build E, Z 1 3rd floor 1x60 min	**Majority judgment** , *Organizer*: Martine Labbé, session 535 — KEYNOTE			
	Michel Balinski, Majority judgment			
DENIGES Build C, Z 5 Ground Floor 1x60 min	**Submodularity in mixed-integer quadratic and conic quadratic optimization**, *Organizer*: Daniel Bienstock, session 540 — KEYNOTE			
	Alper Atamturk, Submodularity in mixed-integer quadratic and conic quadratic optimization			
BROCA Build W, Z 0 3rd floor 1x60 min	**Modern Branch-and-Cut Implementation**, *Organizer*: Marc E Pfetsch, session 542 — KEYNOTE			
	Matteo Fischetti, Modern Branch-and-Cut Implementation			

Invited Talks - Friday 1:30 PM – 2:30 PM

Room				
Auditorium Build Symph H, Z 0 Gambetta 1x60 min	**Bounds for quantum graph parameters by conic and polynomial optimization**, *Organizer*: Frank Vallentin, session 553 — PLENARY			
	Monique Laurent, Bounds for quantum graph parameters by conic and polynomial optimization			

Discrete Optimization & Integer Programming - Friday 3:15 PM – 4:45 PM

Room					
Salle 34 Build B, Z 3 1st floor 3x30 min	**Polyhedral theory in practice**, *Organizer*: Mourad Baiou, session 309				**IPtheory**
	RAFAEL COLARES, The Stop Number Minimization Problem: polyhedral analysis	FRANCISCO BARAHONA, On the nucleolus of shortest path and network disconnection games	MOURAD BAIOU, On some network security games		
Salle 42 Build C, Z 1 3rd floor 3x30 min	**Extended Formulations**, *Chair*: Bartosz Filipecki, session 514				**IPtheory**
	BERND PERSCHEID, An Extended Formulation for the 1-Wheels of the Stable Set Polytope	MIRJAM FRIESEN, Extended formulations for higher-order spanning tree polytopes	BARTOSZ FILIPECKI, Stronger Path-based Extended Formulation for the Steiner Tree Problem		
Salle 44 Build C, Z 1 3rd floor 3x30 min	**Routing**, *Chair*: Cole Smith, session 484				**IPpractice**
	IMKE JOORMANN, Solving the Time-Dependent TSP using Machine Learning Guidance	ANN-BRITH STRÖMBERG, Column generation for routing a fleet of plug-in hybrid vehicles	COLE SMITH, The consistent path problem and binary decision diagrams		
Salle 36 Build B, Z 4 Intermediate 3x30 min	**IP Practice III**, *Chair*: Samuel S Brito, session 507				**IPpractice**
	FRANCO QUEZADA, Valid inequalities for solving a stochastic lot-sizing problem with returns	SAMUEL BRITO, Improving COIN-OR CBC MIP Solver Using Conflict Graphs	MAXIMILIAN JOHN, Two Lower Bound Approaches for the Keyboard Layout Problem		
Salle 39 Build E, Z 1 3rd floor 3x30 min	**Outer Convexification and Mixed-Integer Optimal Control** , *Organizer*: Sebastian Sager, session 103				**MINLP**
	PAUL MANNS, Improved Regularity Assumptions for Partial Outer Convexification of MIPDECOs	CLEMENS ZEILE, Combinatorial Integral Approximation Decompositions for Mixed-Integer Control	OLIVER HABECK, Global optimization of ODE constrained network problems		
DURKHEIM Build A, Z 1 3rd floor 3x30 min	**Intersection cuts, disjunctions, and valid inequalities**, *Organizer*: Eli Towle, session 180				**MINLP**
	DANIEL BIENSTOCK, Outer-product-free Sets for Polynomial Optimization	EGON BALAS, Synthetizing branch-and-bound information into cutting planes	ELI TOWLE, Intersection disjunctions for reverse convex sets		
Salle 35 Build B, Z 4 Intermediate 3x30 min	**Branch-and-cut techniques**, *Organizer*: Teodora Dan, session 277				**MINLP**
	TEODORA DAN, A branch-and-bound algorithm for a bilevel location-allocation model	LOVIS ANDERSON, Improving branching for disjunctive models via approximate convex decompositions	TU NGUYEN, Learning with Cutting Planes		
LEYTEIRE Build E, Z 1 3rd floor 3x30 min	**Submodular Maximization.**, *Organizer*: Justin Ward, session 179				**APPROX**
	ILIJA BOGUNOVIC, Robust Maximization of Submodular Objs. in the Presence of Adversarial Removals	ALFREDO TORRICO, Robust submodular maximization under matroid constraints	AMIN KARBASI, Submodular Optimization: From Discrete to Continuous and Back		
Salle 43 Build C, Z 1 3rd floor 3x30 min	**Submodular and Incremental Maximization**, *Organizer*: Martin Gross, session 340				**APPROX**
	RAJAN UDWANI, Multi-objective Maximization of Monotone Submodular Functions	TASUKU SOMA, A New Approximation Guarantee for Submodular Maximization via Discrete Convexity	MARTIN GROSS, General Bounds for Incremental Maximization		
SIGALAS Build C, Z 2 2nd floor 3x30 min	**Combinatorial aspects of Linear Programming**, *Organizer*: Daniel Dadush, session 259				**COMB**
	SOPHIE HUIBERTS, A Friendly Smoothed Analysis of the Simplex Method	GIACOMO ZAMBELLI, Geometric Rescaling Algorithms for Submodular Function Minimization	NEIL OLVER, A Simpler and Faster Strongly Polynomial Algorithm for Generalized Max-Flow		

Optimization under Uncertainty - Friday 3:15 PM – 4:45 PM

Room					
Salle 32 Build B, Z 5 Ground Floor 3x30 min	**Risk-aware decision making**, *Organizer*: Minseok Ryu, session 251				**Stoch**
	HIDEAKI NAKAO, Medical Homecare Delivery with Time-dependent Stochastic Travel Time	ZHENG ZHANG, A stochastic programming approach for optimization of latent disease detection	MINSEOK RYU, Nurse staffing under uncertain demand and absenteeism		
Salle 33 Build B, Z 5 Ground Floor 3x30 min	**Distributionally Robust Optimization: Models and Applications**, *Organizer*: Selin D Ahipasaoglu, session 355				**Robust**
	BIKRAMJIT DAS, Heavy tails in a moment-constrained robust newsvendor model	HENRY LAM, Robust Extreme Event Analysis	SELIN AHIPASAOGLU, Concentration versus Diversification in Portfolio Selection		
DENIGES Build C, Z 5 Ground Floor 3x30 min	**Distributionally Robust Optimization**, *Organizer*: Daniel Kuhn, session 446				**Robust**
	NAPAT RUJEERAPAIBOON, Chebyshev Inequalities for Products of Random Variables	JOHANNES ROYSET, Variational Theory for Optimization under Stochastic Ambiguity	DANIEL KUHN, Distributionally Robust Inverse Covariance Estimation		
Salle 31 Build B, Z 5 Ground Floor 3x30 min	**Discrete stochastic dynamic programming**, *Chair*: Adam Narkiewicz, session 384				**Markov**
	VICTOR COHEN, MILP formulations for discrete stochastic optimization (LIMIDs)	AXEL PARMENTIER, LP relaxations for discrete stochastic optimization with variational inference	ADAM NARKIEWICZ, A sequential decision process with stochastic action sets		
Salle 30 Build B, Z 5 Ground Floor 3x30 min	**Scalarization, representation and the comparison of methods in Multiobjective Optimization**, *Chair*: Tyler Perini, session 378				**Game**
	KENZA OUFASKA, New scalarization technique for solving multi-objective problems	TYLER PERINI, Approximation of the frontier for a biobjective MIP: comparison between methods	KATERYNA MUTS, Multi-Objective Optimization for the Compiler of Hard Real-Time Systems		

Continuous Optimization - Friday 3:15 PM – 4:45 PM

Room	Session			
GINTRAC Build Q, Z 8 Ground Floor 3x30 min	**Interior Point Methods in Engineering Applications I**, *Organizer*: Jacek Gondzio, session 60			**NLP**
	Sebastiaan Breedveld, A (non)convex interior-point implementation tuned for radiotherapy optimisation	Lovisa Engberg, Refined planning tools for external radiotherapy using interior point methods	Renke Kuhlmann, Computational Study of a Primal-Dual Penalty-Interior-Point Algorithm	
Salle 05 Build Q, Z 11 1st floor 3x30 min	**Nonlinear Optimization**, *Chair*: Marc C Steinbach, session 429			**NLP**
	Ademir Ribeiro, On the Approximate Solutions of Augmented Subproblems within Sequential Methods	Marc Steinbach, An Elastic Primal Active Set Method for Structured SQP	Hao Wang, A Dynamic Penalty Parameter Updating Strategy for SQP Methods	
Salle 20 Build G, Z 6 1st floor 3x30 min	**Global Optimization 2**, *Chair*: Mirjam Duer, session 502			**Global**
	Christian Füllner, Deterministic upper bounds in global minimization with equality constraints	Andrei Orlov, Nonconvex Optimization Approach to Equilibrium and Bilevel Problems	Tatiana Gruzdeva, On Solving the General Fractional Problem via D.C. Optimization	
Salle 8 Build N, Z 12 4th floor 3x30 min	**Advances in the first-order methods for convex optimization**, *Organizer*: Angelia Nedich, session 73			**NonSmooth**
	Hoi To Wai, Accelerated curvature-aided incremental aggregated gradient method	Tatiana Tatarenko, Fast Incremental Gradient Method for Optimization with Linear Constraints	Maryam Yashtini, Efficient Methods For Edge-weighted TV Models with Sphere Constraints	
Salle LC5 Build L, Z 10 Intermediate 1 3x30 min	**Relative Entropy Optimization I**, *Organizer*: Venkat Chandrasekaran, session 111			**SDP**
	Riley Murray, Exactness of Relative Entropy Relaxations for Signomial Programs	Hamza Fawzi, Certificates of nonnegativity via conic lifts	Michal Adamaszek, Exponential cone in MOSEK: overview and applications	
Salle 06 Build Q, Z 11 1st floor 3x30 min	**Algorithms for optimization and variational problems with possibly nonisolated solutions II**, *Organizer*: Alexey F. Izmailov, session 153			**Variat**
	Mikhail Solodov, A globally convergent LP-Newton method for piecewise smooth constrained equation	Daniel Steck, Some Developments on Multiplier Methods in Cone-Constrained Optimization	Paulo Silva, On the second order augmented Lagrangian method for MPCC	
Salle ARNOZAN Build Q, Z 8 Ground Floor 3x30 min	**Nash equilibrium and Games 2**, *Organizer*: Giancarlo Bigi, session 366			**Variat**
	Lorenzo Lampariello, Numerically tractable optimistic bilevel problems	Vadim Shmyrev, Polyhedral complementarity algorithms for equilibrium problems	Giancarlo Bigi, Semi-infinite programming via two player generalized Nash games and saddlepoints	
Salle 21 Build G, Z 6 Intermediate 3x30 min	**Advances in DFO IV**, *Chair*: Katya Scheinberg, session 125			**DerFree**
	Krzysztof Choromanski, New methods for blackbox optimization via structured gradient estimation	Katya Scheinberg, Scaling up and Randomizing Derivative Free Optimization for Machine Learning	Prashant Palkar, Globally Convergent Simulation-Based Optimization with Integer Variables	

Specific Models, Algorithms, and Software - Friday 3:15 PM – 4:45 PM

Room	Session			
Salle 16 Build I, Z 7 2nd floor 3x30 min	**Discrete methods for data centers and graphs**, *Organizer*: Aaron Archer, session 477			**Learning**
	Philipp Keller, Overcommitment in Cloud Services - Bin Packing with Chance Constraints	Aaron Archer, Cache-aware load balancing of data center applications via balanced partitioning	Sergey Pupyrev, Compressing Graphs and Indexes with Recursive Graph Bisection	
FABRE Build J, Z 8 Ground Floor 3x30 min	**Classification, regression and clustering**, *Chair*: Dimitris Bertsimas, session 480			**Learning**
	Dimitris Bertsimas, Interpretable Machine Learning	Inácio Guimarães, Logistic Regression and Principal Curves Applied to Discriminant Analysis	James Brooks, Sufficient Conditions for L1-Norm Best-Fit Lines	
Salle 24 Build G, Z 6 3rd floor 3x30 min	**Vehicle Routing II**, *Chair*: Chris N Potts, session 412			**Logistics**
	Eduardo Uchoa, A Branch-Cut-and-Price Algorithm for the TSP with Hotel Selection	Chris Potts, Models and Algorithms for Dynamic Workforce Scheduling and Routing	Stefan Schaudt, Delivery robots, a transport innovation for the last mile	
Salle 18 Build I, Z 7 1st floor 3x30 min	**Machine Scheduling 1**, *Chair*: Renan S. Trindade, session 527			**Scheduling**
	Noam Goldberg, Maximum Probabilistic All-or-Nothing Paths and Critical Chains	Vitaly Strusevich, Max-Cost Scheduling with Controllable Processing Times and a Common Deadline	Renan Trindade, An arc-flow formulation for minimizing makespan on a batch processing machine	
Salle DENUCE Build Q, Z 8 Ground Floor 3x30 min	**Estimation and Learning for Power Systems**, *Organizer*: Javad Lavaei, session 25			**Energy**
	Yu Zhang, Performance Bound for Power System State Estimation via Conic Relaxations	Richard Zhang, Spurious Critical Points in Power System State Estimation	Ming Jin, Vulnerability analysis and robustification of power grid state estimation	
Salle 22 Build G, Z 6 2nd floor 3x30 min	**Optimization in Energy**, *Chair*: Andrea Simonetto, session 515			**Energy**
	Christiano Lyra, Upstream-downstream dynamic programming for optimization of tree-shaped flows	Milena Petkovic, Mathematical Programming for Forecasting Supplies and Demands in Gas Networks	Andrea Simonetto, Time-varying optimization: algorithms and engineering applications	
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Optimization for Energy System Planning**, *Chair*: Andrew Lu Liu, session 524			**Energy**
	Luigi Boffino, Expansion Planning of a Small Size Electric Energy System	Marion Lemery, Regaining tractability in SDDP algorithms for large energy planning problems	Andrew Liu, Capacity Expansion through Decentralized Optimization	
Salle LA4 Build L, Z 8 Basement 3x30 min	**Industrial dynamics and Environmental policy**, *Organizer*: Inmaculada Garcia Fernandez, session 392			**Sciences**
	Adriana Piazza, Dynamics of Environmental Policy	Nils-Hassan Quttineh, Challenges in Nutrient Recycling and Biogas Plant Localization	Inmaculada Garcia Fernandez, Use of dynamic programming in inventory control for perishable products	
PITRES Build O, Z 8 Ground Floor 3x30 min	**Computational Integer Programming I**, *Organizer*: Domenico Salvagnin, session 273			**Algo**
	Tobias Achterberg, Exploiting Degeneracy in MIP	Pierre Le Bodic, Online Estimation of the Size of the Branch and Bound Tree in MIP Solvers	Alinson Xavier, Multi-Row Intersection Cuts based on the Infinity Norm	

Discrete Optimization & Integer Programming - Friday 5:00 PM – 6:30 PM

Room				
Salle 34	**Machine Learning and Discrete Optimization**, *Organizer*: Sebastian Pokutta, session 308			**IPtheory**
Build B, Z 3 1st floor 4x20 min	Matteo Fischetti, Building adversarial examples in Neural Networks by Mixed Integer Optimization	Anirbit Mukherjee, Mathematics of Neural Networks	Paul Grigas, Smart “Predict, then Optimize”	Sebastian Pokutta, Lazy Conditional Gradients through Simpler Oracles
Salle 44	**Decomposition II**, *Chair*: Natashia Boland, session 487			**IPpractice**
Build C, Z 1 3rd floor 4x20 min	Andre Cire, Discrete Nonlinear Optimization by State-Space Decompositions	Jens Clausen, Strengthening of mixed integer linear program bounds using variable splitting	Cristiam Gil, A column generation based model to pickup and delivery problems with trans	Natashia Boland, Decomposition Branching for Mixed Integer Programming
Salle 36	**Dual Ascent**, *Chair*: Sara Maqrot, session 505			**IPpractice**
Build B, Z 4 Intermediate 2x20 min	Stefania Pan, A dual ascent procedure for solving the generalized set partitioning model	Sara Maqrot, Improving Wedelin's Heuristic with Sensitivity Analysis for Set Partitioning		
DURKHEIM	**Mixed-Integer PDE-Constrained Optimization** , *Organizer*: Sven Leyffer, session 63			**MINLP**
Build A, Z 1 3rd floor 3x30 min	Meenarli Sharma, Inversion of Convection-Diffusion PDE with Discrete Source	Martin Siebenborn, Shape optimization towards binary variables with PDE constraints	Mirko Hahn, Set-valued steepest descent for binary topology and control optimization	
Salle 39	**Global Optimization for nonconvex MINLPs**, *Organizer*: Hassan Hijazi, session 92			**MINLP**
Build E, Z 1 3rd floor 3x30 min	Anya Castillo, Global Optimization for AC Optimal Power Flow Applications	Harsha Nagarajan, Tight Piecewise Formulations and Algorithms for Global Optimization of MINLPs	Hassan Hijazi, Semidefinite Programming Cuts in Gravity	
Salle 35	**Recent Advances and Applications of MINLP**, *Organizer*: Jose M Ucha, session 139			**MINLP**
Build B, Z 4 Intermediate 3x30 min	Victor Blanco, Duality and multidimensional kernels in ℓ_p-Support Vector Machines	Jose Ucha, An algebraic exact method for multi-objective RAP in series-parallel systems.	Jeffrey Zhang, On Testing Attainment of the Optimal Value in Nonlinear Optimization	
LEYTEIRE	**Algorithmic Fairness and Optimization**, *Organizer*: Nisheeth K Vishnoi, session 161			**APPROX**
Build E, Z 1 3rd floor 4x20 min	Krishna Gummadi, Measuring Algorithmic (Un)Fairness via Inequality Indices	Elisa Celis, Controlling Bias in Bandit-based Personalization	Omer Reingold, Calibration for the (Computationally-Identifiable) Masses	Nisheeth Vishnoi, Fair and Diverse DPP-based Data Summarization
Salle 43	**Algorithmic Discrepancy**, *Organizer*: Nikhil Bansal, session 164			**APPROX**
Build C, Z 1 3rd floor 3x30 min	Aleksandar Nikolov, Balancing Vectors in Any Norm	Daniel Dadush, The Gram-Schmidt Walk: A cure to the Banaszczyk Blues	Rebecca Hoberg, A Fourier-Analytic Approach For Random Set systems	
SIGALAS	**Packing Steiner Trees**, *Organizer*: Stephan Held, session 260			**COMB**
Build C, Z 2 2nd floor 3x30 min	Dirk Müller, Global Routing with Timing Constraints	Pietro Saccardi, Steiner Tree Packing in Rhomboidal Tiles	Tilmann Bihler, Reach- and Direction-Restricted Rectilinear Steiner Trees	
Salle 41	**Optimization problems in graphs and related**, *Chair*: Claudio Arbib, session 423			**COMB**
Build C, Z 1 3rd floor 4x20 min	Xiucui Guan, Critical node problem based on connectivity index and properties of components	Binwu Zhang, Inverse Obnoxious Spanning Tree Problems under Hamming Distance	Ping Zhan, The random assignment problem on a full preference domain with submodular	Matteo Tonelli, On uncapacitated metric location and pricing

Optimization under Uncertainty - Friday 5:00 PM – 6:30 PM

Room				
Salle 30	**Topics in stochastic optimization**, *Chair*: Quentin Mercier, session 494			**Stoch**
Build B, Z 5 Ground Floor 3x20 min	Sakina Melloul, Flexible Multi-choice Goal Programming with Fuzzy Data	Kerstin Lux, Optimal inflow control in supply systems with uncertain demands	Quentin Mercier, A descent algorithm for stochastic multiobjective optimization problems	
Salle 37	**Robust Combinatorial Optimization II**, *Organizer*: Agostinho Agra, session 168			**Robust**
Build B, Z 4 Intermediate 4x20 min	Ayse Arslan, Robust Strategic Planning of Phytosanitary Treatments in Agriculture	Marco Silva, Exact Solution Algorithms for the Robust Total Tardiness Problem	Agostinho Agra, A Lagrangean dual model for the robust inventory problem	Yasaman Mozafari, Robust Expansion Planning of Interdependent Electricity, Gas, and Heat
Salle 33	**Wasserstein Distributionally Robust Optimization**, *Organizer*: Peyman Mohajerin Esfaha, session 448			**Robust**
Build B, Z 5 Ground Floor 3x30 min	Viet Anh Nguyen, Risk-Averse Optimization over Structured Wasserstein Ambiguity Set	Jose Blanchet, Wasserstein DRO: Modeling and Optimal Choice of Uncertainty Size	Peyman Mohajerin Esfaha, Data-driven Inverse Optimization with Imperfect Information	
Salle 31	**Tractability and approximation algorithms in dynamic programming**, *Chair*: Alexander V. Hopp, session 383			**Markov**
Build B, Z 5 Ground Floor 3x30 min	Yann Dujardin, Sample-Based Approximate GMDP Solution with Theoretical Guarantees	Giacomo Nannicini, An FPTAS for stochastic DPs with multidimensional action and scalar state	Alexander Hopp, On Friedmann's subexponential lower bound for Zadeh's pivot rule	

Room	Continuous Optimization - Friday 5:00 PM – 6:30 PM				
GINTRAC Build Q, Z 8 Ground Floor 3x30 min	**Moment relaxations for polynomial optimization with symmetries**, *Organizer*: Markus Schweighofer, session 10				**NLP**
	Frank Vallentin, Coloring the Voronoi tessellation of lattices	Cordian Riener, Semidefinite optimization and arithmetic progressions	Philippe Moustrou, The upper density of sets avoiding norm one in the real space of dimension n		
Salle KC7 Build K, Z 10 Intermediate 2 3x30 min	**Subspace methods in NLP II**, *Organizer*: Panos Parpas, session 44				**NLP**
	Panos Parpas, Distributed Subspace Decomposition	Emre Mengi, Subspace Frameworks for Eigenvalue Optimization	Jaroslav Fowkes, A block-coordinate Gauss-Newton method for nonlinear least squares		
Salle 05 Build Q, Z 11 1st floor 4x20 min	**Primal-dual and ADMM algorithms for nonlinear programming**, *Organizer*: Marco Sciandrone, session 91				**NLP**
	Ahmet Alacaoglu, Smooth Primal-Dual Coordinate Descent for Nonsmooth Convex Optimization	N. Serhat Aybat, A primal-dual algorithm for general convex-concave saddle point problems	Mario Figueiredo, ADMM with Plug-and-Play Regularizers: Convergence Guarantees and Applications	Giulio Galvan, Alternating minimization methods for constrained nonconvex optimization	
Salle 9 Build N, Z 12 4th floor 3x20 min	**Linear Optimization I**, *Chair*: Jianming Shi, session 415				**NLP**
	Zhize Li, A Fast Polynomial-time Primal-Dual Projection Algorithm for Linear Programming	Jianming Shi, A polarity-based algorithm for solving linear programming problems	Maxim Demenkov, An algorithm for linear programming based on the projection onto a zonotope		
Salle 20 Build G, Z 6 1st floor 3x30 min	**Global Optimization 1**, *Chair*: Jean-Baptist Hiriart-Urruty, session 501				**Global**
	Fabio Schoen, New clustering methods for large scale global optimization	Sergiy Butenko, Continuous Approaches to Cluster-Detection Problems in Networks	Julio González-Díaz, Computational advances in the RLT algorithms: A freely available implementation		
Salle 8 Build N, Z 12 4th floor 3x30 min	**Nonsmooth DC optimization with applications**, *Chair*: Napsu Karmitsa, session 46				**NonSmooth**
	Sona Taheri, PIECEWISE LINEAR REGRESSION VIA NONSMOOTH DC OPTIMIZATION	Kaisa Joki, Double Bundle Method for Nonsmooth DC Optimization	Napsu Karmitsa, Support vector machines for clusterwise linear regression		
Salle LC4 Build L, Z 9 Intermediate 1 3x30 min	**Nonconvex Optimization: Theory and Methods - Part 3**, *Organizer*: Genaro Lopez, session 188				**NonSmooth**
	Alexander Shtof, Globally Solving a Class of Optimal Power Flow Problems in Radial Networks	Matthew Tam, Algorithms based on unions of nonexpansive maps	Genaro Lopez, What do 'convexities' imply on Hadamard manifolds?		
Salle AURIAC Build G, Z 6 1st floor 3x30 min	**Computer-assisted analyses of optimization algorithms II**, *Organizer*: Adrien Taylor, session 16				**SDP**
	Etienne De Klerk, SDP performance analysis of inexact Newton-type methods for self-concordant func	Riley Badenbroek, A Universal Interior Point Method Using Hit-and-Run Sampling	Adrien Taylor, Worst-case analyses of stochastic gradient-based methods using SDPs		
Salle LC5 Build L, Z 10 Intermediate 1 3x30 min	**Sparse Semidefinite Programming**, *Organizer*: Somayeh Sojoudi, session 17				**SDP**
	Martin Andersen, Sparse Semidefinite Relaxations of Communicability-Based Graph Partition Problem	Cedric Josz, Lasserre hierarchy for large scale polynomial optimization	Somayeh Sojoudi, Fast Algorithms for Max-Det Matrix Completion and Graphical Lasso		
Salle 06 Build Q, Z 11 1st floor 3x30 min	**Nonlinear Optimization and Variational Inequalities IV**, *Organizer*: Cong Sun, session 144				**Variat**
	Junfeng Yang, A TVSCAD approach for image deblurring with impulsive noise	Chengjing Wang, A semismooth Newton based augmented Lagrangian method for solving SVM problems	Chao Ding, Matrix optimization in data science: recent progress on algorithm foundation		
Salle ARNOZAN Build Q, Z 8 Ground Floor 4x20 min	**Variational Analysis 2**, *Organizer*: David Salas, session 367				**Variat**
	Ba Khiet Le, Maximal Monotonicity Arising in Nonsmooth Lur'e Dynamical systems	Emilio Vilches, Lyapunov pairs for perturbed sweeping processes	Parin Chaipunya, Proximal Algorithms in Hadamard Spaces	David Salas, Quasi-Variational Inequality problems over product sets	
Salle KC6 Build K, Z 10 Intermediate 1 4x20 min	**Algorithms for Structured Statistical Optimization**, *Chair*: Ilker Birbil, session 349				**RandomM**
	Ilker Birbil, A Differentially Private Stochastic Gradient Descent Algorithm with Smoothing	Lijun Ding, Leave-one-out approach for statistical optimization	Greg Ongie, Adaptive Sampling for Online Subspace Estimation	Saeed Ghadimi, Approximation Methods for Bilevel Programming	
Salle 21 Build G, Z 6 Intermediate 2x30 min	**Derivative-free global optimization algorithms**, *Chair*: Zaikun Zhang, session 41				**DerFree**
	Limeng Liu, Optimization with global surrogate and trust-region assisted local search	Anne Auger, Benchmarking Bayesian, Derivative-Free, and Stochastic Blackbox Algorithms			

Room	Specific Models, Algorithms, and Software - Friday 5:00 PM – 6:30 PM				
FABRE Build J, Z 8 Ground Floor 4x20 min	**Spectral and Semidefinite Methods for Learning**, *Organizer*: Martin Jaggi, session 321				**Learning**
	Maryam Fazel, Competitive Online Algorithms with Application to Optimal Experiment Design	Michael Fanuel, Positive semi-definite embedding for dimensionality reduction	Kimon Fountoulakis, Variational Perspective on Local Graph Clustering	Saverio Salzo, Solving lp-norm regularization with tensor kernels	
Salle 18 Build I, Z 7 1st floor 4x20 min	**Transportation networks**, *Chair*: Bernard Gendron, session 359				**Network**
	Parisa Charkhgard, The network maintenance problem	Yasufumi Saruwatari, Airspace sectorization by set-partitioning approach	Bin Li, Joint Transceiver Optimization for Wireless Information and Energy Transfer	Bernard Gendron, Node-Based Lagrangian Relaxations for Multicommodity Network Design	
Salle 16 Build I, Z 7 2nd floor 2x20 min	**Logistics Networks**, *Chair*: El Hassan Laaziz, session 468				**Logistics**
	Yasushi Narushima, Robust supply chain network equilibrium model with random demands	Guillaume Marques, Method Benchmarking for Two-Echelon Capacitated Vehicle Routing			
Salle 23 Build G, Z 6 3rd floor 3x30 min	**Energy-aware planning and scheduling 2**, *Organizer*: Christian Artigues, session 178				**Energy**
	Paul Javal, Modelling uncertainties in short-term operational planning optimization	Aurélien Froger, Solving an electric vehicle routing problem with capacitated charging stations	Christian Artigues, Polyhedral approach for a continuous energy-constrained scheduling problem		
Salle 24 Build G, Z 6 3rd floor 3x20 min	**Stochastic Methods for Energy Optimization**, *Chair*: Tristan Rigaut, session 294				**Energy**
	Clara Lage, Stabilization of Price Signals in Energy Optimization	Guilherme Matiussi Ramalho, Stochastic Unit Commitment Problem: an Exact Probabilistic Constrained Approach	Tristan Rigaut, Long term management of energy storage using stochastic optimization		
Salle LA4 Build L, Z 8 Basement 4x20 min	**Optimization and Game Theory**, *Organizer*: Veerle Timmermans, session 402				**Sciences**
	Matthias Feldotto, Computing Approximate Pure Nash Equilibria in Shapley Value Weighted Congestion	Cosimo Vinci, Dynamic taxes for polynomial congestion games	Bjoern Tauer, Competitive Packet Routing	Veerle Timmermans, Equilibrium Computation in Atomic Splittable Polymatroid Congestion Games	
PITRES Build O, Z 8 Ground Floor 3x30 min	**Computational Integer Programming II**, *Organizer*: Domenico Salvagnin, session 274				**Algo**
	Gregor Hendel, Tighter LP relaxations for configuration knapsacks using extended formulations	Dimitrios Letsios, Lexicographic Optimization and Recovery in Two-Stage Robust Scheduling	Roland Wunderling, Dynamic Row Disablement: a practical Implementation of the Kernel Simplex Method		

Sessions with Abstracts

On the relationship between machine learning and optimization

Invited Talks
PLENARY - Mo 11:00am-12:00am, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 552
Organizer: Michel Goemans, MIT, US

1 - On the relationship between machine learning and optimization
Speaker: Francis Bach, INRIA - ENS, FR, talk 1564
Many machine learning frameworks are naturally formulated as optimization problems. Over the last few decades, this has led to fruitful exchanges between the two fields: optimization provides new learning algorithms, while machine learning requires solving new types of optimization problems with a specific structure. In this talk, I will present recent work at the interface between the two fields, highlighting the specificity of learning problems and some open problems.

What's happening in nonconvex optimization? A couple of stories

Invited Talks
KEYNOTE - Mo 1:30pm-2:30pm, Format: 1x60 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

Invited Session 536
Organizer: Jean-Baptist Hiriart-Urruty, Paul Sabatier University, FR

1 - What's happening in nonconvex optimization? A couple of stories
Speaker: Emmanuel Candes, Stanford University, US, talk 1688
Co-Authors: *Yuxin Chen*,
In recent years, there has been astounding progress in the theory and practice (algorithms, professional-grade software development, applications) of convex optimization to the point that it has become a real pillar of modern engineering. On the other hand, the field of non-convex optimization is far less mature and may draw comparisons with 17th century medicine (ad-hoc methods, no performance guarantees, unreliable results, and so on). This is unfortunate because most problems of interest to information scientists are non-convex in nature; e.g. many maximum likelihood estimates are, in fact, solutions to non-convex problems, some of which being notoriously hard. This talk will briefly review a rapidly emerging literature showing that, perhaps surprisingly, some important non-convex problems may not be as hard as they seem. We will discuss some of this exciting research emphasizing applications in signal and image processing such as phase retrieval, and in machine learning such as low-rank factorization.

Theoretical Analysis of Cutting-Planes in IP Solvers.

Invited Talks
KEYNOTE - Mo 1:30pm-2:30pm, Format: 1x60 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 538
Organizer: Gerard Cornuejols, Carnegie Mellon University, US

1 - Theoretical Analysis of Cutting-Plane Selection in IP Solvers.
Speaker: Santanu Dey, GaTech, US, talk 1595
Co-Authors: *Marco Molinaro*,
While many classes of cutting-planes are at the disposal of integer programming solvers, our scientific understanding is far from complete with regards to cutting-plane selection, that is the task of selecting a portfolio of cutting-planes to be added to the LP relaxation at a given node of the branch-and-bound tree. In order to keep the underlying linear program sparse, most commercial Mixed integer linear programming solvers consider sparsity of cuts as an important criterion for cutting-plane selection and use. The use of sparse cutting-planes may be viewed as a compromise between two competing objectives. On the one hand, the use of sparse cutting-planes aids in solving the linear programs encountered in the branch-and-bound tree faster. On the other hand, it is possible that important facet-defining or valid inequalities for the convex hull of the feasible solutions are dense and thus without adding these cuts, one may not be able to attain significant integrality gap closure. We analyze various aspects of sparsity in cutting-plane selection and use.

Multiobjective Optimization with PDE Constraints

Invited Talks
SEMI - Mo 1:30pm-2:30pm, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 550
Organizer: Stephen Wright, U Wisconsin-Madison, US

1 - Multiobjective Optimization with PDE Constraints
Speaker: Michael Hintermüller, WIAS Berlin, DE, talk 1687
Motivated by engineering applications, but in particular also by applications in economics, where multi-agent market models integrate the physics of underlying processes (e.g., leading to spot markets with transport in connection with production and distribution of gas through a network of pipelines), gener-

alized Nash games with partial differential equations (PDEs) and further private as well as global constraints are considered. The PDE typically models the underlying physics, may be subject to further constraints on the physical state and is influenced by the individual agents through their decision making process. The talk addresses some mathematical modeling issues with a particular focus on the interplay of constraint types and underlying topologies in infinite dimensions and the analysis of existence of Nash equilibria. It also includes aspects of an efficient numerical treatment of the problem class. Concerning the latter, path-following semi smooth Newton schemes are highlighted as they exhibit mesh independent convergence upon discretizing the original infinite dimensional problem. With respect to path-following techniques, sensitivity based Moreau-Yosida approaches, e.g. suitable for pointwise constraints on the state or its derivatives, will be intertwined with Nikaido-Isoda techniques for addressing the underlying game structure. Some numerical results for model problems, but also for a simplified spot market model with transport will be reported on. The talk closes by an outlook on possible future research in the field.

Polynomial and tensor optimization I

Continuous Optimization
NLP - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

Invited Session 5
Organizer: Jiawang Nie, Univ. of California San Diego, US

1 - Sparse Polynomial Interpolation: Compressed Sensing, Super-resolution, or Prony?
Speaker: Jean Lasserre, CNRS, FR, talk 309
Co-Authors: *Cedric Josz*, *Bernard Mourrain*,
We show that the sparse polynomial interpolation problem reduces to a discrete super-resolution problem on the n-dimensional torus. Therefore the semidefinite programming approach initiated by Candes and Fernandez-Granda in the univariate case (and later extended to the multi-variate setting) can be applied. In particular, exact recovery is guaranteed provided that a geometric spacing condition on the support holds and the number of evaluations are sufficiently many (but not many). It also turns out that the (compressed sensing) LP-formulation of ℓ_1-norm minimization is also guaranteed to provide exact recovery provided that the evaluations are made in a certain manner and even though the Restricted Isometry Property for exact recovery is not satisfied. (A naive compressed sensing LP-approach does not offer such a guarantee.) Finally we also describe the algebraic Prony method for sparse interpolation, which also recovers the exact decomposition but from less point evaluations and with no geometric spacing condition. We also compare the three techniques on some numerical experiments.

2 - Eigenvalues inequalities for nonnegative tensors and their tropical analogues
Speaker: Stephane Gaubert, INRIA, FR, talk 1415
Co-Authors: *Shmuel Friedland*,
We extend characterizations and inequalities for the eigenvalues of nonnegative matrices, such as Donsker-Varadhan, Friedland-Karlin, Karlin-Ost, and Kingman inequalities, to nonnegative tensors. To this end, we relate the spectral theory of nonnegative tensors to risk-sensitive control, showing that the spectral radius coincides with the value of an ergodic problem. As a limiting case, we characterize the spectral radius of a tropical tensor as the mean payoff of a one player stochastic game, and provide inequalities relating the spectral radius to its tropical analogue.

3 - Signal Denoising, Tensors and Singular Values
Speaker: Harm Derksen, University of Michigan, US, talk 318
Co-Authors: *Neriman Tokcan*,
I will introduce a model for signal and image denoising that can be formulated in terms of two competing norms on a vector space. The problem of denoising becomes a convex optimization problem. This model also applies to tensors and can be used to find a low tensor rank decomposition using the heuristic of convex relaxation. With this approach we can generalize the notion of singular values of a matrix to the singular spectrum of a tensor.

Progress in Algorithms for Optimal Power Flow Problems I

Specific Models, Algorithms, and Software
Energy - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 8
Organizer: Miguel Anjos, Polytechnique Montreal, CA

1 - Solving an Optimal Power Flow (OPF) problem with preventive security constraints
Speaker: Manuel Ruiz, RTE, FR, talk 1237
Co-Authors: *Julie Sliwak*, *Miguel Anjos*, *Lucas Letocart*, *Emiliano Traversi*,
Power systems optimization problems being mathematically challenging, ARPA-E (Advanced Research Projects Agency-Energy) organizes the Grid Optimization Competition to accelerate the development of methods for solving these problems. As grid flexibility, reliability and safety are taking greater importance within the context of energy transition, the problem selected in the Phase 0 of the competition is the Preventive Security Constrained Optimal Power Flow (PSCOPF). Besides inheriting the OPF's nonlinearity and nonconvexity, this problem aims at anticipating credible contingency cases, which means considering simultaneously several configurations of the power network. The PSCOPF actually involves several non-separable variants of the OPF problem in the same optimization problem. Indeed, all injection variables in a contingency case depend on the base case variables. In this work, feasible solutions are computed using nonlinear interior point methods. These solutions are local optima and lower bounds are computed using state-of-the-art convex relaxations for OPF (the rank-one SDP relaxation, SOCP or moment relaxations) to evaluate their quality. Results on the Grid Optimization Competition datasets from 14 to 179 buses and from 1 to 50 contingencies are presented. All the implementations are based on a Julia modeler for polynomial optimization problems with bounded complex variables.

2 - Tight-and-Cheap Conic Relaxation for the AC Optimal Power Flow Problem

Speaker: Miguel Anjos, Polytechnique Montreal, CA, talk 256
Co-Authors: *Christian Bingane*, *Sébastien Le Digabel*,
The classical alternating current optimal power flow problem is highly nonconvex and generally hard to solve. Convex relaxations, in particular semidefinite, second-order cone, convex quadratic, and linear relaxations, have recently attracted significant interest. The semidefinite relaxation is the strongest among them and is exact for many cases. However, the computational efficiency for solving large-scale semidefinite optimization is lower than for second-order cone optimization. We propose a conic relaxation obtained by combining semidefinite optimization with the reformulation-linearization technique, commonly known as RLT. The proposed relaxation is stronger than the second-order cone relaxation and nearly as tight as the standard semidefinite relaxation. Computational experiments using standard test cases with up to 6515 buses show that the time to solve the new conic relaxation is up to one order of magnitude lower than for the standard semidefinite relaxation.

3 - Coordinated Planning and Operation of M-FACTS and Transmission Switching

Speaker: Mostafa Sahraei Ardakani, University of Utah, US, talk 169
Co-Authors: *Yuanrui Sang*,
High congestion costs demand for more efficient utilization of the transmission system. Transmission switching (TS) and modular FACTS (M-FACTS) devices are two technologies that provide such efficiency gains through controlling the power flows. In order to capture the full benefit of these technologies, it is essential to acknowledge the interdependence between them. However, integration of M-FACTS and TS within optimal power flow (OPF) adds numerous integer variables to the model, which produces challengingly large mixed-integer optimization problems. This presentation will discuss a method, to exploit the structure of power flows and eliminate M-FACTS integer variables at the operation stage. Furthermore, the presentation will introduce heuristics to substantially reduce the remaining integer variables both in planning and operation models. The resulting computationally-efficient OPF framework enables coordinated planning and operation of M-FACTS and TS. The simulation results suggest that: 1) substantial economic savings can be achieved through utilization of both TS and M-FACTS, beyond the independent capabilities of each technology; 2) performing TS actions affect the optimal location and set point of M-FACTS devices; and 3) operation of M-FACTS devices affect the location and frequency of TS actions. It is, thus, essential to acknowledge the interdependence between the two technologies, via computationally-efficient models. Failure to do so will lead to economic inefficiencies that can be avoided through co-optimization of generation dispatch, TS, and M-FACTS.

Exact Optimization Algorithms for Compressed Sensing

Discrete Optimization & Integer Programming
MINLP - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1
Invited Session 56

Organizer: Marc Pfetsch, TU Darmstadt, DE

1 - A primal-dual homotopy algorithm for sparse recovery with inf. norm constraints

Speaker: Christoph Brauer, TU Braunschweig, DE, talk 200
Co-Authors: *Dirk Lorenz*, *Andreas Tillmann*,
We propose a primal-dual homotopy method for l1-minimization problems with infinity norm constraints in the context of sparse reconstruction. The natural homotopy parameter is the value of the bound for the constraints and we show that there exists a piecewise linear solution path with finitely many break points for the primal problem and a respective piecewise constant path for the dual problem. We show that by solving a small linear program, one can jump to the next primal break point and then, solving another small linear program, a new optimal dual solution is calculated which enables the next such jump in the subsequent iteration. Using a theorem of the alternative, we show that the method never gets stuck and indeed calculates the whole path in a finite number of steps. Numerical experiments demonstrate the effectiveness of our algorithm. In many cases, our method significantly outperforms commercial LP solvers; this is possible since our approach employs a sequence of considerably simpler auxiliary linear programs that can be solved efficiently with specialized active-set strategies.

2 - SparkMIP: Mixed-Integer Programming for the (Vector) Matroid Girth Problem

Speaker: Andreas Tillmann, RWTH Aachen University, DE, talk 593
We investigate the NP-hard problem of computing the spark of a matrix (i.e., the smallest number of linearly dependent columns), a key parameter in compressed sensing and sparse signal recovery. To that end, we identify polynomially solvable special cases, gather upper and lower bounding procedures, and propose several exact (mixed-)integer programming models and linear programming heuristics. In particular, we develop a branch-and-cut scheme to determine the girth of a matroid, focussing on the vector matroid case, for which the girth is precisely the spark of the representation matrix. Extensive numerical experiments demonstrate the effectiveness of our specialized algorithms compared to general-purpose black-box solvers applied to several mixed-integer programming models.

3 - Complex-valued ℓ_0 minimization problems with constant modulus constraints

Speaker: Frederic Matter, TU Darmstadt, DE, talk 380
Co-Authors: *Tobias Fischer*, *Ganapati Hegde*, *Marius Pesavento*, *Marc Pfetsch*, *Andreas Tillmann*,
We consider the problem of finding complex-valued least squares solutions with the additional constraint that each entry of the solution is either zero or has a constant modulus of one. As a generalization of compressed sensing, we are interested in sparse solutions that fulfill a given bound for the least squares error. We use an ℓ_0-term as objective function and add the bound for the least squares error as a constraint. This problem can be cast as a real-valued MINLP and we use a spatial branch-and-cut approach to solve it with the framework SCIP. As the constant modulus constraints are nonconvex, we develop a specialized branching and propagation method to efficiently handle these constraints. In order to find a good initial primal solution, we present a heuristic. For a demonstration of the effectiveness of our method, we look at the problem of joint antenna selection and phase-only

beamforming and present numerical results for this application.

Mixed-integer derivative-free optimization

Continuous Optimization
DerFree - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 80
Chair: Clément Royer, UW-Madison, US

1 - Underlying algorithms and theory to our approach to MINLP without derivatives
Speaker: Andrew Conn, IBM T. J. Watson Res. Center, US, talk 1134
Co-Authors: *Delphine Sinoquet*, *Claudia D'Ambrosia*, *Leo Liberti*,
For a variety of reasons we have favoured trust region approaches to derivative-free optimization. In this talk we will discuss the extensions we needed to handle binary variables, how they align with our general convergence and issues related to exploiting the structure present as well as difficulties that arise. These include restricting the quadratic models, solving mixed integer quadratic programs and handling well-poisedness. Whereas we are, by design, content to obtain local minima with respect to the continuous variables, of necessity we have to address globality with respect to the binary variables, which can be a significant issue since the problems we typically wish to address involve expensive simulations.
2 - Benchmark of a trust region method for solving black-box mixed-integer problems
Speaker: Delphine Sinoquet, IFPEN, FR, talk 610
Co-Authors: *Andrew Conn*, *Claudia D Ambrosio*, *Leo Liberti*,
Many engineering applications of optimization involve expensive-to-evaluate simulators, often considered as black-boxes because of the complexity of the underlying equations and the unavailability of any derivatives. Generally, few variables are considered (tens of variables) in such optimizations but they can be of different natures: continuous and discrete. To solve these problems, we designed a trust region derivative-free method extended to mixed continuous-discrete variables. In this talk, the results of this method applied on several benchmarks of functions (analytic and "real" simulation based) are presented and compared with results obtained by mesh adaptive search method NOMAD and global surrogate optimization methods based on radial basis functions and Gaussian processes.
3 - A unified approach for solving mixed integer Box-Constrained optimization
Speaker: Ubaldo Garcia Palomares, Universidade de Vigo, ES, talk 750
This talk is mainly based on [1], which is an outgrowth of works devoted to the application of non monotone Direct Search Methods (DSMs) to locate the global minimum of an objective function subjected to bounds on its variables. We show how easy it is to adapt DSMs when discrete variables regularly spaced on a grid are present. As expected the construction of the search directions plays a fundamental role. It is theoretically possible to search on directions that modify all variables at once, but at all iterations function evaluations are carried out only on discrete feasible points, avoiding spurious computations on non feasible points. We also applied the method to a discretized continuous problem with encouraging results. Preliminary computational results on bound constraints models are shown. [1] Unified approach for solving Box-Constrained models with continuous or discrete variables by Non monotonous DSMs accepted in Optimization Letters

Geometry of Polynomials and Applications in Approximate Counting

Discrete Optimization & Integer Programming
APPROX - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 99
Organizer: Shayan Oveis Gharan, University of Washington, US

1 - On a conjecture of Sokal on the location of roots of the independence polynomial
Speaker: Guus Regts, University of Amsterdam, NL, talk 296
Co-Authors: *Han Peters*, *Viresh Patel*,
Sokal conjectured about 17 years ago that there exists an open region D in the complex plane that contains the interval $[0, \lambda_\Delta)$ where $\lambda_\Delta = \frac{(\Delta-1)^{\Delta-1}}{(\Delta-2)^\Delta}$ such that the independence polynomial of any graph of maximum degree at most Δ does not vanish on D. In joint work with Han Peters we have settled this conjecture using complex dynamical systems. In this talk I will explain the connection between zeros of the independence polynomial and complex dynamical systems and give some ideas of our proof of this result. I will also explain how, based on joint work with Viresh Patel, building on a recent line of work initiated by Barvinok, this result yields an efficient algorithm for approximating evaluations of the independence polynomial on D. I will end the talk with some open problems relating the location of the roots of the independence polynomial and the complexity of approximating evaluations of the independence polynomial.
2 - Zeros of polynomials and Ising partition functions
Speaker: Piyush Srivastava, TIFR Mumbai, IN, talk 949
Co-Authors: *Jingcheng Liu*, *Alistair Sinclair*,
This talk presents a recent method proposed by Alexander Barvinok which uses the analyticity of the free energy in the complex plane to design algorithms for the approximation of partition functions. We then look at connections of this work with the classical Lee-Yang theory to give new algorithms for the approximation of the ferromagnetic Ising partition functions in settings where rigorous analyses of algorithms based on traditional ideas such as decay of correlations or Markov chain Monte Carlo are not yet available. Based on joint work with Jingcheng Liu and Alistair Sinclair, an extended abstract of which appeared in the proceedings of IEEE FOCS, 2017.
3 - A Deterministic Approximation Algorithm for Counting Bases of Matroids
Speaker: Nima Anari, Stanford University, US, talk 791
Co-Authors: *Shayan Oveis Gharan*, *Cynthia Vinzant*,
We give a deterministic $2^{O(\text{rank})}$ approximation algorithm to

count the number of bases of a given matroid and the number of common bases of any two matroids. Based on a lower bound of Azar et al., this is almost the best possible result assuming oracle access to independent sets of matroids. There are two main ingredients in our result: For the first ingredient, we build upon recent results of Huh et al. and Adiprasito et al. on combinatorial hodge theory to derive a connection between matroids and log-concave polynomials. We expect that several new applications in approximation algorithms will be derived from this connection in future. Formally, we prove that the multivariate generating polynomial of the bases of any matroid is log-concave as a function over the positive orthant. For the second ingredient, we develop a general framework for approximate counting in discrete problems, based on convex optimization. The connection goes through subadditivity of the entropy. For matroids, we prove that an approximate superadditivity of the entropy holds, by relying on log-concavity of the corresponding polynomials.

Using SDP relaxations and solving them faster

Continuous Optimization
SDP - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 20 Building: G, 1st floor, Zone: 6

Invited Session 113
Organizer: Elisabeth Gaar, AAU Klagenfurt, AT

1 - Exact SDPs for a Class of (Random and Non-Random) Nonconvex QCQPs
Speaker: Samuel Burer, University of Iowa, US, talk 98
Co-Authors: *Yinyu Ye*,
We study a class of quadratically constrained quadratic programs (QCQPs), called diagonal QCQPs, which contain no off-diagonal terms, and we provide a sufficient condition on the problem data guaranteeing that the basic Shor semidefinite relaxation is exact. Our condition complements and refines those already present in the literature and can be checked in polynomial time. We then extend our analysis from diagonal QCQPs to general QCQPs, i.e., ones with no particular structure. By refor- mulating a general QCQP into diagonal form, we establish new sufficient conditions for the semidefinite relaxations of general QCQPs to be exact. Finally, these ideas are extended to show that a class of random general QCQPs has exact semidefinite relaxations with high probability as long as the number of variables is significantly larger than the number of constraints. To the best of our knowledge, this is the first result establishing the exactness of the semidefinite relaxation for random general QCQPs.

2 - SDP Based Solution Methods for Binary Quadratic Problems
Speaker: Nicolo Gusmeroli, AAU - Klagenfurt, AT, talk 378
Co-Authors: *Angelika Wiegele*, *Franz Rendl*,
Binary quadratic programs (BQP) with equality constraints have a convex quadratic function, linear equality constrains and binary variables. Many problems, like Max-Cut, k-cluster, ... can be modeled as BQP. A wide range of solution techniques were proposed and studied in the past in order to solve the problem either to optimality or with heuristics. We present some approaches such as exact penalization methods, branch and bound and a bundle algorithm in combination with semidefinite relaxations. Then we see the possible combinations between them in order to obtain practical results. In this talk we explain some of the choices throughout the algorithms and we exploit their practical performance, relating it with computational time for some testbed examples. Furthermore we compare our results for the binary quadratic problem with other approaches, first for unconstrained problems and then to instances with equality constraints.

3 - Sieve-SDP: A simple facial reduction algorithm to preprocess SDPs
Speaker: Yuzixuan Zhu, University of North Carolina, US, talk 317
Co-Authors: *Gabor Pataki*, *Quoc Tran-Dinh*,
We introduce Sieve-SDP, a simple algorithm to preprocess semidefinite programs (SDPs). Sieve-SDP belongs to the class of facial reduction algorithms. It inspects the constraints of the problem, deletes redundant rows and columns, and reduces the size of the variable matrix. It often detects infeasibility. It does not rely on any optimization solver: the only subroutine it needs is Cholesky factorization, hence it can be implemented in a few lines of code in machine precision. We present extensive computational results on several problem collections from the literature. We also highlight an issue arising in SDPs with positive duality gap: on such problems SDP solvers may compute a "fake" solution with an arbitrarily small constraint violation, and arbitrarily small duality gap.

Tight relaxations in nonconvex MINLP

Discrete Optimization & Integer Programming
MINLP - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 128
Organizer: Ambros Gleixner, Zuse Institute Berlin, DE

1 - Using mixed volume theory to compute convex hull volume for trilinear monomials
Speaker: Emily Speakman, Otto von Guericke University, DE, talk 878
Co-Authors: *Gennadiy Averkov*,
Speakman and Lee (2017) gave a formula for the volume of the convex hull of the graph of a trilinear monomial, $y = x_1 x_2 x_3$, in terms of the (non-negative) upper and lower bounds on the variables. This was done in the context of using volume as a measure for comparing alternative convexifications and therefore to guide the implementation of spatial branch and bound for mixed integer nonlinear optimization problems. Here, we introduce an alternative method for computing this volume, making use of the rich theory of mixed volumes. This new method may also lead to a more natural approach for considering the problem in higher dimensions.

2 - Revising the handling of nonlinear constraints in SCIP
Speaker: Stefan Vigerske, GAMS Software GmbH, DE, talk 1005
Co-Authors: *Benjamin Müller*, *Felipe Serrano*, *Fabian Wegscheider*,
We discuss ongoing work on renovating the handling of non-

linear constraints in SCIP. The new design aims to improve numerical robustness and performance. Further, it simplifies the addition of new mathematical operators and structure-specific solution algorithms (convexification, bound tightening, etc.), thus turning SCIP into an even more flexible framework to experiment with new ideas for tighter relaxations of MINLPs.

3 - Two-dimensional Projections for Separation and Propagation of Bilinear Terms

Speaker: Ambros Gleixner, Zuse Institute Berlin, DE, talk 1248

Co-Authors: *Benjamin Müller*, *Felipe Serrano*,

One of the most fundamental ingredients in mixed-integer nonlinear programming solvers is the well-known McCormick relaxation for a bilinear product of two variables x and y over a box-constrained domain. The starting point of this talk is the fact that these may be far from tight if the feasible region and its convexification projected in the x-y-space is a strict subset of the box. We develop an algorithm that solves a sequence of linear programs in order to compute globally valid inequalities on x and y in a similar fashion as optimization-based bound tightening. These valid inequalities allow us to exploit polyhedral results from the literature in order to strengthen the LP relaxation and improve feasibility-based bound tightening. We use the MINLP solver SCIP to analyze the impact of the procedure for solving instances of the MINLPLib2 to global optimality.

Proximal Methods for Structured Problems

Continuous Optimization

Variat - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 147

Organizer: Ting Kei Pong, HK Polytechnic University, HK

1 - A successive DC approximation method for nonconvex nonsmooth optimization

Speaker: Tianxiang Liu, PolyU, HK, talk 75

Co-Authors: *Ting Kei Pong*, *Akiko Takeda*,

In this talk, we consider a class of nonconvex nonsmooth optimization problems whose objective is the sum of a nonnegative smooth function and a brunch of nonnegative possibly nonsmooth functions, some of which are composed with linear maps. This kind of problems arises in variant applications and is challenging due to the coupled nonsmooth functions. To solve it, we propose a successive difference-of-convex approximation method, in which we approximate the nonsmooth functions by their Moreau envelopes and make use of the DC structure of the Moreau envelope. We prove the convergence of the method to a stationary point of the objective under suitable assumptions and discuss how the method can be applied to concrete applications. Finally, numerical simulations are shown to illustrate the performance of the method.

2 - Cubic Regularization Revisited: Faster (Local) Rates under Weaker Assumptions

Speaker: Man-Chung Yue, Imperial College London, GB, talk 48

Co-Authors: *Zirui Zhou*, *Anthony So*,

We revisit the cubic regularization (CR) method for solving smooth non-convex optimization problems and study its local convergence behaviour. In their seminal paper, Nesterov and Polyak showed that the sequence of iterates of the CR method converges quadratically a local minimum under a stringent non-degeneracy assumption that requires the local minimum to be isolated. However, many optimization problems from applications, e.g. phase retrieval and low-rank matrix recovery, have non-isolated local minima. For problems with degenerate local minima, they also obtained weaker results that the sequence of function values enjoys a superlinear convergence of order 4/3 (resp. 3/2) if the function is gradient dominated (resp. star-convex and globally non-degenerate). Motivated by these local convergence results, we propose a local error bound (EB) condition and show that the sequence of iterates of the CR method converges quadratically to a local minimum under the EB condition. Furthermore, we establish the equivalence between our EB condition and a quadratic growth condition. Using this equivalence, we prove that our EB condition holds if the function is gradient dominated or star-convex and globally non-degenerate, thus improving the results of Nesterov and Polyak. Finally, we apply our results to two concrete non-convex optimization problems that arise from phase retrieval and low-rank matrix recovery. For both problems, we prove that with overwhelming probability, the local EB condition is satisfied and the CR method converges quadratically to a global optimizer.

3 - Iteratively reweighted l1 algorithms with extrapolation

Speaker: Ting Kei Pong, HK Polytechnic University, HK, talk 17

Co-Authors: *Peiran Yu*,

Iteratively reweighted l1 (IRL1) algorithm is a popular algorithm for solving a large class of optimization problems whose objective is the sum of a Lipschitz differentiable loss function and a possibly nonconvex sparsity inducing regularizer. Motivated by the success of extrapolation techniques in accelerating first-order methods, in this talk, we explore how widely used extrapolation techniques such as those in FISTA can be incorporated to possibly accelerate the IRL1 algorithm. We will present three versions of such algorithms, discuss their convergence and compare their numerical performance against some other popular first-order methods. This is joint work with Peiran Yu.

Algorithms for optimization and variational problems with possibly nonisolated solutions I

Continuous Optimization

Variat - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Invited Session 152

Organizer: Andreas Fischer, TU Dresden, DE

1 - A special complementarity function revisited

Speaker: Nico Strasdat, TU Dresden, DE, talk 229

Co-Authors: *Roger Behling*, *Andreas Fischer*, *Klaus Schönefeld*,

Recently, a local framework of Newton-type methods for constrained systems of equations has been developed which, applied to the solution of Karush-Kuhn-Tucker (KKT) systems, enables local quadratic convergence under conditions that allow nonisolated and degenerate KKT points. This result is based on a reformulation of the KKT conditions as a constrained piecewise smooth system of equations. It is an open question whether a comparable result can be achieved for other (not piecewise smooth) reformulations. It will be shown that this is possible if the KKT system is reformulated by means of the Fischer-Burmeister complementarity function under conditions that allow degenerate KKT points and nonisolated Lagrange multipliers. To obtain this result, novel constrained Levenberg-Marquardt subproblems are introduced which allow significantly longer steps for updating the multipliers. Based on this, a convergence rate of at least 1.5 is shown.

2 - Critical solutions of nonlinear equations: attraction for Newton-type methods

Speaker: Alexey Izmailov, Moscow State University, RU, talk 108

Co-Authors: *Aleksey Kurennoy*, *Mikhail Solodov*,

It is known that when the set of Lagrange multipliers associated with a stationary point of a constrained optimization problem is not a singleton, this set may contain so-called critical multipliers. This special subset of Lagrange multipliers defines, to a great extent, the stability pattern of solution in question subject to perturbations of the problem data, and the behavior of Newton-type methods. Criticality of a Lagrange multiplier can be equivalently characterized by the absence of the local Lipschitzian error bound in terms of the natural residual of the optimality system, and this view of criticality serves as a basis for extension of this concept to general nonlinear equations (not necessarily with primal-dual optimality structure). This extension is of special interest when the solution in question can be nonisolated (and in particular, singular). We demonstrate that under some natural condition, various Newton-type methods have large domains of attraction to critical solutions. Apart from other things, the new results obtained on this give a new understanding of critical Lagrange multipliers and their properties, from some more general principles.

3 - Local attraction of Newton methods to critical solutions of constrained systems

Speaker: Andreas Fischer, TU Dresden, DE, talk 230

Co-Authors: *Alexey Izmailov*, *Mikhail Solodov*,

For a smooth system of equations subject to convex constraints with nonempty interior, we investigate the behavior of a family of Newton-type methods in the neighborhood of a nonisolated solution. There are several results on the superlinear convergence of such methods if a Lipschitzian error bound at the solution holds. In contrast to this, we are interested in situations where this error bound is violated. Instead of a Lipschitzian error bound, we assume that the equation mapping is 2-regular at some specfic solution with respect to a direction in the null space of the Jacobian. If this direction is strictly feasible, we can show that there is a domain of starting points from which the Newton-type methods are well-defined and converge linearly to the specific solution, interestingly despite the fact that this solution is nonisolated. Finally, the application of the result to reformulations of the nonlinear complementarity problem will be sketched.

Approximate dynamic programming

Optimization under Uncertainty

Markov - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 31 Building: B, Ground Floor, Zone: 5

Invited Session 159

Organizer: David Brown, Duke University, US

1 - Information Relaxation Bounds for Partially Observed Markov Decision Processes

Speaker: Martin Haugh, Imperial College London, GB, talk 314

Co-Authors: *Octavio Ruiz-Lacedelli*,

Partially observed Markov decision processes (POMDPs) are an important class of control problems that are generally intractable and so we must be satisfied with (hopefully) good sub-optimal policies. But how do we evaluate the quality of these sub-optimal policies? This question has been addressed in recent years in the MDP literature through the use of information relaxation based duality where the non-anticipativity constraints are relaxed but a penalty is imposed for violations of these constraints. In this paper we extend the information relaxation approach to POMDPs. It is of course well known that a POMDP can be formulated as an MDP and so the previously developed theory for MDPs also applies to POMDPs. But constructing dual bounds in practice is challenging in most POMDP settings and the nature of the challenge depends on how the POMDP is formulated. If we work with explicit dynamics for the hidden state transitions and observations then the evaluation of so-called dual feasible penalties requires the evaluation of expectations that in general are not available explicitly and are strongly action-dependent. If instead we work with the belief-state formulation of the POMDP then there is no difficulty in evaluating these expectations but the inner problems that arise in the information relaxation framework become intractable. We circumvent both problems using a recently developed change-of-measure approach and show that it works well in applications from robotic navigation and telecommunications. Our approach can easily be extended to other non-Markovian settings.

2 - Approximate Dynamic Programming for Dynamic Assortment Optimization

Speaker: Huseyin Topaloglu, Cornell Tech, US, talk 1280

Co-Authors: *Mika Sumida*, *Paat Rusmevichientong*,

We consider multi-product dynamic assortment problems. We have limited inventories for the products. Customers arrive randomly over time. Each customer is offered an assortment of products. She chooses within the offered assortment or decides to leave without a purchase according to a certain choice model. The goal is to find a policy to decide which assortment to offer to each customer to maximize the total expected revenue over a finite selling horizon. The dynamic programming formulation of the problem involves a high-dimensional state variable, which keeps track of the remaining inventories of the products. We present a tractable approach to compute a policy that is guaranteed to obtain at least 50**3 - Approximations to Stochastic Dynamic Programs via Information Relaxation Duality**

Speaker: David Brown, Duke University, US, talk 1284

Co-Authors: *Santiago Balseiro*,

In the analysis of complex stochastic dynamic programs, we often seek strong theoretical guarantees on the suboptimality of heuristic policies. One technique for obtaining performance bounds is perfect information analysis: this approach provides bounds on the performance of an optimal policy by considering a decision maker who has access to the outcomes of all future uncertainties before making decisions, i.e., fully relaxed nonanticipativity constraints. A limitation of this approach is that in many problems perfect information about uncertainties is quite valuable and thus the resulting bound is weak. In this paper we study the information relaxation duality approach developed in Brown, Smith, and Sun (2010) to show that by including a penalty that punishes violations of these nonanticipativity constraints, we can derive stronger analytical bounds on the suboptimality of heuristic policies in stochastic dynamic programs that are too difficult to solve. The general framework we develop ties the heuristic policy and the performance bound together explicitly through the use of an approximate value function: heuristic policies are greedy with respect to this approximation, and penalties are also generated in a specific way using this approximation. We demonstrate the use of this technique on stochastic knapsack problems and sequential search problems and show in each problem that the greedy heuristic policy is asymptotically optimal in specific "large" regimes of interest.

MINLP methods in gas transport optimization (I)

DISCRETE OPTIMIZATION & INTEGER PROGRAMMING
MINLP - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4

INVITED SESSION 162
Organizer: Lars Schewe, FAU, DE

1 - MIP techniques for instationary gas transport optimization and gas market models
Speaker: Lars Schewe, FAU, DE, talk 1298
In this talk, we present exact MIP techniques for MINLP, which were developed to solve problems in gas transport optimization. The core idea is to relax the nonlinear constraints describing the gas physics with piecewise-linear relaxations. In this talk, we show how these methods can be used to tackle both instationary gas transport optimization problems and also multilevel gas market models. The focus of the talk is on provable results, but we will also show computational results on benchmark instances.

2 - Solving MINLPs by Simultaneous Convexification with Application to Gas Networks
Speaker: Nick Mertens, TU Dortmund, DE, talk 742
Co-Authors: *Maximilian Merkert*, *Dennis Michaels*, *Frauke Liers*, *Alexander Martin*,
An important step in general mixed-integer nonlinear optimization is the design of convex relaxations of the feasible set. This is usually done by using convex underestimators of all constraints separately. A tighter representation can be found by considering more than one constraint at a time via so called simultaneous convexification. Based on existing results, a separation method for the convex hull of constrained sets is presented in this talk. It relies on determining the convex envelope of linear combinations of the constraints and on solving a non-smooth convex problem. The structure of the convex envelope of specific absolute value functions is derived and used to apply the separation method to gas network optimization.

3 - Complementarity-Based Nonlinear Programming Techniques for Optimal Mixing in Gas
Speaker: Falk Hante, FAU Erlangen-Nürnberg, DE, talk 1288
Co-Authors: *Martin Schmidt*,
We consider nonlinear and nonsmooth mixing aspects in gas transport optimization problems. Since mixed-integer reformulations of pooling-type mixing models already render small-size instances intractable, we investigate the applicability of smooth nonlinear programming techniques for equivalent complementarity-based reformulations. In particular we apply an inverse parametric quadratic programming approach to obtain complementarity-based reformulations of the mixing equations. In contrast to a more compact complementarity-based reformulation, this approach retains classical stationarity concepts as a necessary optimality condition for the resulting problem. We present a computational study that was performed on publicly available data of real-world size problem instances from steady-state gas transport. Our numerical results show that both complementarity-based models outperform the mixed-integer reformulation significantly and that the complementarity-based problem featuring classical stationarity can be solved more reliable.

Preference robust optimization

OPTIMIZATION UNDER UNCERTAINTY
ROBUST - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

INVITED SESSION 166
Organizer: Erick Delage, HEC Montréal, CA

1 - Robust choice with multi-attribute quasi-concave choice functions
Speaker: William Haskell, National Univ. of Singapore, SG, talk 1168
Co-Authors: *Wenjie Huang*, *Huifu Xu*,
Decision maker's preferences are usually captured by some form of choice function which is used to rank prospects. We consider the problem of ambiguity in choice functions with a multi-attribute prospect space. Our main result is a robust preference model where the optimal decision is based on the worst-case choice function from an ambiguity set constructed by preference elicitation on pairwise comparisons. In contrast to existing research where choice functions are assumed to be convex, we consider quasi-concave choice functions and use their support functions to develop a tractable formulation for the robust choice function via mixed integer linear programming. Moreover we develop a general representation result that covers this class of choice functions as well as many others including multivariate expected utility and aspirational preferences. We demonstrate the effectiveness of our approach on a security budget allocation problem.

2 - Optimizing aspirational preferences when the choice of a measure is ambiguous
Speaker: Jonathan Li, Telfer School of Management, CA, talk 1409
Co-Authors: *Erick Delage*,
Aspirational preferences describe a general class of prefer-

ences over random payoffs where diversification is preferred for payoffs satisfying certain aspiration levels and concentration is preferred otherwise. While such class of preferences are potentially more realistic (than for example pure diversification preferences), it is unclear how to find a functional representation, i.e. a measure, that accurately capture such preferences for individuals. In this work, we consider the case where some preference information can be elicited from individuals and propose a robust performance criterion that is fully consistent with the available preference information. In particular, our criterion, which we call preference robust aspirational measure, is robust in the sense that it would never assign a higher value (in terms of certainty equivalent) than the value prescribed by the "true" unknown aspirational preference. We also show how such robust measure can be amenable to large-scale optimization.

3 - Utility-based Shortfall Risk Models when Preference Information is Incomplete

Speaker: Erick Delage, HEC Montréal, CA, talk 1081

Co-Authors: *Shaoyan Guo*, *Huifu Xu*,

Utility-based shortfall risk measures are proposed by Föllmer and Schied and have received an increasing amount of attention over the past few years for their potential to quantify more accurately the risk of large losses than conditional value at risk. In this paper, we consider the case when the true utility/loss function cannot be specified either because there is missing information about how the decision maker perceives risk, or because he/she is simply hesitant about it. We propose a preference robust shortfall risk model that exploits empirical data about subjective judgements to construct a set of plausible utility-based loss functions and suggest minimizing shortfall risk as measured using the worst loss function from this set. We develop tractable reformulations when the underlying probability distribution is discrete. In the case when the probability distribution is continuous, we propose a sample average approximation scheme and show that its optimal solution and value converges to the true ones as the sample size increases.

Nonconvex Optimization: Theory and Methods - Part 1

Continuous Optimization

NonSmooth - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 184

Organizer: Shoham Sabach, Technion - Israel Institute of, IL

1 - From error bounds to the complexity of first-order descent methods

Speaker: Jerome Bolte, TSE, FR, talk 463

We show that error bounds can be used as effective tools for deriving complexity results for first-order descent methods in convex minimization. For this we establish the equivalence between error bounds and KL inequality for convex functions having a moderately flat profile near the set of minimizers (eg Holderian growth). In a second stage, we show how KL inequalities can in turn be employed to compute new complexity bounds for a wealth of descent methods for convex problems. Our approach is completely original and makes use of a one-dimensional worst-case proximal sequence in the spirit of the famous majorant method of Kantorovich. Our result applies to a very simple abstract scheme that covers a wide class of descent methods. We analyze in particular, for the first time, the proximal gradient method and its linear complexity. Our main results inaugurate a simple method: derive an error bound, compute the desingularizing function whenever possible, identify essential constants in the descent method and finally compute the complexity using the one-dimensional worst case proximal sequence. Our method is illustrated through the famous iterative shrinkage thresholding algorithm (ISTA), for which we show linear complexity. Joint work with T.P. Nguyen, J. Peypouquet, B. Suter (10-2015).

2 - Globally Solving the Trust Region Subproblem Using Simple First-Order Methods

Speaker: Yakov Vaisbourd, TAU, IL, talk 493

Co-Authors: *Amir Beck*,

We consider the trust region subproblem which is given by a minimization of a quadratic, not necessarily convex, function over the Euclidean ball. Based on the well-known second-order necessary and sufficient optimality conditions for this problem, we present two sufficient optimality conditions defined solely in terms of the primal variables. Each of these conditions corresponds to one of two possible scenarios that occur in this problem, commonly referred to in the literature as the presence or absence of the "hard case". We consider a family of first-order methods, which includes the projected and conditional gradient methods. We show that any method belonging to this family produces a sequence which is guaranteed to converge to a stationary point of the trust region subproblem. Based on this result and the established sufficient optimality conditions, we show that convergence to an optimal solution can be also guaranteed as long as the method is properly initialized. In particular, if the method is initialized with the zeros vector and reinitialized with a randomly generated feasible point, then the best of the two obtained vectors is an optimal solution of the problem in probability 1.

3 - Nonconvex Lagrangian-Based Optimization: Schemes and Global Convergence

Speaker: Shoham Sabach, Technion - Israel Institute of, IL, talk 165

We introduce a novel approach addressing global analysis of a difficult class of nonlinearly composite nonconvex optimization problems. This genuine nonlinear class captures many problems in modern disparate fields of applications. We develop an original general Lagrangian methodology relying on the idea of turning an arbitrary descent method into a multiplier method. We derive a generic Adaptive Lagrangian Based mUltiplier Method (ALBUM) for tackling the general nonconvex nonlinear composite model which encompasses fundamental Lagrangian methods. This paves the way to prove global convergence results to a critical point of the problem in the broad semialgebraic setting. The potential of our results is demonstrated through the study of two major Lagrangian schemes whose convergence was never analyzed in the proposed general setting: the proximal multiplier method and the proximal alternating direction of multipliers scheme. Joint work with Jerome Bolte (Toulouse 1 Capitole University) and Marc Teboulle (Tel Aviv University).

Coordinate Descent and Randomized Direct Search Methods

Continuous Optimization
RandomM - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 211
Organizer: Martin Takac, Lehigh University, US

1 - When Cyclic Coordinate Descent Outperforms Randomized Coordinate Descent
Speaker: Asu Ozdaglar, MIT, US, talk 1486
Co-Authors: *Mert Gurbuzbalaban*, *Nuri Vanli*, *Pablo Parrilo*,
The coordinate descent (CD) method is a classical optimization algorithm that has seen a revival of interest because of its competitive performance in machine learning applications. A number of recent papers provided convergence rate estimates for their deterministic (cyclic) and randomized variants that differ in the selection of update coordinates. These estimates suggest randomized coordinate descent (RCD) performs better than cyclic coordinate descent (CCD), although numerical experiments do not provide clear justification for this comparison. In this paper, we provide examples and more generally problem classes for which CCD (or CD with any deterministic order) is faster than RCD in terms of asymptotic worst-case convergence. Furthermore, we provide lower and upper bounds on the amount of improvement on the rate of CCD relative to RCD, which depends on the deterministic order used. We also provide a characterization of the best deterministic order (that leads to the maximum improvement in convergence rate) in terms of the combinatorial properties of the Hessian matrix of the objective function.
2 - Random direct search method for unconstrained smooth minimization
Speaker: El houcine Bergou, KAUST-INRA, SA, talk 421
Co-Authors: *Peter Richtarik*, *Eduard Gorbunov*,
In this work we consider the problem of unconstrained minimization of a smooth function in R^n in a setting where only function evaluations are possible. We design a novel random direct search (RDS) method and analyze its complexity. At each iteration, RDS generates a random search direction according to a certain fixed probability law. Our assumptions on this law are very mild. Given a current iterate x, the objective function is compared at three points: x, $x + \alpha s$ and $x - \alpha s$, where $\alpha > 0$ is a stepsize parameter and s is the random search direction. The best of these three points is the next iterate. The complexity of RDS depends on the probability law via a simple characteristic closely related to the cosine measure which is used in the analysis of deterministic direct search (DDS) methods. Unlike in DDS, where $O(n)$ function evaluations must be performed in each iteration in the worst case, our random search method only requires two new function evaluations per iteration. Consequently, while DDS depends quadratically on n, our method depends linearly on n. In particular, in the nonconvex case, RDS needs $O(n\epsilon^{-2})$ function evaluations to find a point at which the gradient of the objective function is below ϵ, in expectation. In the convex case, the complexity is $O(n\epsilon^{-1})$. In the strongly convex case, the complexity is $O(n \ln \epsilon^{-1})$.
3 - Active Metric Learning for Supervised Classification
Speaker: Dimitri Papageorgiou, ExxonMobil, US, talk 1275
Co-Authors: *Krishnan Kumaran*, *Martin Takac*,
Clustering and classification critically rely on distance metrics that provide meaningful comparisons between data points. We present mixed-integer optimization approaches to find optimal distance metrics that generalize the Mahalanobis metric extensively studied in the literature. Additionally, we generalize and improve upon leading methods by removing reliance on pre-designated “target neighbors,” “triplets,” and “similarity pairs.” Another salient feature of our method is its ability to enable active learning by recommending precise regions to sample after an optimal metric is computed to improve classification performance. This targeted acquisition can significantly reduce computational burden by ensuring training data completeness, representativeness, and economy. We demonstrate classification and computational performance of the algorithms through several simple and intuitive examples, followed by results on real image and medical datasets.

Convex regularization and inverse problems

Continuous Optimization
NLP - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 216
Organizer: Pierre Weiss, CNRS, FR

1 - T-systems for super-resolution microscopy
Speaker: Vincent Duval, INRIA Paris, FR, talk 1023
Co-Authors: *Gabriel Peyre*, *Emmanuel Soubies*, *Quentin Denoyelle*,
The BLASSO, or LASSO for measures, is a variant of the LASSO for the recovery of Dirac masses in a gridless setting. To exactly recover Dirac masses with arbitrary signs, it is necessary (and sufficient, as proved in the seminal paper by Candès and Fernandez Granda) that the masses are sufficiently separated. In this talk, I will show that for some observation operators, it is possible to recover N arbitrarily close Dirac masses, provided they have positive amplitudes, from noisy observations. The corresponding stability constant $O(1/t^{2N-1})$, where t is the minimal separation distance. I will discuss the applicability of this result to Multi-Angle TIRF microscopy.
2 - Convex regularisation, sparsity and representation theorem
Speaker: Frederic De Gournay, IMT toulouse, FR, talk 1130
Co-Authors: *Vincent Duval*, *Pierre Weiss*, *Claire Boyer*, *Antonin Chambolle*, *Yohann de Castro*,
This talk will show-case a recent representation theorem for convex regularisation. In a nutshell, with very few hypothesis, it is shown that if one has m measurements and regularises a possibly non-convex data-fitting term with a norm then there exists a solution which is a positive combination of at most m extreme points of the norm. If the data-fitting term is convex it is possible to characterise the set of solutions. Several extensions are proposed especially when the regularizing term is not supposed to be a norm. The theorem holds in infinite dimension allowing for example to caracterize the convex regularisation by the TV semi-norm.

3 - Bounds on the size of polyedral cones
Speaker: Jonas Kahn, CNRS, FR, talk 1033
We give bounds on the conic width and/or the statistical dimension of a cone from a few of their elementary properties, such as the number of facets and angle of a circular circumscribed cone. Any such bound can be translated to a bound on exact recovery for LASSO estimators within a synthesis framework.

Provable guarantees for Cut Generating Functions

Discrete Optimization & Integer Programming
IPtheory - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 220
Organizer: Amitabh Basu, Johns Hopkins University, US

1 - Using the geometry of S-free sets to find mixed-integer cut-generating functions
Speaker: Joseph Paat, ETH Zurich, CH, talk 1131
Co-Authors: *Amitabh Basu*, *Santanu Dey*,
S-free sets are geometric tools used for generating cutting planes for a continuous version of Gomory's corner polyhedron. Conforti et al. discovered that certain S-free sets have a special property, which we refer to as the 'covering property', that allows these cuts to be extended to strong cuts for the mixed-integer version of Gomory's corner polyhedron. In this talk, we examine the geometry of S-free sets without the covering property and see how to lift the corresponding cuts to strong cuts for the mixed-integer setting. This work was done in collaboration with Amitabh Basu and Santanu Dey.
2 - Can cut generating functions be good and efficient?
Speaker: Sriram Sankaranarayanan, Johns Hopkins University, US, talk 391
Co-Authors: *Amitabh Basu*,
Making cut generating functions (CGFs) computationally viable is a central question in modern integer programming research. One would like to find CGFs that are simultaneously good, i.e., there are good guarantees for the cutting planes they generate, and efficient, meaning that the values of the CGFs can be computed cheaply (with procedures that have some hope of being implemented in current solvers). We investigate in this work to what extent this balance can be struck. We propose a family of CGFs which, in a sense, achieves this harmony between good and efficient. In particular, we show that our proposed CGFs give a good approximation of the closure given by CGFs obtained from maximal lattice-free sets and their so-called trivial liftings, and simultaneously, show that these CGFs can be computed with explicit, efficient procedures. We close the paper with some computational experiments with this family of cuts. Our proposed family of cuts seem to give some concrete advantage on randomly generated instances; however, their performance on MIPLIB 3.0 problems is not comparable to CPLEX or a simple GMI cut generator, except for a specific family of problems.
3 - Optimal cutting planes from the group relaxations
Speaker: Amitabh Basu, Johns Hopkins University, US, talk 409
Co-Authors: *Michele Conforti*, *Marco Di Summa*, *Giacomo Zambelli*,
We study quantitative criteria for evaluating the strength of valid inequalities for Gomory and Johnson's finite and infinite group models and we describe the valid inequalities that are optimal for these criteria. We justify and focus on the criterion of maximizing the volume of the nonnegative orthant cut off by a valid inequality. For the finite group model of prime order, we show that the unique maximizer is an automorphism of the Gomory Mixed-Integer (GMI) cut for a possibly different finite group problem of the same order. We extend the notion of volume of a simplex to the infinite dimensional case. This is used to show that in the infinite group model, the GMI cut maximizes the volume of the nonnegative orthant cut off by an inequality.

On the Tree Augmentation Problem

Discrete Optimization & Integer Programming
COMB - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

Invited Session 240
Organizer: Laura Sanità, University of Waterloo, CA

1 - Beating Approximation Factor 2 For Weighted Tree Augmentation With Bounded Costs
Speaker: David Adjiashvili, ETH Zurich, CH, talk 272
The Weighted Tree Augmentation Problem (WTAP) is a fundamental well-studied problem in the field of network design. Given an undirected tree $G = (V, E)$, an additional set of edges $L \subseteq V \times V$ disjoint from E called *links* and a cost vector $c \in \mathbb{R}^L_{\geq 0}$, WTAP asks to find a minimum cost set $F \subseteq L$ with the property that $(V, E \cup F)$ is 2-edge connected. The special case where $c_\ell = 1$ for all $\ell \in L$ is called the Tree Augmentation Problem (TAP). Up until recently, approximation algorithms with factor better than two were known only for TAP. Using a novel LP we achieve a first improvement of this factor for the special case in which the costs lie in the interval $[1, M]$ for any constant M. This is the first algorithm with factor better than two for any class of cost functions, apart from uniform costs, and all trees.
2 - Improved Approximation for Tree Augmentation via Chvatal Gomory Cuts
Speaker: Jochen Koenemann, University of Waterloo, CA, talk 137
Co-Authors: *Samuel Fiorini*, *Martin Gross*, *Laura Sanità*,
In the weighted tree augmentation problem (WTAP) we are given a tree T in a graph G=(V,E). Edges in $E \setminus T$ are called links and carry non-negative weights. The goal is to find a minimum-weight set L of links such that T+L is 2-edge-connected. WTAP is a classical NP- and APX-hard network design problem (even when all links have weight 1; call this TAP). The best known approximation algorithm achieves a performance guarantee of 2 (due to Fredrickson and Jaja). Kortsarz and Nutov improved this to 3/2 in the special case of TAP. Very recently recently Adjashvili gave a 1.96-approximation for WTAP whenever link weights are bounded, and a 5/3-approximation for TAP. We show how to improve the result of Adjashvili and obtain a 3/2-apx for both weighted and unweighted tree augmentation in the bounded link weight setting. The key ingredient is a strengthened lin-

ear programming formulation for WTAP.

3 - Improved Approximation for Tree Augmentation: Saving by Rewiring

Speaker: Rico Zenklusen, ETH Zurich, CH, talk 407

Co-Authors: *Fabrizio Grandoni*, *Christos Kalaitzis*,

The Tree Augmentation Problem (TAP) is a fundamental network design problem in which we are given a tree and a set of additional edges, also called links. The task is to find a link set of minimum size, whose addition to the tree leads to a 2-edge-connected graph. A long line of results on TAP culminated in the previously best known approximation guarantee of 1.5 by Kortsarz and Nutov, achieved through a combinatorial approach. More recently, this factor has been matched by an SDP-based approach by Cheriyan and Gao, and an LP-based (1+epsilon)-approximation has been obtained by Fiorini, Gross, Könemann, and Sanità. In this paper, we show that approximation factors below 1.5 can be achieved, by presenting a 1.458-approximation based on several new techniques. The main ingredient of our approach is a rewiring technique that is based on a stochastic version of a matching problem, and allows for saving links by replacing appropriate pairs of links by a single one.

Combinatorial Optimization in Chip Design

Specific Models, Algorithms, and Software

Scheduling - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 23 Building: G, 3rd floor, Zone: 6

Invited Session 257

Organizer: Stefan Hougardy, University of Bonn, DE

1 - Faster Adder Circuits for Inputs with Prescribed Arrival Times

Speaker: Ulrich Brenner, University of Bonn, DE, talk 387

Co-Authors: *Anna Hermann*,

We present an algorithm that computes a Boolean circuit for an And-Or path with given arrival times for the input signals t(0)...t(m-1). Our objective function is delay, a generalization of depth. The maximum delay of the circuit we compute is log(W) + log(log(m)) + log(log(log(m))) + 5, where log(W) is a lower bound on the delay of any circuit depending on inputs t(0) ... t(m-1) with prescribed arrival times. Fast realizations of And-Or paths play an important role for optimizing the cycle time of modern logic chips. Moreover, since the carry bit computation in adders reduces to evaluating And-Or paths, up to a small additive constant, an adder with the same delay can be constructed. Our method yields the fastest circuits both for And-Or paths and adders in terms of delay known so far.

2 - BonnCell: Automatic Cell Layout for 7nm Processors

Speaker: Pascal Cremer, University of Bonn, DE, talk 450

Co-Authors: *Stefan Hougardy*, *Thekla Hamm*, *Benjamin Klotz*, *Robert Vicari*, *Simon Thomä*,

Cells are the smallest building blocks of computer processors. They consist of up to roughly 100 transistors and implement basic logical function, storage of data or other functions. We present BonnCell, an automatic cell layout tool. Given a representation of the desired electrical properties of the cell, BonnCell generates a full physical layout. Multi patterning technology used in 7nm technology and beyond imposes more and more complex design rules on the layout of these cells. The often non local nature of these new design rules is a great challenge not only for human designers but also for existing algorithms. We deal with these challenges by globally optimizing several design objectives simultaneously. Our transistor placement algorithm not only minimizes the total cell area but simultaneously optimizes the routability of the cell and finds a best folding of the transistors. Our routing engine computes a detailed routing of all nets simultaneously. It computes an electrically correct routing using a mixed integer programming formulation. To improve yield and optimize DFM, additional constraints are added to this model. We present experimental results on current 7nm designs. Our approach allows to compute optimized layouts within a few minutes, even for large complex cells.

3 - Provably Fast and Near-Optimum Gate Sizing

Speaker: Siad Daboul, University of Bonn, DE, talk 345

Co-Authors: *Nicolai Hähnle*, *Stephan Held*, *Ulrike Schorr*,

In the gate sizing problem widths for millions of transistors on a computer chip have to be chosen to minimize the power dissipation while meeting timing constraints. The gate sizing problem can be relaxed to a geometric program. However, polynomial time interior point methods are too slow for practical instance sizes. Instead, Lagrangian relaxation and the subgradient method are often employed, though without polynomial running time. We present a new approach based on the resource sharing algorithm, which solves a generalized fractional packing problem. For the first time, we achieve fast theoretical and practical running times for this central problem in chip design. For the discrete cell selection problem, including multiple voltage thresholds, we employ the new algorithm heuristically. We achieve superior benchmark results compared with the previously best known algorithms.

Scenario discretization techniques in stochastic optimization

Optimization under Uncertainty

Stoch - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Invited Session 287

Organizer: Fabian Bastin, Université de Montréal, CA

1 - On a two-stage stochastic optimization problem with stochastic constraints

Speaker: Thuy Anh Ta, University of Montreal, CA, talk 1128

Co-Authors: *Fabian Bastin*, *Pierre L'Ecuyer*,

We consider a two-stage stochastic discrete program in which some of the second stage constraints have no closed form and need to be approximated by simulation (i.e., expected value constraints). We study the sample average approximation (SAA), which allows to approximate the solution to the two-stage problem. In particular, we study a nested sampling approach that includes the number of second stage scenarios and the number of replications per scenario to estimate the second stage constraint. We show that, in the second-stage problem, given a scenario, with probability one, optimal values and solutions to the SAA converge to those of the exact problem when the sample sizes go to infinity. However, in the two-stage problem, these convergence results of the second-stage problem do not hold uniformly for all scenarios. Despite of having this issue, we show that, with probability one, the optimal values and solutions given by the SAA approach converge to the true one with large enough sample sizes. We apply the SAA method to the staffing problem in call centers, i.e., the problem of how to optimize the numbers of multi-skill agents while satisfying some quality of service (QoS) constraints. The staffing allocation has to be decided under an uncertain arrival rate, but can be adjusted at some additional cost when the arrival rate is more precisely known. The results show the efficiency of the SAA approach with relatively large numbers of samples.

2 - Multistage stochastic optimization: discretization of probability distributions

Speaker: Julien Keutchayan, Polytechnique Montréal, CA, talk 1125

Co-Authors: *David Munger*, *Fabian Bastin*, *Michel Gendreau*,

We present a new approach for generating scenarios trees based on a newly introduced quality measure called the figure of demerit. This figure assesses the suitability of scenario trees with respect to the structure of a given multistage stochastic optimization problem (as opposed to other scenario-tree methods that are concerned with the suitability w.r.t. the underlying stochastic process only). In effect, this new approach guides the scenario-tree generation towards regions of the distribution support that entail more variability of the recourse functions . As a result, the output tree structures have typically denser branching at nodes where the variability is higher. Such non-symmetrical structures suitable to the problem increase the efficiency of the multistage discretization scheme, which allows to consider problems with longer planning horizon. Another notable feature of our approach is its ability to handle both recombining and non-recombining scenarios trees. The former has a size that grows only polynomially with the number of stages and is relevant for problems with weak stochastic dependence across stages.

3 - Effective Heuristics for the Short-Term Hydro-Generation Planning Problem

Speaker: Michel Gendreau, Polytechnique Montréal, CA, talk 670

Co-Authors: *Alexia Marchand*, *Marko Blais*, *Grégory Emiel*,

Short-term hydro-generation scheduling aims at minimizing energy consumption for the next 7 to 15 days on an hourly basis, while meeting the electrical load as well as many operational, regulatory and safety requirements. This problem can be modeled as a mixed integer linear program (MILP). Depending on the size of the system and the time horizon, the resulting MILP is often too large to be solved in reasonable time with commercial solvers. In this talk, we present two heuristics aimed at providing near-optimal solutions in operational time. The first heuristic is a three-phase approach based on price decomposition. For any partition of the production system into subsystems, the first phase solves a linear program to estimate the marginal cost of electricity in each subsystem. The second phase solves local MILP's corresponding to each subsystem, and gives a solution that is almost feasible. The final phase slightly perturbs the solution to obtain a feasible solution that is proven to be near-optimal. The second heuristic is a tabu search with new neighborhoods that can handle multi-objective problems, non-linear and non-convex constraints, as well as unfeasible solutions. A decomposition mechanism allows parallelism and search acceleration for very large-scale horizons and production systems. Computational experiments on real instances from Hydro-Québec show that both approaches find solutions almost as good as MILP solutions within only a fraction of computation time.

Global Optimization

Discrete Optimization & Integer Programming

CP - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 299

Organizer: Hassan Hijazi, Los Alamos National Laboratory, US

1 - A class of proximal algorithms based on Chebychev centers for nonsmooth convex o

Speaker: Adam Ouorou, Orange Labs Research, FR, talk 657

We revisit the proximal Chebychev center cutting plane algorithm proposed by the author in 2009 for solving nonsmooth convex problems. We propose some improvements to have more control on the Chebychev radius, amiming at getting closer to the desired property of decreasing radius in Elzinga-Moore cutting plane algorithm. A cooperative scheme is also proposed where different schemes of generating trial points share these solutions to accelarate finding an optimal solution in a parallel implementation.

2 - Convex relaxations for Mixed-Integer Multilinear Functions

Speaker: Kaarthik Sundar, Los Alamos National Laboratory, US, talk 1402

Co-Authors: *Harsha Nagarajan*, *Hassan Hijazi*, *Russell Bent*,

In this talk, we shall present convex relaxations for mixed-integer multilinear terms that feature product of multiple continuous and binary variables. These terms frequent mixed-integer nonlinear programs arising in critical infrastructure networks and chemical process networks, to name a few. We shall examine multiple equivalent formulations for their convex relaxations and show results concerning the polyhedral properties of the these formulations. Connections to previous theoretical results in developing disjunctive relaxations using theory of perspective functions will be made. On a general mixed-integer nonlinear program with mixed-integer multilinear terms, we shall numerically show the gain in computation times from using these relaxations in comparison to the state-of-the-art relaxation approaches.

3 - Sparse Certificates for Polynomial Optimization

Speaker: Tillmann Weisser, LAAS-CNRS, FR, talk 860

Algebraic certificates for non negativity on a basic semi algebraic set are key for polynomial optimization. Various certificates have been proposed that can be computed using linear, second order cone, or semi definite programming. The certificate based on Putinar's Positivstellensatz has proven to be a powerful tool. However at the same time it is one of the most expensive certificates in terms of computational effort needed to compute it. For this reason Putinar certificates were limited to small scale problems until Waki et al. 2006/Lasserre 2006 proposed a way to exploit a certain sparsity pattern of the optimization problem. As an extension of Weisser, Lasserre, Toh 2017 we proof that the very same sparsity structure can be exploited for certificates based on other theorems for positivity. This establishes sparse hierarchies that can potentially outperform the standard hierarchy based on Putinar's theorem.

Distributed Optimization

Specific Models, Algorithms, and Software
Learning - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 325
Organizer: Franck Iutzeler, Univ. Grenoble Alpes, FR

1 - Distributed Optimization with Sparse Communications and Structure Identification
Speaker: Franck Iutzeler, Univ. Grenoble Alpes, FR, talk 452
Co-Authors: *Dmitry Grishchenko*, *Jerome Malick*, *Massih-Reza Amini*,
We propose an efficient distributed algorithm for solving regularized learning problems. In a distributed framework with a master machine coordinating the computations of many slave machines, our proximal-gradient algorithm allows local computations and sparse communications from slaves to master. Furthermore, with the ℓ_1-regularizer, our approach automatically identifies the support of the solution, leading to sparse communications from master to slaves, with near-optimal support. We thus obtain an algorithm with two-way sparse communications.

2 - Random gradient extrapolation for distributed and stochastic optimization
Speaker: Guanghui Lan, Georgia Institute of Technolog, US, talk 1584
we consider a class of finite-sum convex optimization problems defined over a distributed multiagent network with m agents connected to a central server. In particular, the objective function consists of the average of m (>=1) smooth components associated with each network agent together with a strongly convex term. Our major contribution is to develop a new randomized incremental gradient algorithm, namely random gradient extrapolation method (RGEM), which does not require any exact gradient evaluation even for the initial point, but can achieve the optimal $O(\log(1/\epsilon))$ complexity bound in terms of the total number of gradient evaluations of component functions to solve the finite-sum problems. Furthermore, we demonstrate that for stochastic finite-sum optimization problems, RGEM maintains the optimal $O(1/\epsilon)$ complexity (up to a certain logarithmic factor) in terms of the number of stochastic gradient computations, but attains an $O(\log(1/\epsilon))$ complexity in terms of communication rounds (each round involves only one agent). It is worth noting that the former bound is independent of the number of agents m, while the latter one only linearly depends on m or even square root m for ill-conditioned problems. To the best of our knowledge, this is the first time that these complexity bounds have been obtained for distributed and stochastic optimization problems. Moreover, our algorithms were developed based on a novel dual perspective of Nesterov's accelerated gradient method.

3 - Distributed Computation of Wasserstein Barycenters over Networks
Speaker: Alexander Gasnikov, MIPT, RU, talk 315
Co-Authors: *Cesar Uribe*, *Pavel Dvurechensky*, *Darina Dvinskikh*, *Angelia Nedich*,
We propose a new class-optimal algorithm for the distributed computation of Wasserstein Barycenters over networks. Assuming that each node in a graph has a probability distribution, we prove that every node is able to reach the barycenter of all distributions held in the network by using local interactions compliant with the topology of the graph. We show the minimum number of communication rounds required for the proposed method to achieve arbitrary relative precision both in the optimality of the solution and the consensus among all agents for undirected fixed networks. For more details see arXiv:1803.02933.

Theory and Methods for ODE- and PDE-Constrained Optimization 1

Continuous Optimization
Control - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Contributed Session 331
Chair: Carl Greiff, Lund Unversity, SE

1 - On the Barzilai-Borwein step-sizes in Hilbert spaces
Speaker: Behzad Azmi, RICAM Linz, AT, talk 831
Co-Authors: *Karl Kunisch*,
Due to simplicity and numerical efficiency, the Barzilai and Borwein (BB) method has received a significant amount of attention in different fields of optimization. In this method, to incorporate the quasi-Newton property, the Hessian is approximated by a scalar multiple of the identity in such a manner that the secant condition holds. In this talk, we discuss the convergence of this method for problems posed in infinite-dimensional Hilbert spaces. First, based on the spectral analysis, the R-linear global convergence of this method for strictly convex quadratic problems is presented. Then this result is extended to the local convergence for twice continuously Fréchet differentiable functions. Next, aiming at problems governed by partial differential equations, the results concerning the mesh-independent principle for the BB-method are presented. Numerical experiments are also given.

2 - Shape Optimization with Stress Constraints for Frictional Contact Problems
Speaker: Benjamin Horn, TU Darmstadt, DE, talk 754
Co-Authors: *Stefan Ulbrich*,
We present nonsmooth optimization techniques using second order information for shape optimization problems including stress constraints. This approach is applied to the design challenge of a mechanical connector with respect to fatigue strength aspects. To this end, we follow the concept of an algorithm based product development, which couples the CAD system with the finite element simulation used by the optimization routines. To ensure a consistent model representation, we choose an isogeometric approach to model the contact problem. This leads to a shape optimization governed by a linear elasticity problem with contact and Coulomb friction. The frictional contact conditions itself are modeled by a mortar approach using dual basis functions and solved by a

semismooth Newton method. To guarantee a predefined level of fatigue strength, we include stress constraints based on the damage parameter of Smith,Watson and Topper. To determine this measure we calculate approximated elasto-plastic strains and stresses using the von-Neuber hypothesis and the Ramberg-Osgood material law. The stress constraint itself is handled by the Moreau-Yoshida regularization. The resulting shape optimization problem is nonconvex and due to the contact conditions and the chosen objective functions nonsmooth. We solve this optimization problem with a bundle trust region algorithm enhanced by second order information, which is modified to ensure a feasible shape in each iteration. The design subgradients required by the bundle method can be calculated efficiently with the adjoint approach.

3 - Quadratic programmimg for time-optimal control in differentially flat systems
Speaker: Carl Greiff, Lund Unversity, SE, talk 1484
Co-Authors: *Anders Robertsson*,
The notion of trajectory time-warping is explored in the context of differentially flat systems to enable time-optimal motion by quadratic programming. In the event of non-convex constraints, an iterative heuristic similar to sequential convex programming is employed to find locally optimal solutions. The invocation of the flatness property enables transformations of highly non-linear dynamics to a set of differentially independent flat outputs. This allows the definition of an auxiliary problem, where the non-linear constraints can be replaced by constraints on trajectory smoothness, and constraints on a time-warping preserving this smoothness. The proposed methods complement classical approaches to optimal control, and yields time-optimal solutions with respect to constraints on the first two derivatives on the flat output trajectory and all time-warping derivatives. Examples are given with trajectory tracking of a ground vehicle configured on SE(2), with and without differential constraints, and complex looping manoeuvres of an aerial vehicle configured on SE(3). Simulation-based results are complemented by a real-time example of time-warped trajectory tracking of a quad-rotor.

Matching and Matroids

Discrete Optimization & Integer Programming
APPROX - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4
Invited Session 341
Organizer: José Soto, Universidad de Chile, CL

1 - Maximizing Efficiency in Dynamic Matching Markets
Speaker: Maximilien Burq, MIT, US, talk 1309
Co-Authors: *Itai Ashlagi*, *Amin Saberi*, *Patrick Jaillet*,
We study the problem of matching agents who arrive at a marketplace over time and leave after d time periods. Agents can only be matched while they are present in the marketplace. Each pair of agents can yield a different match value, and the planner's goal is to maximize the total value over a finite time horizon. We study matching algorithms that perform well over any sequence of arrivals when there is no a priori information about the match values or arrival times. Our main contribution is a 1/4-competitive algorithm. The algorithm randomly selects a subset of agents who will wait until right before their departure to get matched, and maintains a maximum-weight matching with respect to the other agents. The primal-dual analysis of the algorithm hinges on a careful comparison between the initial dual value associated with an agent when it first arrives, and the final value after d time steps. It is also shown that no algorithm is 1/2-competitive. We extend the model to the case in which departure times are drawn i.i.d from a distribution with non-decreasing hazard rate, and establish a 1/8-competitive algorithm in this setting. Finally we show on real-world data that a modified version of our algorithm performs well in practice.

2 - Online Weighted Matching: Beating the 1/2 Barrier
Speaker: Morteza Zadimoghaddam, Google Inc., CH, talk 188
We study the problem of online weighted bipartite matching in which we want to find a maximum weighted matching between two sets of entities, e.g. matching impressions in online media to advertisers. Karp et al. (STOC 1990) designed the elegant algorithm Ranking with competitive ratio $1 - 1/e$ for the unweighted case. Without the commonly accepted Free Disposal assumption, it is easy to show that no competitive ratio can be achieved in the weighted case. However, under this assumption, it is not hard to show that algorithm Greedy is 12 competitive, and this is tight for deterministic algorithms. After more than 25 years from the seminal work of Karp et al., it is still an open question whether an online algorithm with competitive ratio better than 1/2 exists or not. We answer this question affirmatively by presenting randomized algorithm StochasticGreedy with competitive ratio greater than 0.501. We also optimize this algorithm and propose slightly changed algorithm OptimizedStochasticGreedy with competitive ratio greater than 0.5018. In light of the hardness result of Kapralov et al. (SODA 2013) that restricts beating the 1/2-competitive ratio for Monotone Submodular Welfare Maximization problem, our result can be seen as an evidence that solving weighted matching problem is strictly easier than submodular welfare maximization in online settings.

3 - Strong Algorithms for the Ordinal Matroid Secretary Problem
Speaker: José Soto, Universidad de Chile, CL, talk 1170
Co-Authors: *Victor Verdugo*, *Abner Turkieltaub*,
An edge-weighted graph is presented edge by edge in uniform random order to an algorithm that wants to construct a large weight forest. When an edge appears, the algorithm must decide whether to take it or not, without creating any cycle. But there is a catch: the algorithm cannot see the weights, it can only compare pairs of revealed elements. Can the algorithm output a forest whose weight is large compare to the optimum one? If we replace forest in a graph by independent set on a matroid we get the description of the ordinal matroid secretary problem (MSP). In this talk, I will present a technique to design, for certain matroids, algorithms with the following property: every element of the global optimum appears in the output solution with constant probability. Our technique allows us to improve the current best competitive guarantees of the MSP on most of the studied matroid, achieving a factor 4 for graphical matroids, a factor 5.19 for laminar matroids, and constant factors for k column sparse matroids, hypergraphic matroids, certain gammoids and graph packing matroids. If time permits I will discuss other competitive notions for this problems and some algorithms for the general matroid case that are based on the O(log log r) utility-competitive algorithm by Feldman et al. [SODA 2015]. This talk is based on the article of the same name presented in SODA 2018.

Implementation of interior-point methods for large-scale problems and applications I

Specific Models, Algorithms, and Software
Algo - Mo 3:15pm-4:15pm, Format: 2x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

Invited Session 353
Organizer: Jordi Castro, Univ. Politècnica de Catalunya, ES

1 - A feasible direction interior point algorithm for linear programming
Speaker: Jose Herskovits, UFRJ, BR, talk 31
Co-Authors: *Miluzca Victorio*, *Nelson Maculan*,
FDIPA is a feasible direction algorithm for nonlinear programming. It consists on the iterative solution, in the primal and dual variables, of Karush-Kuhn-Tucker optimality conditions. At each iteration, a descent direction is first computed by solving a linear system of equations. Then, a restoring direction is obtained by solving a second system with the same matrix. Following, a feasible descent direction is obtained as a precisely defined linear combination of both previously computed directions. A line search is then carried out to get a new feasible iterate with a lower objective. We describe some techniques for linear programming based on these concepts. An important point has to do with the linear systems solution. Truncated iterative methods are particularly appropriate in the present case, since iterations can be stopped once a feasible descent direction was obtained.

2 - A specialized interior-point algorithm for very large minimum cost flows in bipa
Speaker: Stefano Nasini, IESEG School of Management, FR, talk 38
Co-Authors: *Jordi Castro*,
One of the most efficient interior-point methods for block-angular structured problems computes the Newton direction by a combination of Cholesky factorizations and precoditioned conjugate gradients. In this work we apply this algorithmic approach to solve very large instances of minimum cost flows problems in bipartite networks, for convex objective functions with diagonal Hessians (i.e., either linear, quadratic or separable nonlinear objectives). After analyzing the theoretical properties of the interior-point method for this kind of problems, we provide extensive computational experiments with linear and quadratic instances of up to 1 billion arcs and 200 and 5 million nodes in each subset of the node partition. For linear and quadratic instances our approach is compared with the barriers algorithms of CPLEX (both standard path-following and homogeneous-self-dual); for linear instances it is also compared with the different algorithms (namely: network simplex, capacity scaling, cost scaling and cycle canceling) of the state-of-the-art network flow solver LEMON. The specialized interior-point approach significantly outperformed the other approaches in most of the linear and quadratic transportation instances tested. In particular, it always provided a solution within the time limit and it never exhausted the 192 Gigabytes of memory of the server used for the runs.

Distributionally Robust Optimization - New Theory and Applications

Optimization under Uncertainty
Robust - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 33 Building: B, Ground Floor, Zone: 5

Invited Session 356
Organizer: Zhichao Zheng, Singapore Management Uni, SG

1 - Data-Driven Bounded Rationality in Games- A Robust Framework
Speaker: Yini Gao, Singapore Management Universit, SG, talk 440
Co-Authors: *Chung Piaw Teo*,
Experimental studies have shown that Nash Equilibrium is a poor description of human players' behaviour in unrepeated simultaneous games. In our paper, we propose a semi-parametric framework to model bounded rational behaviour. Specifically, we adopt a result in distributionally robust optimization and propose a flexible data-driven bounded rationality model, "Marginal Moment Game model (MMGM)". We firstly show that the MMGM is a generalization of logit Quantal Response Equilibrium (QRE) proposed by McKelvey and Ralfrey (1994)) and it is also equivalent to the control cost model proposed by Van Damme (1987). We then demonstrate the application of the MMGM to different game play data sets and evaluate the generalization and predictive performance of the model compared with two benchmark models - QRE and Qlk (Quantal level-k).

2 - Distributionally Robust Mechanism Design
Speaker: Cagil Kocyigit, EPFL, CH, talk 405
Co-Authors: *Garud Iyengar*, *Daniel Kuhn*, *Wolfram Wiesemann*,
We study a mechanism design problem where a good is auctioned to multiple bidders, for each of whom it has a value that is unknown to the seller and the other bidders. The agents perceive the ensemble of all bidder values as a random vector governed by a probability distribution from a commonly known ambiguity set. The seller aims to design a revenue maximizing mechanism that is not only immunized against the ambiguity of the bidder values but also against the uncertainty about the bidders' attitude towards ambiguity. We argue that the seller achieves this goal by maximizing the worst-case expected revenue across all value distributions in the ambiguity set and by positing that the bidders have Knightian preferences. For ambiguity sets containing all distributions supported on a hypercube, we show that the Vickrey auction is the unique mechanism that is optimal, efficient and Pareto robustly optimal. If the bidders' values are additionally known to be independent, then the revenue of the (unknown) optimal mechanism does not exceed that of a second price auction with only one additional bidder. For ambiguity sets under which the bidders' values are dependent and characterized through moment bounds, we provide a new class of randomized mechanisms, the highest-bidder-lotteries, whose revenues cannot be matched by any second price auction with a constant number of additional bidders. Moreover, we show that the optimal highest-bidder-lottery is a 2-approximation of

the (unknown) optimal mechanism, whereas the best second price auction fails to provide a constant approximation.

3 - Schedule Reliability in Liner Shipping by Distributionally Robust Optimization

Speaker: Zhichao Zheng, Singapore Management Uni, SG, talk 398

Co-Authors: *Abraham Zhang*, *Chung Piaw Teo*,

Container liner shipping is crucial to global supply chain performance as it is the primary mode of moving manufactured products across continents. Partly due to inherent uncertainties at sea and ports, the liner shipping industry has long had a notorious reputation of schedule unreliability. This paper attempts to optimize the schedule reliability in liner shipping using distributionally robust optimization techniques. This approach deos not assume the distributions of stochastic time parameters and only requires their first and second moments which can be derived from historical data. Given a bunker consumption limit for the voyage, the model finds the designed sailing speeds of the vessel at different legs to minimize schedule delays at ports under the worst case distribution. Using real data from Maersk Line, we demonstrate that our schedule outperforms the Daily Maersk service schedules, which have achieved very high vessel schedule reliability in practice.

Risk and Energy Markets

Optimization under Uncertainty

Game - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 376

Chair: Julio Deride, Sandia National Laboratories, US

1 - On solving risk-averse equilibrium problems via reformulations

Speaker: Olivier Huber, UW-Madison, US, talk 1126

Co-Authors: *Michael Ferris*,

In stochastic programming, there is a recent push for a richer modeling of behavior with respect to uncertainty. Coherent risk measures capture behavior richer than classical risk neutral settings. Operators such as CVaR can be used to describe risk-averse approaches and a rich duality structure allows coherent risk measures to be expressed as a support function of a related risk set. Various computational approaches can be used with coherent risk measures, including three efficient transformation techniques: solving a saddle-point problem (a variational inequality), formulating a dual problem via a Fenchel-like scheme, and using the epigraph representation of a support function. In our approach, the structure of the problem and how to preserve it during the transformations is of paramount importance. We also investigate time consistency within the context of multistage stochastic programming with risk-averse behavior. We focus on problems that are either a Generalized Nash Equilibrium Problem (GNEP), or a Multiple Objectives Problem with Equilibrium Constraints (MOPEC), coupled to a multistage stochastic process. Our examples include a model of an electricity market modeled as a MOPEC with weather-dependent electricity generation. The reformulation process is implemented in SELKIE, a library that performs model transformations and solve equilibrium problems, that is available in the GAMS and Julia modeling environments.

2 - On risk averse competitive equilibrium

Speaker: Henri Gerard, Ponts ParisTech, FR, talk 1407

Co-Authors: *Vincent Leclère*, *Andy Philpott*,

Motivated by the management of electricity markets, we discuss risked competitive partial equilibrium in a setting in which agents are endowed with coherent risk measures. In this case, A. Philpott, M. Ferris and R. Wets (2014) have shown that it is possible to define a complete market for risk. Then a perfectly competitive partial equilibrium will be efficient, i.e. will also maximize risk-adjusted social welfare. If the market for risk is not complete, then equilibrium can be inefficient. We make the following contributions: – we show a reverse statement between risk averse equilibrium problems in complete markets adapting a result from D. Ralph and Y. Smeers (2015), – in contrast to social planning models, we show by example that risked equilibria are not unique, even when agents' objective functions are strictly concave, – we also show that standard computational methods find only a subset of the equilibria, even with multiple starting points.

3 - Stochastic General Equilibrium Model with Application to Energy Markets

Speaker: Julio Deride, Sandia National Laboratories, US, talk 1606

In this talk we study a Stochastic General Equilibrium problems with financial markets, providing a new characterization of equilibrium prices as a solution of an associated optimization problem. Considering the concept of non-arbitrage for financial markets, along with a revision of the dual problem for each agent, we defined a bifunction, called Walrasian, that captures the misbalance on the markets of goods. Moreover, its maxinf-points turned out to be equilibrium points and, in addition, we proved that every equilibrium point can be obtained as a limit maxinf point for a family of perturbed problems. For numerical purposes, the approximation theory developed relies on the notion of lopsided convergence, the appropriate topology for the family of max-inf optimization problems. Finally, we present an application of this computational setting on Energy Markets, and discuss the dynamics of the equilibrium when multi commodities are introduced, along with financial contracts.

Portfolio Optimization

Specific Models, Algorithms, and Software

Sciences - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle LA4 Building: L, Basement, Zone: 8

Contributed Session 393

Chair: Bernardo Pagnoncelli, Universidad Adolfo Ibanez, CL

1 - A Multiplicative Weights Update Algorithm for Portfolio Selection Problems

Speaker: Luca Mencarelli, IFP Energies nouvelles, FR, talk 162

We deal with Mean-Variance Portfolio Selection Problems with separable possibly non-convex transaction cost functions. We present an adaptation of the Multiplicative Weights Update Algorithm for Mixed-Integer Nonlinear Optimisation to this kind of financial problems by specifying the pointwise reformulation and the computational procedure for computing the costs/gains vector. Computational experiments with respect to real-wold instances show the goodness of the method.

2 - Regularized portfolio optimization with risk measures
Speaker: Bernardo Pagnoncelli, Universidad Adolfo Ibanez, CL, talk 523
Co-Authors: *Felipe Del Canto*, *Arturo Cifuentes*,
Since the publication of Markowitz's seminal paper, portfolio optimization problems have been thoroughly studied under the paradigm of risk and return. To deal with uncertainty, it is common to use scenarios and solve the Sample Average Approximation (SAA) of the problem. In this talk, I will apply a regularization scheme developed by Ban et al (2016) and extend it to include several risk measures that are popular in the literature. Our results show that regularization schemes yield out-of-sample solutions with less variability and more diversified portfolios than the ones obtained with SAA. I will present numerical experiments that include the 2008 subprime crisis.

3 - Log-optimal portfolios under random horizon
Speaker: Sina Yansori, University of Alberta, CA, talk 312
Co-Authors: *Tahir Choulli*,
This talk is about investigation and measure the impact of a random horizon on the optimal investment/portfolio. This random horizon is a general random time that might represent the default time of a firm, the death time of an insured, or more generally an occurrence time of an event that might impact the market somehow. We consider a market model resulting from progressively enlarging an initial market model with a random time. Herein, in this setting, we address the numeraire portfolio and the utility optimization problem. Due to the duality between the investment strategies and the deflators, our first goal translates on describing the impact of the random horizon on the optimal deflator. Thus, our first result lies in explicitly describing the set of all deflators for a model stopped at a random time. Once the set of all deflators is completely and explicitly parametrized, as our second result, we address the minimization problem over the set of these deflators to solve the dual problem. For the case of log utility, this optimal deflator is completely and explicitly described in different manners using the flow information generated by the initial market model. Then we solve the optimal investment under random horizon for this economic model. As a result, we conclude that the random horizon leads naturally to an implied random utility. Concerning the numeraire portfolio, we establish a one-to-one connection between the numeraire portfolio for models stopped at the random time and numaraire portfolio for models under public information only.

Advances in Linear, Non Linear and Mixed-Integer Optimization

Specific Models, Algorithms, and Software
Algo - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 400
Chair: Hiroshige Dan, Kansai University, JP

1 - Computational Experiments with Nested Dantzig-Wolfe Decompositions
Speaker: Erik Mühmer, RWTH Aachen University, DE, talk 1424
Co-Authors: *Marco Lübbecke*, *Jonas Witt*,
A common technique used to solve specially structured integer programs is branch-and-price. In branch-and-price subproblems are typically solved using branch-and-cut or specialized combinatorial algorithms. However, related work indicates that for specific problems speedups can be achieved by applying branch-and-price to the subproblems as well. Hence, we aim at exploiting such nested decompositions in GCG, a generic branch-cut-and-price solver based on SCIP. GCG uses Dantzig-Wolfe decompositions relying on structures that are either provided by the user or detected by GCG itself. We extend GCG to apply branch-and-price recursively, where the nested structure is provided by the user. We present computational results comparing the recursive branch-and-price strategy with the standard technique on suitable problems. Future work includes employing problem specific detectors that reveal the underlying structure of a problem automatically. Moreover, we plan to generalize this idea by implementing a generic detection of nested structures.

2 - Restrict-and-fix: a constructive heuristic for mixed-integer programs
Speaker: Xavier Schepler, Recommerce Lab, FR, talk 1573
Co-Authors: *Julien Kritter*, *Sophie Michel*, *Cédric Joncour*,
We consider a constructive heuristic for mixed-integer programs, that we call “restrict-and-fix”. Restrict-and-fix requires a solver able to tackle a sequence of easier mixed-integer programs, denoted as sub-problems, which are mainly obtained through constraint relaxations in the original mixed-integer program to solve. These constraint relaxations involve integrality relaxation of some variables, but also combinatorial relaxation of constraints, in order to decompose the original formulation. The solution to each sub-problem allows to fix a subset of the variables in the original mixed-integer program as well as in the subsequent sub-problems. This heuristic is a generalization of the relax-and-fix heuristic. We propose an open source implementation of the restrict-and-fix heuristic. We will present this heuristic as well as numerical results with several formulations from the operational research literature, such as those of the capacitated multi-item lot sizing problem and the vehicle routing problem. The results show that the ability of the heuristic to efficiently address a formulation depends on its structure and on the definition of the sub-problem sequence.

3 - Automatic Differentiation Software for Indexed Optimization Problems
Speaker: Hiroshige Dan, Kansai University, JP, talk 1049
Co-Authors: *Masashi Noguchi*, *Koei Sakiyama*,
Automatic differentiation (AD) is an essential technique for implementing nonlinear optimization solvers. In this research, we have implemented an AD software which is designed for NLPs with indexed variables and functions. If we naively construct the computational graph of an optimization problem with indexed variables and functions, the size of the graph could become bigger than necessary and the construction time could be much longer. For avoiding such phenomena, our software inspects the indexes in the target problem and do not make vertices which have the same meaning. According to numerical experiments, our software works well. Moreover, our AD software can compute derivative values by using arbitrary precision arithmetic, which is one of the brute-force methods for avoiding numerical vulnerability. We have

implemented an NLP solver based on our AD software. As a result, it can solve NLPs by using arbitrary precision arithmetic and we can observe the numerical behavior of NLP algorithms for ill-posed problems in detail.

Scheduling with setup, uncertainty and precedences

Discrete Optimization & Integer Programming
COMB - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 41 Building: C, 3rd floor, Zone: 1

Invited Session 419
Organizer: Monaldo Mastrolilli, IDSIA, CH

1 - Empowering the Configuration-IP
Speaker: Kim-Manuel Klein, EPFL, CH, talk 120
Co-Authors: *Klaus Jansen*, *Marten Maack*, *Malin Rau*,
Integer linear programs of configurations, or configuration IPs, are a classical tool in the design of algorithms for scheduling and packing problems, where a set of items has to be placed in multiple target locations. Herein a configuration describes a possible placement on one of the target locations, and the IP is used to chose suitable configurations covering the items. We give an augmented IP formulation, which we call the module configuration IP. It can be described within the framework of n-fold integer programming and therefore be solved efficiently using the algorithm by Hemmecke, Onn, and Romanchuk. Furthermore, we investigate how structural properties can be applied to reduce the description of the IP and thereby speed up the resulting algorithms. As an application, we consider scheduling problems with setup times, in which a set of jobs has to be scheduled on a set of identical machines, with the objective of minimizing the makespan. For instance, we investigate the case that jobs can be split and scheduled on multiple machines. However, before a part of a job can be processed an uninterrupted setup depending on the job has to be paid. For both of the variants that jobs can be executed in parallel or not, we obtain an efficient polynomial time approximation scheme (EPTAS) of running time $f(1/\epsilon)poly(|I|)$ with a single exponential term in f for the first and a double exponential one for the second case. Previously only constant factor approximations of 5/3 and $4/3+\epsilon$ respectively were known.

2 - Scheduling under Explorable Uncertainty
Speaker: Nicole Megow, University of Bremen, DE, talk 423
Co-Authors: *Christoph Duerr*, *Thomas Erlebach*, *Julie Meißner*,
Explorable uncertainty refers to settings where parts of the input data are initially unknown, but can be obtained at a certain cost using queries. An algorithm can make queries one by one until it has obtained sufficient information to solve a given problem. We discuss a new scheduling problem, in which the exact processing times are unknown but can be queried. A query corresponds to a test that can reduce the running-time of a job by an a priori unknown amount and is executed on the machine that also schedules the jobs, thus contributing directly to the objective value of the resulting schedule. We consider the objective of minimizing the sum of completion times and give nearly tight lower and upper bounds on the competitive ratio for deterministic and randomized algorithms. We also show that minimizing the makespan is a considerably easier problem for which we give optimal deterministic and randomized online algorithms.

3 - Min-sum scheduling under precedence constraints
Speaker: Jose Verschae, P Univ Catolica, CL, talk 461
Co-Authors: *Andreas Schulz*,
In many scheduling situations, it is important to consider non-linear functions of job completions times in the objective. This was already recognized by Smith (1956). Recently, the theory community has begun a thorough study of the resulting problems, mostly on single-machine instances for which all permutations of jobs are feasible. However, a typical feature of many scheduling problems is that some jobs can only be processed after others. In this paper, we give the first approximation algorithms for min-sum scheduling with (nonnegative, non-decreasing) non-linear functions and general precedence constraints. In particular, for 1 / prec / sum wj f(Cj), we propose a polynomial-time universal algorithm that performs well for all functions f simultaneously. Its approximation guarantee is 2 for all concave functions, at worst. We also provide a (non-universal) polynomial-time algorithm for the more general case 1 / prec / sum fj(Cj). The performance guarantee is no worse than 2+ epsilon for all concave functions. Our results match the best bounds known for the case of linear functions, a widely studied problem, and considerably extend the results for minimizing sum wj f(Cj) without precedence constraints.

Sparse Recovery

Continuous Optimization
NLP - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle KC7 Building: K, Intermediate 2, Zone: 10

Contributed Session 432
Chair: Mustafa Pinar, Bilkent University, TR

1 - LP-based Sparse Solutions Revisited
Speaker: John Chinneck, Carleton University, CA, talk 630
Finding sparse solutions for underdetermined linear systems is the key step in compressive sensing and a number of other important problems. One category of solutions uses linear programming, e.g. Basis Pursuit. However there are a number of different ways to formulate the LP which have not been explored and which lead to different algorithms with different characteristics in terms of sparsity of the solution and speed. Variations include which elements are elasticized (variables vs. constraints), how variables are encouraged/discouraged or prevented from adding to the supports, etc. The talk presents a variety of new LP-based formulations and associated algorithms, along with numerical evaluation and comparisons.

2 - Sparse Recovery and Convex Quadratic Splines
Speaker: Mustafa Pinar, Bilkent University, TR, talk 660
Recovering sparse vectors via L1 minimization as an approximation to the minimization of the support has been well-studied, i.e, min ||x||1 st Ax = y as a proxy to min nonz(x) st. A x = y. The L1 problem is known to lead to exact recovery under different conditions, e.g., the null-space condition, the RIP and so on. I investigate the use of the Huber function which is an instance of convex quadratic splines for the recovery of sparse vectors by convex differentiable minimization. It is shown that for a sufficiently small value of a scalar param-

eter, the Huber minimization gives a differentiable path to the L1 solution. Conditions for uniqueness of the L1 and Huber minimizers are discussed. Furthermore, the Huber problem leads to almost-sparse vectors, a feature which maybe valuable by itself.

3 - Efficient ℓ_0 Trend Filtering
Speaker: Olof Troeng, Lund University, SE, talk 1350
Co-Authors: *Mattias Fält*,
The problem of approximating a time-series by a continuous, piecewise-linear function, subject to a quadratic cost on the approximation error, and a constant cost for each breakpoint, is known as ℓ_0 trend filtering. Existing algorithms for this problem have superpolynomial time-complexity (Kim et al., Siam Review, 2009). We propose an algorithm based on dynamic programming with a hybrid value function. The value function can be represented exactly by a piecewise-quadratic representation, which allows the algorithm to find the globally optimal solution. Based on extensive numerical experiments, we strongly believe that the time-complexity is polynomial.

Topics in power systems

Specific Models, Algorithms, and Software
Energy - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6
Invited Session 438
Organizer: Alberto Lamadrid, Lehigh University, US

1 - Consumers Flexibility Estimation at the TSO Level for Balancing Services
Speaker: Giulia De Zotti, DTU, DK, talk 1656
Co-Authors: *Ali Pourmousavi*, *Juan Morales*, *Henrik Madsen*, *Niels Kjølstad Poulsen*,
Demand flexibility resources will be an inevitable part of the future power system operation to compensate stochastic variations of ever-increasing renewable generation. One way to achieve demand flexibility is to provide time-varying prices to customers at the edge of the grid. However, appropriate models are needed to estimate the potential flexibility of different types of consumers for day-ahead and real-time ancillary services provision. The proposed method should account for rebound effect and variability in the customers' reaction to the price signals. In this study, an efficient and effective algorithm for consumers' flexibility estimation by the transmission system operator is provided based on offline data. No aggregator or real-time communication is involved in the process of estimation. Also, the consumers' elasticity and technical differences between various types of load are taken into account in the formulation. The problem is formulated as a mixed-integer linear programming problem, which is then converted to a chance-constrained program to account for the stochastic behaviour of the consumers. Simulation results show the applicability of the proposed method for the provision of ancillary services from consumers at the transmission system operator level.

2 - Decentralized control of DC-segmented power systems
Speaker: Joshua Taylor, University of Toronto, CA, talk 683
DC-segmented power systems consist of AC subsystems connected to each other only by DC lines. DC-segmentation improves the transient stability and transmission capacity of power systems. Centralized control of large power systems entails burdensome communication requirements which are expensive and introduce delays. Decentralized control circumvents these problems, but finding decentralized controllers is intractable for general systems. Poset-causal systems are a special class for which the optimal neighbor-to-neighbor decentralized controller is easy to obtain. In this paper we show that DC-segmented systems are poset-causal. We observe in numerical examples that the optimal decentralized controller attains almost the same performance as the optimal centralized controller.

3 - Response to Disruptions in Electricity with Stochastic Microgrids
Speaker: Alberto Lamadrid, Lehigh University, US, talk 684
Co-Authors: *Luis Zuluaga*, *Kwami Sedzro*, *Xin Chi*,
We study a stochastic algorithm to form microgrids, as a mechanism to respond to disturbances in the electricity system. We propose a heuristic approach to solve a mixed integer linear program (MILP) that determines the location of distributed generation, the topology of the microgrids, and the control actions required to maximize the post-disaster welfare and facilitate the post-disaster recovery effort. The microgrid formation problem, under failure scenario ω for all $\omega \in \Omega$, can be defined as a clustering problem with flow and connectivity constraints. The objective is to cluster the set of vertices $\mathcal{N}$ into $|\mathcal{K}|$ microgrids. We approach this problem in three stages: (1) the distributed generation problem. (2) The partition of the network into microgrids. (3) The welfare maximization considering technical constraints (e.g. Kirchhoff's laws). We test our results on different sized networks to verify its scalability.

Facility Layout

Specific Models, Algorithms, and Software
Logistics - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8
Contributed Session 450
Chair: Anders Gullhav, NTNU, NO

1 - Combinatorial Bounds for the (extended) Double Row Facility Layout Problem
Speaker: Mirko Dahlbeck, Universität Göttingen,Dortmund, DE, talk 1304
Co-Authors: *Anja Fischer*, *Frank Fischer*,
The NP-hard Double Row Facility Layout Problem (DRFLP) consists of a set of departments and pairwise transport weights between them and asks for a non-overlapping arrangement of the departments along both sides of a common path such that the weighted sum of the (center-to-center) distances between the departments is minimized. We extend existing DRFLP solution approaches such that asymmetric transport weights, individual in- and output positions of the departments as well as asymmetric clearance conditions can be taken into account. Furthermore we present combinatorial lower bounds for DRFLP which can be computed very fast. These bounds generalize the star inequalities of the minimum arrangement problem and use ideas from scheduling. They are the basis of a new distance-based integer linear program for computing even stronger lower bounds, which can be extended to a formulation for DRFLP as well. We evaluate the quality of our new lower bounds on benchmark instances from the literature

and on large randomly generated instances.

2 - A Matheuristic Approach to the Hospital Facility Layout Problem

Speaker: Anders Gullhav, NTNU, NO, talk 1019

Co-Authors: *Henrik Andersson*, *Bjørn Nygreen*, *Vilde Kvillum*, *Anne Marit Vigerust*,

When building or reconstructing a hospital, a decision of great importance is to design its internal layout. We consider the Hospital Facility Layout Problem (HFLP), where a diverse set of hospital functions, such as operating rooms, bed wards, medical imaging labs, and emergency rooms, has to be assigned unique locations. A layout that reduces the amount of transportation of patients, personnel and materials is desirable in terms of operational effectiveness. We formulate the HFLP as an IP, whose objective function is to minimize the transportation costs between pairs of functions, expressed as the product of the functions' relatedness and distance between their assigned locations. Hence, the problem contains a quadratic assignment problem. To solve real-world instances, we propose a matheuristic approach that is based on iteratively solving relaxed IPs of the original problem. To our knowledge, our approach is novel within the HFLP literature. Moreover, we present results from artificial and real-world instances, which show the applicability of our approach.

3 - A Multi task robot layout optimization with inventory lot-sizing problem

Speaker: Hanane Khamlichi, FST - Tangier, MA, talk 1328

Co-Authors: *Kenza Oufaska*, *Rachid Dkiouak*, *Tarik Zouadi*,

Recognizing that many factors must be considered in choosing how to layout a facility. A suitable flexible facility layout planning is necessary to enhance efficiency, and flexibility in any manufacturing environment. Today, the factories understand that choosing a layout type has significant impact on the ability of the firm to compete in the market and its long-term success. The strategy of Adopting one fixed layout without considering the demand changes causes additional manufacturing costs and increases jobs tardiness. Cellular manufacturing (CM) concept is derived from a group technology (GT) concept. Today, this concept is used in many companies to enhance flexibility, reduce set up, handling and inventory costs and optimize the factories layout. The objective is to group a set of problem, thus a single solution can be found to a set of problems, which leads the companies to save money and efforts. In this work, we propose a multi-period model to determine the best cell formation and the necessary configurations over each period. The model integrates the robots cell formation decisions, the group layout and the lot-sizing problem, and aims to minimize intra and inter-cell materials handling, and robot's relocation. The paper proposes a MIP formulation for the problem, which is solved using commercial software CPLEX, also we present a hybrid genetic algorithm to solve the problem. Computational results on several randomly generated instances show the effectiveness of the proposed approaches.

Algorithms for nonlinear conic problems

Continuous Optimization

SDP - Mo 3:15pm-4:45pm, Format: 3x30 min

Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

Contributed Session 463

Chair: Takayuki Okuno, RIKEN AIP, JP

1 - Augmented Lagrangian for nonlinear SDPs applied to the covering problem

Speaker: Leonardo Mito, IME-USP, BR, talk 1570

Co-Authors: *Gabriel Haeser*, *Ernesto Birgin*, *Daiana Viana*, *Walter Bofill*,

In this work we present an Augmented Lagrangian algorithm for nonlinear semidefinite programs (NLSDPs), which is a natural extension of its consolidated counterpart in nonlinear programming. This method works with two levels of constraints, one that is penalized and other that is kept within the subproblems. This is done in order to allow exploiting the subproblem structure while solving it. The global convergence theory is based on recent results regarding approximate Karush-Kuhn-Tucker optimality conditions for NLSDP, which is stronger than Fritz John optimality conditions that are usually employed. Additionally, we approach the so-called sphere covering problem exploiting some convex algebraic geometry results, such as Stengle's positivstellensatz and its variations. The problem can be written in terms of a standard NLSDP using Gram representations for real polynomials that are sums of squares of other polynomials. Numerical experiments are presented.

2 - Long-Step Path-Following Algorithm for Nonlinear Symmetric Programming Problems

Speaker: Cunlu Zhou, University of Notre Dame, US, talk 667

Co-Authors: *Leonid Faybusovich*,

We develop a direct long-step path-following algorithm for a class of symmetric programming problems with nonlinear convex objective functions. The direct approach allows us to consider linear equality constraints in explicit form and use all of the structural properties of a natural formulation of the problem. We establish the complexity estimates similar to the case of a linear-quadratic objective function. We also present the numerical results for the class of optimization problems involving quantum (von Neumann) entropy.

3 - A primal-dual path following method for nonlinear semi-infinite SDPs

Speaker: Takayuki Okuno, RIKEN AIP, JP, talk 704

Co-Authors: *Masao Fukushima*,

In this talk, we consider nonlinear semi-infinite programs with semi-definite matrix constraints and infinitely many convex inequality constraints, called NSISDP for short. Although the NSISDP has important applications such as FIR filter design problems, robust beam forming problems, and so on, it has not been studied sufficiently so far. Our aim in this research is to design a new algorithm for the NSISDP. We actually propose an algorithm that follows central path consisting of barrier KKT points of the NSIDP. To achieve a rapid convergence, we incorporate the local reduction SQP method into the above algorithm. Also, we find a dual optimal matrix solution associated to the semi-definite constraint by solving scaled Newton equations. The proposed method may be viewed as an extension of the primal-dual interior point method for the nonlinear SDPs proposed by Yamashita, et al (2012) (H. Yamashita, H. Yabe, and K. Harada, A primal–dual interior point method for nonlinear semi-definite programming, Mathematical Programming, 135 (2012), pp.

89–121). However, the extension is not straightforward due to the existence of the semi-infinite constraints. We establish not only global convergence but also two-step superlinear convergence of the proposed algorithm. Finally, we report some numerical results.

Decisions and learning from data

Specific Models, Algorithms, and Software
Learning - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 16 Building: I, 2nd floor, Zone: 7

Contributed Session 481
Chair: Christopher McCord, MIT, US

1 - Gaussian mixture penalization for trajectory optimization problems
Speaker: Cédric Rommel, CMAP INRIA Safety Line, FR, talk 1082
Co-Authors: *Frédéric Bonnans*, *Pierre Martinon*, *Baptiste Gregorutti*,
We consider the task of solving an optimal control problem where the system dynamics have been estimated from recorded data. Additionally, we want to avoid optimized trajectories that go too far away from the domain occupied by the data, since the model validity is not guaranteed outside this region. This motivates the need for a proximity indicator between a given trajectory and a set of reference trajectories. In this presentation, we propose such an indicator based on a parametric estimator of the training set distribution. We then introduce it as a penalty term in the optimal control problem. Our approach is illustrated with an aircraft minimal consumption problem and data from real recorded flights. We observe in our numerical results the expected trade-off between the flight consumption and the penalty term.

2 - Optimization over Continuous Decisions with Observational Data
Speaker: Christopher McCord, MIT, US, talk 1468
Co-Authors: *Dimitris Bertsimas*,
We consider optimization under uncertainty over continuous and multi-dimensional decision spaces in problems in which we are only provided with observational data. We propose a novel algorithmic framework that is tractable, asymptotically consistent, and superior to comparable methods on example problems. Our approach leverages highly effective predictive machine learning methods for the purpose of prescribing decisions. We demonstrate the efficacy of our method on examples involving both synthetic and real data sets.

3 - Combining Machine Learning and Optimization: Learning to emulate an expert
Speaker: Oskar Schneider, FAU, DE, talk 889
Co-Authors: *Andreas Bärmann*, *Sebastian Pokutta*,
In this talk, we demonstrate how to learn the objective function of a decision maker while only observing the problem input data and the decision maker's corresponding decisions over multiple rounds. Our approach is based on online learning techniques and works for linear objectives over arbitrary sets for which we have a linear optimization oracle and as such generalizes previous work based on KKT-system decomposition and dualization approaches. We prove that our algorithm converges at a rate of O(1/sqrt(T)) and present an in-depth computational study, which confirms the theoretical results for several combinatorial optimization problems.

IP Practice I

Discrete Optimization & Integer Programming
IPpractice - Mo 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Contributed Session 506
Chair: Maurice Queyranne, UBC Sauder School of Business, CA

1 - IP models for dimensionality reduction and feature selection in categorical da
Speaker: Raphael Hauser, Oxford Mathematical Institute, GB, talk 1531
Co-Authors: *Reka Agnes Kovacs*, *Oktay Gunluk*,
Low-rank approximations of data matrices are an important dimensionality reduction and feature selection tool in machine learning and regression analysis. In the case of categorical variables this problem is equivalent to finding low-rank approximations to Boolean matrices for which we discuss an integer programming formulation and an algorithm based on delayed pattern generation and Lagrangean duality.

2 - Network models for multiobjective discrete optimization
Speaker: Carlos Cardonha, IBM Research, BR, talk 558
Co-Authors: *Merve Bodur*, *Andre Cire*, *David Bergman*,
This work provides a novel framework for solving multiobjective discrete optimization problems with an arbitrary number of objectives. Our framework formulates these problems as network models, in that enumerating the Pareto frontier amounts to solving a multicriteria shortest path problem in an auxiliary network. We design tools and techniques for exploiting the network model in order to accelerate the identification of the Pareto frontier, most notably a number of operations to simplify the network by removing nodes and arcs while preserving the set of nondominated solutions. We show that the proposed framework yields orders-of-magnitude performance improvements over existing state-of-the-art algorithms on four problem classes containing both linear and nonlinear objective functions.

3 - Optimum Turn-Restricted Paths, Nested Compatibility, and Optimum Convex Polygons
Speaker: Maurice Queyranne, UBC Sauder School of Business, CA, talk 646
Co-Authors: *Laurence Wolsey*,
We consider two apparently unrelated classes of combinatorial and geometric optimization problems. First, we give compact extended formulations, i.e., polynomial-size linear programming formulations with integer optima, for optimum path problems with turn restrictions satisfying a nested compatibility condition in acyclic digraphs. We then apply these results to optimum convex polygon problems in the plane, by interpreting certain Dynamic Programming algorithms as sequences of optimum turn-restricted path problems with nested compatibility in acyclic digraphs. As a result, we derive compact extended formulations for these geometric problems as well.

Adaptivity in non smooth optimization

CONTINUOUS OPTIMIZATION
NONSMOOTH - Mo 3:15pm-4:15pm, Format: 2x30 min
Room: Salle 9 Building: N, 4th floor, Zone: 12

INVITED SESSION 558
Organizer: Masaru Ito, Nihon University, JP

1 - An adaptive first order method for weakly smooth and uniformly convex problems
Speaker: Masaru Ito, Nihon University, JP, talk 990
Co-Authors: *Mituhiro Fukuda*,
We consider a convex optimization problem where the objective function satisfies the following two conditions: First, the objective function is weakly smooth, namely, it is differentiable and its gradient satisfies a Holder condition. Second, the objective function is assumed to be uniformly convex which is a generalization of the strong convexity. Each of these two conditions involves coefficient and exponent parameters. We present a restarting technique of a first order method based on Nesterov's universal gradient method to adapt these parameters. We show a complexity bound with respect to the optimality measure based on the 'gradient mapping.' If we restrict the method to the case where the objective function is smooth and strongly convex, it partially improves the complexity bound compared to existing methods.

2 - A Subgradient Algorithm for solving variational Inequality Problem
Speaker: Somayya Komal, KMUTT, Bangkok, Thailand, TH, talk 732
Co-Authors: *Poom Kumam*,
Censor et. al. (J. Optim. Theory Appl. 148, 318-335, 2011) introduced The subgradient extragradient method for solving the varional inequality (VI) problem by replacing the second projection onto the feasible set of the VI, in the extragradient method, with a subgradient projection onto some defined half-space. After introducing this method, a number of mathematicians proposed extensions and modifications with applications to various problems. In this paper, we introduced an inertial modified subgradient extragradient method by improving the stepsize. Convergence criteria for proposed method is proved under standard and necessary conditions. Also, will propose numerical experiment to illustrate the efficiency and behaviour of our defined Algorithem.

Gradient Methods for Constrained Optimization Problems

CONTINUOUS OPTIMIZATION
NLP - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

INVITED SESSION 4
Organizer: Igor Konnov, Kazan Federal University, RU

1 - Simple Adaptive Versions of Iterative Optimization Methods
Speaker: Igor Konnov, Kazan Federal University, RU, talk 324
We suggest a simple adaptive step-size procedure for a general class of iterative optimization methods. This procedure reduces the implementation cost of each iteration essentially since does not require any line-search. At the same time, it takes into account behavior of the iteration sequence and maintains the basic convergence properties of the gradient descent methods. We prove convergence of a general method for non-convex optimization problems. We describe applications of this general framework to smooth optimization problems and general variational inequalities.

2 - Subgradient Projection Algorithm with Computational Errors
Speaker: Alexander Zaslavski, The Technion - IIT, IL, talk 474
We study the subgradient projection algorithm for minimization of convex and nonsmooth functions, under the presence of computational errors. It is shown that our algorithms generate a good approximate solution, if computational errors are bounded from above by a small positive constant. Moreover, for a known computational error, we find out what an approximate solution can be obtained and how many iterates one needs for this.

3 - An active-set framework for minimizing nonconvex functions over the simplex
Speaker: Andrea Cristofari, University of Padua, IT, talk 584
Co-Authors: *Marianna De Santis*, *Stefano Lucidi*, *Francesco Rinaldi*,
An active-set framework is proposed to minimize a nonconvex function over the unit simplex. Using a suitable strategy to predict the active variables (i.e., those equal to zero) at a stationary point, we devise a general scheme which consists in two main steps per iteration: in the first step we estimate the active variables and set them to zero, and in the second step we update all the remaining variables by computing a search direction in the subspace of the estimated nonactive variables and using the Armijo line search. Convergence to stationary points is established under a general condition on the search direction. In particular, it is shown that this condition is satisfied by the Frank-Wolfe, the away-step Frank-Wolfe and the projected gradient direction. For all these directions, we also prove eventual linear rate under additional assumptions on the objective function over the subspace of the nonactive variables. Finally, numerical results are provided, showing the efficiency of the proposed approach.

Polynomial and tensor optimization III

CONTINUOUS OPTIMIZATION
NLP - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

INVITED SESSION 7
Organizer: Jiawang Nie, Univ. of California San Diego, US

1 - Higher order cone programming
Speaker: Lek-Heng Lim, University of Chicago, US, talk 368
Co-Authors: *Lijun Ding*,
We introduce a conic embedding condition that gives a hierarchy of cones and cone programs. This condition is satisfied by a large number of convex cones including the cone of copositive matrices, the cone of completely positive matrices, and

all symmetric cones. We discuss properties of the intermediate cones and conic programs in the hierarchy. In particular, we demonstrate how this embedding condition gives rise to a family of cone programs that interpolates between LP, SOCP, and SDP. This family of kth order cones may be realized either as cones of n-by-n symmetric matrices or as cones of n-variate even degree polynomials. The cases $k = 1, 2, n$ then correspond to LP, SOCP, SDP; or, in the language of polynomial optimization, to DSOS, SDSOS, SOS.

2 - Ranks and decompositions of Hankel tensors

Speaker: Ke Ye, Chinese Academy of Sciences, CN, talk 13
Co-Authors: *Jiawang Nie*,

Hankel tensors are generalizations of Hankel matrices. In this talk we will discuss the relations among various ranks of Hankel tensors. We will also give an algorithm that can compute the Vandermonde ranks and decompositions for all Hankel tensors. For a generic n-dimensional Hankel tensor of even order or order three, we will show that the the cp rank, symmetric rank, border rank, symmetric border rank, and Vandermonde rank all coincide with each other. We will also discuss some numeric results about Hankel tensor decompositions. This talk is based on a joint work with Jiawang Nie.

3 - Symmetric Sums of Squares over k-Subset Hypercubes

Speaker: Annie Raymond, University of Massachusetts, US, talk 363
Co-Authors: *James Saunderson*, *Mohit Singh*, *Rekha Thomas*,

We develop a symmetry-reduction method that finds sums of squares certificates for non-negative symmetric polynomials over k-subset hypercubes that improves on a technique due to Gatermann and Parrilo. For every symmetric polynomial that has a sos expression of a fixed degree, our method finds a succinct sos expression whose size depends only on the degree and not on the number of variables. Our results relate naturally to Razborov's flag algebra calculus for solving problems in extremal combinatorics.

4 - Tight relaxations for polynomial optimization and lagrange multiplier expression

Speaker: Jiawang Nie, Univ. of California San Diego, US, talk 5

This talk proposes tight semidefinite relaxations for polynomial optimization. The optimality conditions are investigated. We show that generally Lagrange multipliers can be expressed as polynomial functions in decision variables over the set of critical points. The polynomial expressions can be determined by linear equations. Based on these expressions, new Lasserre type semidefinite relaxations are constructed for solving polynomial optimization. We show that the hierarchy of new relaxations has finite convergence, or equivalently, the new relaxations are tight for a finite relaxation order.

Advances in DFO I

Continuous Optimization
DerFree - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 40
Chair: Sébastien Le Digabel, Polytechnique Montreal, CA

1 - Calculus Rules of the Simplex Gradient

Speaker: Warren Hare, University of British Columbia, CA, talk 517
Co-Authors: *Gabriel Jarry-Bolduc*,

The Simplex Gradient, essentially the gradient of a linear interpolation approximation, is a common tool in derivative-free optimization. Recent work by Regis extended the definition of the Simplex gradient to include a unified framework for under-determined and over-determined interpolation sets. Regis also introduced a sum-rule and product-rule for the simplex gradient of two functions. Unfortunately, the product-rule only works under a restrictive set of assumptions. In this talk, we review Regis' framework, and product rule. We then provide an alternate product rule, which requires no unreasonable assumptions for application. We introduce a chain rule, and include several corollaries (such as a quotient rule).

2 - Derivative free global Optimization with categorical-continuous variables

Speaker: Miguel Munoz Zuniga, IFPEN, FR, talk 612
Co-Authors: *Delphine Sinoquet*,

Real industrial studies often boils down to complex optimization problems involving mixed variables and time consuming simulators. To deal with these difficulties we propose the use of a Gaussian process regression surrogate with a suitable kernel able to capture simultaneously the output correlations with respect to continuous and categorical/discrete inputs. The surrogate is integrated in the Efficient Global Optimization method based on the maximization of the Expected Improvement criterion. This maximization is a Mixed Integer Non-Linear problem which we tackle with an adequate optimizer : the Mesh Adaptive Direct Search, integrated in the NOMAD library. We introduce a random exploration of the categorical space and validate the full strategy accuracy on toy problems and compare with other optimizers on a benchmark of functions.

3 - A Taxonomy of Constraints for Blackbox-Based Optimization

Speaker: Stefan Wild, Argonne National Laboratory, US, talk 1183
Co-Authors: *Sébastien Le Digabel*,

The types of constraints encountered in black-box simulation-based optimization problems differ significantly from those treated in nonlinear programming. We introduce a characterization of constraints to address this situation. We provide formal definitions for several constraint classes and present illustrative examples in the context of the resulting taxonomy. We believe that this taxonomy is a critical step for modeling and problem formulation, as well as optimization software development and deployment. Such a taxonomy can also be used as the basis for a dialog with practitioners in moving problems to increasingly solvable branches of optimization as well as informing the development of new classes of mathematical optimization algorithms. Attendees are invited to provide constraint (counter)examples as part of this effort.

Novel data-driven OR techniques for power system operations and planning

Specific Models, Algorithms, and Software
Energy - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 23 Building: G, 3rd floor, Zone: 6

Invited Session 52

Organizer: Juan Morales, University of Malaga, ES

1 - Chronological Time-Period Clustering for Optimal Capacity Expansion Planning
Speaker: Salvador Pineda Morente, University of Málaga, ES, talk 270
Co-Authors: *Juan Morales*,
To reduce the computational burden of capacity expansion models, power system operations are commonly accounted for in these models using representative time periods of the planning horizon such as hours, days or weeks. However, the validity of these time-period aggregation approaches to determine the capacity expansion plan of future power systems is arguable, as they fail to capture properly the mid-terms dynamics of renewable power generation and to model accurately the operation of electricity storage. In this paper we propose a new time-period clustering method that overcomes the aforementioned drawbacks by maintaining the chronology of the input time series throughout the whole planning horizon. Thus, the proposed method can correctly assess the economic value of combining renewable power generation with interday storage devices. Numerical results from a test case based on the European electricity network show that our method provides more efficient capacity expansion plans than existing methods while requiring similar computational needs.

2 - Energy and Reserve Dispatch with Distributionally Robust Joint Chance Constraints
Speaker: Christos Ordoudis, DTU, DK, talk 731
Co-Authors: *Viet Anh Nguyen*, *Daniel Kuhn*, *Pierre Pinson*,
We propose a new approximation scheme for distributionally robust joint chance constrained programs, where the ambiguity set represents a Wasserstein ball centered at a nominal distribution that is estimated from the available data. We show that the resulting approximate problem is tractable and that a minimizer can be obtained by solving a sequence of conic programs. We demonstrate the superior performance of the proposed approach relative to the Bonferroni approximation in the context of an energy and reserve dispatch problem.

3 - Predicting the electricity demand response via data-driven inverse optimization
Speaker: Juan Morales, University of Malaga, ES, talk 267
Co-Authors: *Javier Saez-Gallego*,
A method to predict the aggregate demand of a cluster of price-responsive consumers of electricity is discussed in this presentation. The price-response of the aggregation is modeled by an optimization problem whose defining parameters represent a series of marginal utility curves, and minimum and maximum consumption limits. These parameters are, in turn, estimated from observational data using an approach inspired from duality theory. The resulting estimation problem is nonconvex, which makes it very hard to solve. In order to obtain good parameter estimates in a reasonable amount of time, we divide the estimation problem into a feasibility problem and an optimality problem. Furthermore, the feasibility problem includes a penalty term that is statistically adjusted by cross validation. The proposed methodology is data-driven and leverages information from regressors, such as time and weather variables, to account for changes in the parameter estimates. The estimated price-response model is used to forecast the power load of a group of heating, ventilation and air conditioning systems, with positive results.

Mixed-Integer Conic Optimization

Discrete Optimization & Integer Programming
MINLP - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1
Invited Session 57
Organizer: Sven Wiese, MOSEK ApS, DK

1 - Exact methods based on SDP for the k-item quadratic knapsack problem
Speaker: Lucas Letocart, LIPN, CNRS Universite Paris 13, FR, talk 721
Co-Authors: *Frederic Roupin*, *Angelika Wiegele*,
The 0-1 k-item quadratic knapsack problem consists of maximizing a quadratic objective function subject to a linear capacity constraint with an additional cardinality constraint. We propose exact methods based on semidefinite optimization. First, we present a specific branch and cut with a semidefinite relaxation solved using a dedicated interior point method. The cuts are handled thanks to a bundle method. Two heuristics and a branch and prune are also integrated in order to speed up the resolution. Then, we propose to incorporate the heuristics and the branch and prune in the BiqCrunch solver, which uses a branch-and-bound method featuring an improved semidefinite bounding procedure, mixed with a polyhedral approach, in order to compare theses two approaches.

2 - Knapsack Constraints over the Positive Semidefinite Cone
Speaker: Tristan Gally, TU Darmstadt, DE, talk 712
Co-Authors: *Marc Pfetsch*,
Mixed-integer semidefinite programs (MISDPs) consisting of semidefinite constraints $C - \sum_{i=1}^{m} A_i y_i \succeq 0$ with some or all y_i being integer have received increasing attention in recent years. In this talk we will concentrate on SDP-constraints with specific structure, namely C and all A_i being positive semidefinite and y being binary, which appear in different applications like truss topology design and cardinality-constrained least-squares. Under these additional assumptions the SDP-constraint exhibits the same monotonicity structure as classical knapsack constraints. During the talk we will discuss similarities and differences to the linear case and show how concepts like covers and lifting can be extended to these SDP-knapsack constraints.

3 - The Mixed-integer Conic Optimizer in MOSEK
Speaker: Sven Wiese, MOSEK ApS, DK, talk 534
It is a well-known folklore that almost all practical (mixed-integer) convex optimization problems can be expressed using the linear, the quadratic, the semidefinite, the exponential and the power cones. The former three belong to the class of symmetric cones, whereas the latter two are non-symmetric. We call modeling with affine expressions and these five 5 cone types extremely disciplined modeling. It is much easier to build software for extremely disciplined optimization models rather than for general convex problems, due to the limited and explicit structure, and this fact is exploited in the software package MOSEK. MOSEK has for many years been able to solve conic optimization problems over the symmetric cones, but in the upcoming version 9, MOSEK can handle the two non-symmetric cones as well, i.e. the exponential and the power cone. We will discuss the continuous and

mixed-integer conic optimizer in MOSEK, and present computational results that illustrate the performance of MOSEK on problems including non-symmetric cones.

Polynomial optimization in binary variables

Discrete Optimization & Integer Programming
MINLP - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Invited Session 58
Organizer: Elisabeth Rodriguez-Heck, University of Liege, BE

1 - Unconstrained 0-1 polynomial optimization through convex quadratic reformulation
Speaker: Arnaud Lazare, UMA-CEDRIC ENSTA, FR, talk 457
Co-Authors: *Sourour Elloumi*, *Amélie Lambert*,
This paper addresses the resolution of unconstrained binary polynomial programs (P). We propose a new 3-phases algorithm to solve (P). The first phase consists in reformulating (P) into a quadratic program (QP) using standard linearization inequalities. In the second phase, we reformulate (P) into a convex quadratic program (QPC). This convexification is computed thanks to a semidefinite relaxation. We compute the optimal value of the continuous relaxation of (QPC) using the binary identity. Moreover, in order to start the third phase (Branch and Bound phase) with a tight bound, we use new valid equalities depending on the chosen quadratization. These equalities highly increase the quality of the bound as it will be shown by testing our method on several benchmark instances and comparing it to other polynomial solvers.
2 - A study of specially structured polynomial matroid optimization problems
Speaker: Anja Fischer, TU Dortmund University, DE, talk 757
Co-Authors: *Frank Fischer*, *Tom McCormick*,
We consider polynomial matroid optimization problems where the non-linear monomials in the objective function satisfy certain monotonicity properties. The monomials are linearized and we study the corresponding polytope. Extending results of Edmonds we present a complete description of that polytope. Apart from linearization constraints one needs appropriately strengthened rank inequalities whose separation problem reduces to a submodular function minimization problem. These polyhedral results lead to a new hierarchy for solving general polynomial matroid optimization problems, which is compared to the hierarchy of Sherali-Adams. Finally, we show how our results can be extended if the monotonicity properties are relaxed appropriately.
3 - Linear and quadratic reformulations of nonlinear 0-1 optimization problems
Speaker: Elisabeth Rodriguez-Heck, University of Liege, BE, talk 462
Co-Authors: *Endre Boros*, *Yves Crama*,
We are interested in the problem of nonlinear unconstrained optimization in binary variables. A common approach to solve such a problem consists in defining first a linear or a quadratic reformulation of the objective function by introducing artificial variables, and then using linear or quadratic integer programming techniques to optimize the reformulation. In the framework of linear reformulations, we define a class of inequalities that strengthen a well-known linearization technique. Concerning quadratic reformulations, we focus on the question of using the smallest possible number of artificial variables. We present a quadratic reformulation that reduces the required number of artificial variables from linear to logarithmic for monomials with a positive coefficient, which is a very simple but fundamental class of functions. Moreover, we extend this result to more general classes of functions and we show that a logarithmic number of variables is the best we can hope for. Finally we present a computational study comparing several linear and quadratic reformulations.

Lattice methods in Integer Optimisation

Discrete Optimization & Integer Programming
IPtheory - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 78
Organizer: Iskander Aliev, Cardiff University, GB

1 - Approximation of corner polyhedra with intersection cuts
Speaker: Gennadiy Averkov, OvGU Magdeburg, DE, talk 77
Co-Authors: *Amitabh Basu*, *Joseph Paat*,
How complex should be the intersection cuts to guarantee a constant-factor approximation of the corner polyhedron? The study of this important question was initiated in works of Andersen, Wagner, Weismantel, Awaten, Cornuéjols, Denin, Tuncel and Basu, Bonami, Cornuéjols, Margot. In a joint work with Amitabh Basu and Joseph Paat we consider the case, when all non-basic variables are continuous, and determine a threshold value N on the number of facets such that if the intersect cuts use maximal lattice-free sets with at most N facets, no constant-factor approximation is possible, while using cuts from maximal lattice-free sets with N+1 facets, it is possible to approximate the corner polyhedron up to a constant factor.
2 - The Support of Integer Optimal Solutions
Speaker: Timm Oertel, Cardiff University, GB, talk 100
Co-Authors: *J. De Loera*, *Iskander Aliev*, *Friedrich Eisenbrand*, *Robert Weismantel*,
The support of a vector is the number of nonzero-components. We show that given an integral $m \times n$ matrix A, the integer linear optimization problem $\max\left\{c^T x : Ax = b,\ x \geq 0,\ x \in \mathbb{Z}^n\right\}$ has an optimal solution whose support is bounded by $2m\ \log(2\sqrt{m}\|A\|_\infty)$, where $\|A\|_\infty$ is the largest absolute value of an entry of A. Compared to previous bounds, the one presented here is independent on the objective function. We furthermore provide a nearly matching asymptotic lower bound on the support of optimal solutions.
3 - Distances to Lattice Points in Knapsack Polyhedra
Speaker: Iskander Aliev, Cardiff University, GB, talk 211
Co-Authors: *Martin Henk*, *Timm Oertel*,
We give an optimal upper bound for the distance from a vertex of a knapsack polyhedron to its nearest feasible lattice point. The proofs are based on using discrete lattice coverings asso-

ciated with Hermite Normal Form of a lattice basis matrix.

Solving large scale convex composite programming

Continuous Optimization
SDP - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 20 Building: G, 1st floor, Zone: 6

Invited Session 130
Organizer: Kim-Chuan Toh, National U. of Singapore, SG

1 - A block symmetric Gauss-Seidel decomposition theorem for convex composite QP
Speaker: Kim-Chuan Toh, National U. of Singapore, SG, talk 174
Co-Authors: *Xudong Li*, *Defeng Sun*,
For a symmetric positive semidefinite (SPD) linear system of equations, we show that each cycle of the classical block symmetric Gauss-Seidel (block sGS) method exactly solves the associated QP problem but added with an extra proximal term. By leveraging on such a connection to optimization, we are able to extend the result (called the block sGS decomposition theorem) for solving a convex composite QP (CCQP) with an additional possibly nonsmooth term. Based on the block sGS decomposition theorem, we are able to extend the classical block sGS method to solve a CCQP. In addition, our extended block sGS method has the flexibility of allowing for inexact computation in each step of the block sGS cycle. We can also accelerate the inexact block sGS method to achieve a better iteration complexity. As a fundamental building block, the block sGS decomposition theorem has played a key role in various recently developed algorithms such as the inexact semiproximal ALM/ADMM for linearly constrained multi-block convex composite conic programming (CCCP), and the accelerated block coordinate descent method for multi-block CCCP.
2 - Fast algorithms for large scale generalized distance weighted discrimination
Speaker: Xin Yee Lam, NUS, SG, talk 445
Co-Authors: *J.S. Marron*, *Kim-Chuan Toh*, *Defeng Sun*,
High dimension low sample size statistical analysis is important in a wide range of applications. In such situations, the highly appealing discrimination method, support vector machine, can be improved to alleviate data piling at the margin. This leads naturally to the development of distance weighted discrimination (DWD), which can be modeled as a second-order cone programming problem and solved by interior-point methods when the scale (in sample size and feature dimension) of the data is moderate. Here, we design a scalable and robust algorithm for solving large scale generalized DWD problems. Numerical experiments on real data sets from the UCI repository demonstrate that our algorithm is highly efficient in solving large scale problems, and sometimes even more efficient than the highly optimized LIBLINEAR and LIBSVM for solving the corresponding SVM problems.
3 - An Efficient Semismooth Newton Based Algorithm for Convex Clustering
Speaker: Yancheng Yuan, NUS, SG, talk 446
Co-Authors: *Defeng Sun*, *Kim-Chuan Toh*,
Clustering may be the most fundamental problem in unsupervised learning which is still active in machine learning research because its importance in many applications. Popular methods like K-means, may suffer from instability as they are prone to get stuck in its local minima. Recently, the sum-of-norms (SON) model (also known as clustering path), which is a convex relaxation of hierarchical clustering model, has been proposed by Lindsten et al. and Hocking et al. Although numerical algorithms like ADMM and AMA are proposed to solve convex clustering model, it is known to be very challenging to solve large-scale problems. We propose a semi-smooth Newton based augmented Lagrangian method for large-scale convex clustering problems. Extensive numerical experiments on both simulated and real data demonstrate that our algorithm is highly efficient and robust for solving large-scale problems. Moreover, the numerical results also show the superior performance and scalability of our algorithm compared to existing first-order methods.

Structure and Learning in Power Grid Optimization

Specific Models, Algorithms, and Software
Energy - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6

Invited Session 135
Organizer: Deepjyoti Deka, Los Alamos National Lab, US

1 - Chance-Constrained Outage Scheduling using a Machine Learning Proxy
Speaker: Gal Dalal, Technion, IL, talk 432
Co-Authors: *Elad Gilboa*, *Louis Wehenkel*, *Shie Mannor*,
Outage scheduling aims at defining, over a horizon of several months to years, when different components needing maintenance should be taken out of operation. Its objective is to minimize operation-cost expectation while satisfying reliability-related constraints. We propose a distributed scenario-based chance-constrained optimization formulation for this problem. To tackle tractability issues arising in large networks, we use machine learning to build a proxy for predicting outcomes of power system operation processes in this context. On the IEEE-RTS79 and IEEE-RTS96 networks, our solution obtains cheaper and more reliable plans than other candidates.
2 - Statistical Learning For DC Optimal Power Flow
Speaker: Sidhant Misra, Los Alamos National Laboratory, US, talk 383
Co-Authors: *Line Roald*, *Yeesian Ng*,
The optimal power flow problem plays an important role in the market clearing and operation of electric power systems. However, with increasing uncertainty from renewable energy operation, the optimal operating point of the system changes more significantly in real-time. In this paper, we aim at developing control policies that are able to track the optimal set-point with high probability. The approach is based on the observation that the OPF solution corresponding to a certain uncertainty realization is a basic feasible solution, which provides an affine control policy. The optimality of this basis policy is restricted to uncertainty realizations that share the same set of active constraints. We propose an ensemble control policy that combines several basis policies to improve

performance. Although the number of possible bases is exponential in the size of the system, we show that only a few of them are relevant to system operation. We adopt a statistical learning approach to learn these important bases, and provide theoretical results that validate our observations. For most systems, we observe that efficient ensemble policies constructed using as few as ten bases, are able to obtain optimal solutions with high probability.

3 - Non-Stationary Streaming PCA
Speaker: Apurv Shukla, Columbia University, US, talk 316
Co-Authors: *Seyoung Yun*, *Daniel Bienstock*,
Machine learning algorithms are usually applied in a noisy and non-stationary environment where as the prevalent modeling assumptions do not account for noise and non-stationarity simultaneously. In this work, assuming a non-stationary spiked covariance generative model, we propose and establish the convergence of a two-phase streaming PCA algorithm based on Block-Stochastic Power Method (Mitgliakis et. al. [2013]) and Frequent Directions (Liberty et. al.[2015]). Further, we characterize the hardness of the learning problem by establishing a lower bound on the sample complexity for the problem. Finally, we demonstrate the efficacy of our algorithm on synthetic data as well as real-world data.

Nonlinear Optimization and Variational Inequalities VI

Continuous Optimization
Variat - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 146
Organizer: Cong Sun, Beijing Univ. Post. Telecomm., CN

1 - Balance analysis of sparsity and robustness for portfolio adjustment problem
Speaker: Fengmin Xu, Xi'an Jiaotong University, CN, talk 797
Co-Authors: *Zhihua Zhao*,
Financial institutions manage portfolios that take less risk when volatility is too high, and produce large utility gains through making adjustments. But the adjustment methods may make investors fall into distressful circumstances because some of them seem to be full of incongruity. The goal of our study is to investigate how sparsity and robustness interact to optimal portfolio positions to portfolio adjustment problems. We formulate a sparse and robust portfolio adjustment (SRPA) optimization problem, and generate a high-quality solution via an efficient ADMM. Through balance analysis, we are able to identify two key contributors to portfolio adjustment, the changes of optimal portfolio positions and the move of the transaction critical point, quantifying the market uncertainty effect for various portfolio strategies. We illustrate the above financial phenomena in numerical examples and verify the good performance of the proposed method in actual data sets from China stock market.Our results contribute to a better understanding of sparsity and robustness effects for portfolio adjustment problem.

2 - Two-stage stochastic program and stochastic variational inequalities
Speaker: Chao Zhang, Beijing Jiaotong University, CN, talk 1047
We investigate the optimality conditions of a general two-stage stochastic program that can be transformed to a two-stage stochastic variational inequalities. Real applications of two-stage programs are provided. Properties such as the convexity and solvability of the stochastic variational inequalities are discussed.

3 - Proximal Stochastic Quasi-Newton methods for Nonconvex Composite Optimization
Speaker: Xiao Wang, Chinese Academy of Sciences, CN, talk 465
Co-Authors: *Xiaoyu Wang*, *Yaxiang Yuan*,
We propose a generic algorithmic framework for proximal stochastic quasi-Newton methods for solving nonconvex composite optimization problems. Stochastic second-order information is explored to construct proximal subproblem. Under mild conditions we show the non-asympotic convergence of the proposed algorithm to stationary point of original problems and analyze its computational complexity. Besides, we extend the proximal form of Polyak- Lojasiewicz(PL) inequality to constrained settings and obtain the constrained proximal PL (CP-PL) inequality. Under CP-PL inequality linear convergence rate of the proposed algorithm is achieved. Moreover, we propose a modified self-scaling symmetric rank one (MSSR1) method that falls under the proposed framework. Finally, we report some numerical experiments to reveal the effectiveness of the proposed algorithm.

4 - General inertial proximal gradient method for nonconvex nonsmooth optimization
Speaker: Zhongming Wu, Southeast University, CN, talk 583
Co-Authors: *Min Li*,
We consider a general inertial proximal gradient method with constant and variable stepsizes for a class of nonconvex nonsmooth optimization problems. This method incorporates two different extrapolations with respect to the previous iterates into the backward proximal step and the forward gradient step in classic proximal gradient method. Under more general parameter constraints, we prove that the proposed method generated a convergent subsequence and each limit point is a stationary point of the problem. Furthermore, the generated sequence is globally convergent to a stationary point if the objective function satisfies the Kurdyla-Lojasiewicz property. Local linear convergence can also be established for the proposed method with constant stepsizes by using a common error bound condition.

MINLP methods in gas transport optimization (II)

Discrete Optimization & Integer Programming
MINLP - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4

Invited Session 163
Organizer: Lars Schewe, FAU, DE

1 - Exploiting acyclic orientations to solve nonlinear potential-based flow problems
Speaker: Benjamin Hiller, Zuse Institute Berlin, DE, talk 905
Co-Authors: *Kai-Helge Becker*,

We consider optimization problems involving nonlinear potential-based flows, which arise e.g. in the planning and operation of gas and water networks. In particular, we aim at solving such problems for complex topologies with many cycles like the German gas network. The existence of cycles implies that the flow direction along an arc is not known beforehand, which leads to weaker relaxations for these MINLP optimization problems. To improve these models, we study the underlying nonlinear flow problem from a combinatorial perspective. In fact, the fact that the flow is potential-driven implies that the resulting flows are acyclic in the following sense: If each network arc is oriented in the direction of flow over this arc, then there is no directed cycle in the resulting network. We exploit the interplay of this acyclicity property with the network flow structure to construct stronger models and present some computational results.

2 - ASTS-Orientations on Undirected Graphs - A tool for optimizing network flows

Speaker: Kai Becker, Zuse-Institute Berlin, DE, talk 1446

Co-Authors: *Benjamin Hiller*,

We study a certain type of acyclic orientations of undirected graphs to see how these may be used to improve the optimization of flows on potential-driven networks. All feasible flows in potential-driven networks induce an orientation on the undirected graph underlying the network. Clearly, this orientation must satisfy two conditions: they are acyclic and there are no "dead ends" in the network, i.e. each source requires outgoing flows, each sink requires incoming flows, and each transhipment vertex requires both an incoming and an outgoing flow. In this paper we will call an orientation that satisfies these two conditions an acyclic source-transhipment-sink orientation (ASTS-orientation). The basic idea of the approach behind this paper is that it may be possible to invent a computationally favourable optimization algorithm for potential-driven networks by enumerating all ASTS-orientations of the graph underlying the network and then carrying out an optimization algorithm for each ASTS-orientations on a network where the flow direction has already been fixed. This paper provides the theoretical foundations for such an endeavour.

3 - Robust Optimal Discrete Arc Sizing for Tree-Shaped Potential Networks

Speaker: Johannes Thürauf, Universität Erlangen-Nürnberg, DE, talk 546

Co-Authors: *Lars Schewe*, *Martin Schmidt*, *Martin Robinius*, *Detlef Stolten*, *Lara Welder*,

We consider the problem of discrete arc sizing for tree-shaped potential networks with respect to infinitely many demand scenarios. The problem can be seen as a strictly robust counterpart of a single-scenario nonlinear network design problem, which is NP-complete even on trees. In order to obtain a tractable problem, we introduce a method for generating a finite scenario set such that optimality of a sizing for this finite set implies the sizing's optimality for the originally given infinite set of scenarios. We further prove that the size of the finite scenario set is quadratically bounded above in the number of nodes of the underlying tree and that it can be computed in polynomial time. The resulting problem can then be solved as a standard mixed-integer linear optimization problem. Finally, we show the applicability of our theoretical results by computing globally optimal arc sizes for a realistic hydrogen transport network of Eastern Germany.

Advances in optimization methods for time dependent problems:I

Continuous Optimization

Control - Mo 5:00pm-6:30pm, Format: 4x20 min

Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Invited Session 223

Organizer: Matthias Heinkenschloss, Rice University, US

1 - Exponentially convergent receding horizon constrained optimal control

Speaker: Mihai Anitescu, Argonne National Laboratory, US, talk 529

Co-Authors: *Wanting Xu*,

Receding horizon control has been a widespread method in industrial control engineering as well as an extensively studied subject in control theory. In this work, we consider a lag L receding horizon strategy that applies the initial L optimal controls from each quadratic program to each receding horizon. We investigate a discrete-time and time-varying linear-quadratic optimal control problem that includes a nonzero reference trajectory and constraints on both state and control. We prove that, under boundedness and controllability conditions, the solution obtained by the receding horizon strategy converges to the solution of the full problem interval exponentially fast in the length of the receding horizon for some lag L. The exponential rate of convergence provides a systematic way of choosing the receding horizon length given a desired accuracy level. We illustrate our theoretical findings using a small, synthetic production cost model with real demand data.

2 - Parallel strategies for DAE optimization with direct Schur-complement decomp.

Speaker: Carl Laird, Sandia National Laboratories, US, talk 1356

Co-Authors: *Santiago Rodriguez*, *Bethany Nicholson*,

We present a nonlinear interior-point algorithm for parallel solution of optimization problems with differential-algebraic equations. The problem is solved with a full-space approach where the DAE is discretized using orthogonal collocation on finite elements, and the fully discretized problem is presented to the solver. Based on IPOPT, every scale dependent step in the interior-point algorithm is implemented to be aware of the structure induced by the time discretization, and both the model evaluations and the linear algebra operations are parallelized. At each iteration, the KKT system is decomposed using a direct Schur-complement based decomposition that allows for parallel solution of the KKT system. In this presentation, we show the scalability of this approach as a function of the number of state and algebraic variables, and explore opportunities to avoid forming the Schur-complement explicitly, and instead support iterative solution of the Schur-complement.

3 - Shape optimization for unsteady fluid-structure interaction

Speaker: Johannes Haubner, Technical University of Munich, DE, talk 1028

Co-Authors: *Michael Ulbrich*,

We consider shape optimization for unsteady fluid-structure interaction problems that couple the Navier-Stokes equations with elasticity equations. We focus on the monolithic ALE formulation which is obtained by transforming the fluid equations to a fixed reference domain. The shape optimization problem is reformulated as an optimal control problem with the method of mappings approach, which requires another transformation to a shape reference domain. We show that the state variables of the transformed unsteady fluid-structure interaction problem are Fréchet-differentiable with respect to the domain transformation. Additionally, an optimization algorithm with adjoint based gradient computation is applied. Numerical results for our implementation, which builds on FEniCS, dolfin-adjoint, and IPOPT, are presented and the question how to use IPOPT with the correct inner products is addressed.

4 - A parallel-in-time gradient-type method for optimal control problems

Speaker: Matthias Heinkenschloss, Rice University, US, talk 512

A parallel-in-time gradient type method for the solution of time dependent optimal control problems is introduced. Each iteration of the classical gradient method requires the solution of the forward-in-time state equation followed by the solution of the backward-in-time adjoint equation to compute the gradient. To introduce parallelism, the time steps are split into N groups corresponding to time subintervals. At the time subinterval boundaries state and adjoint information from the previous iteration is used. On each subinterval the state state and adjoint equations are solved, gradient-type information is generated, and the controls are updated. These computations can be performed in parallel. State and adjoint information at time subinterval boundaries is then exchanged with neighboring subintervals and the process is repeated. Convergence results for of this new method are given. Numerical examples on a 3D parabolic advection diffusion control problem and on a well rate optimization problem for a two-phase immiscible reservoir show good speed-up of the new method.

Distributionally Robust Stochastic Programming: Theory and Applications

Optimization under Uncertainty

Stoch - Mo 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Invited Session 250

Organizer: Ran Ji, George Mason University, US

1 - Ambiguous Chance-constrained Binary Programs Under Mean-covariance Information

Speaker: Yiling Zhang, University of Michigan, US, talk 43

Co-Authors: *Ruiwei Jiang*, *Siqian Shen*,

We consider chance-constrained binary programs, where each row of the inequalities that involve uncertainty needs to be satisfied probabilistically. Only the information of the mean and covariance matrix is available, and we solve distributionally robust chance-constrained binary programs (DCBP). Using two different ambiguity sets, we equivalently reformulate the DCBPs as 0-1 second-order cone (SOC) programs. We further exploit the submodularity of 0-1 SOC constraints under special and general covariance matrices, and utilize the submodularity as well as lifting to derive extended polymatroid inequalities to strengthen the 0-1 SOC formulations. We incorporate the valid inequalities in a branch-and-cut algorithm for efficiently solving DCBPs. We demonstrate the computational efficacy and solution performance using diverse instances of a chance-constrained bin packing problem.

2 - Distributionally Robust Optimization with optimal transport (Wasserstein) costs

Speaker: Karthyek Murthy, SUTD, SG, talk 1007

Co-Authors: *Jose Blanchet*, *Fan Zhang*,

The idea of distributionally robust optimization (DRO) has gained prominence recently to help beat “optimizer’s curse” when performing optimization under uncertainty. Specifically, DRO formulations utilising Wasserstein distances / optimal transport costs have attracted much attention because they have been shown to include some of the successful and widely used machine learning estimators such as support vector machines, square-root Lasso, regularized logistic regression, etc. as particular examples of the formulation. Our emphasis in this talk is to extend the utility of the Wasserstein-DRO formulation beyond these regression and classification problems by developing fast, scalable iterative schemes that are applicable for a larger class of useful models in Operations Research and Machine Learning. Specifically, we show that iterative schemes utilising stochastic gradients converge converge "at least" as fast (or) even significantly faster than their non-robust counterparts in large data settings. With optimal transport costs being the ideal notion generalising Wasserstein distances, we shall also see the substantial improvement in out-of-sample performance offered by learning the underlying "ground metric" in a data-driven fashion (instead of using the rigid notion of Wasserstein distances).

3 - Distributionally Robust Chance-Constrained Optimization with Wasserstein Metric

Speaker: Ran Ji, George Mason University, US, talk 255

Co-Authors: *Miguel Lejeune*,

We study distributionally robust chance-constrained optimization problems (DRCCP) with Wasserstein ambiguity set. We investigate the problems with chance constraints with random right-hand side and random technology matrix under two different types of uncertainty: uncertain probabilities and continuum of realizations. For each case, we propose a set of deterministic mixed-integer linear inequalities to reformulate the feasible set of the specific DRCCP problem. This is accomplished by first reformulating the distributionally robust (DR) chance constraints into DR expectation ones and by then using convex optimization duality. We also derive valid inequalities to strengthen the reformulations. The computational studies show the applicability and scalability of the proposed solution framework to solve practically-sized problems.

Extending the Reach of First-Order Methods, Part I

Continuous Optimization

NonSmooth - Mo 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 285

Organizer: Haihao Lu, MIT, US

1 - Subgradient Method Convergence Rates without Lipschitz Continuity or Convexity
Speaker: Benjamin Grimmer, Cornell University, US, talk 1154
Co-Authors: *Damek Davis*,
We extend the classic convergence rate theory for projected subgradient methods to apply to non-Lipschitz functions. For the deterministic projected subgradient method, we present a global $O(1/\sqrt{T})$ convergence rate for any convex function which is locally Lipschitz around its minimizers. Further, we show a $O(1/\sqrt{T})$ convergence rate for the stochastic projected subgradient method on convex functions with at most quadratic growth, which improves to $O(1/T)$ under either strong convexity or a weaker quadratic lower bound condition. Finally, we introduce a nonconvex variation of the stochastic subgradient method where convergence to a stationary point can be guaranteed at the same rate as the stochastic gradient method for smooth nonconvex problems.
2 - Relative smoothness condition and its application to third-order methods.
Speaker: Yurii Nesterov, UCL, BE, talk 720
In this talk, we show that the recently developed relative smoothness condition can be used for constructing implementable third-order methods for Unconstrained Convex Optimization. At each iteration of these methods, we need to solve an auxiliary problem of minimizing a convex multivariate polynomial, which is a sum of the third-order Taylor approximation and a regularization term. It appears that this nontrivial nonlinear optimization problem can be solved very efficiently by a gradient-type minimization method based on the relative smoothness condition. Its linear rate of convergence depends only on absolute constant. This result opens a possibility for practical implementation of the third-order methods.
3 - Generalized Stochastic Frank-Wolfe Method
Speaker: Haihao Lu, MIT, US, talk 1430
Co-Authors: *Robert Freund*,
We propose a new stochastic variance reduction technique. In the case where the regularizer is an indicator function, this technique reduces to a stochastic Frank-Wolfe method, and we show that similar to batched Frank-Wolfe method the new approach enjoys convergence rate O(1/epsilon). In the case where the regularizer is a strongly-convex function, similar to existing variance reduction techniques (like SVRG, SAG etc) the new approach has linear convergence rate. Meanwhile, we show that this new technique is equivalent to a randomized coordinate type of method in the dual space, which builds the natural connections between dual methods and primal methods.

Riemannian geometry in optimization for learning

Specific Models, Algorithms, and Software
Learning - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 320
Organizer: Nicolas Boumal, Princeton University, US

1 - Global rates of convergence for nonconvex optimization on manifolds
Speaker: Nicolas Boumal, Princeton University, US, talk 625
Co-Authors: *Coralia Cartis*, *P.-A. Absil*,
I will present some recent bounds on the number of iterations one might need to compute approximate stationary points (both first and second order) for optimization problems on smooth manifolds. In particular, I will present reasonable assumptions one can make about a problem so that the classical proofs from unconstrained optimization carry over painlessly. The talk will focus on gradient descent and show extensions to trust-region methods and adaptive cubic regularization on manifolds. Such bounds are relevant to understand the worst-case computational cost of learning algorithms when the sought parameters live on a smooth, known manifold.
2 - A parallel Douglas-Rachford algorithm for data on Hadamard manifolds
Speaker: Ronny Bergmann, TU Chemnitz, DE, talk 808
In many applications like DT-MRI or a data set of multivariate Gaussian distributions. Since these measurements suffer from errors or even loss of data, we aim to transfer image processing methods to manifold-valued data. In this talk we present a parallel Douglas-Rachford algorithm for manifold-valued data and proof its convergence to a minimizer for Hadamard manifolds of constant curvature. We illustrate the algorithm using the total variation regularization or ROF model and demonstrate the performance within the Manifold-Valued Image Restoration Toolbox (MVIRT). This work is joint work with Johannes Persch and Gabriele Steidl.
3 - Riemannian optimization for the canonical tensor rank approximation problem
Speaker: Paul Breiding, MPI MiS Leipzig, DE, talk 1227
Co-Authors: *Nick Vannieuwenhoven*,
In recent years, tensors have found application in a growing number of applications, and tensor decompositions such as the canonical polyadic decomposition (CPD) are now increasingly employed for revealing practical multi-linear structures underlying multidimensional data. Unfortunately, in applications, we are not usually dealing with tensors that admit a mathematically exact CPD with few summands, because of the usual representation, roundoff, measurement, and model errors. Therefore, one is usually interested in finding a closest low-rank CPD near a given tensor. We call this problem the tensor approximation problem (TAP). State-of-the-art algorithms solve the TAP by numerically solving an optimization problem defined in Euclidean space. In this talk we want to discuss the theoretical and practical advantages of formulating the TAP as a Riemannian optimization problem. The performance of Riemannian-Gauss-Newton (RGN) methods solving the TAP depends on the condition number of the tensor rank decomposition. Experiments show that the our RGN method outperforms state-of-the-art methods on the smale scale.
4 - Primal-Dual Optimization Algorithms over Riemannian Manifolds
Speaker: Junyu Zhang, University of Minnesota, US, talk 663
Co-Authors: *Shiqian Ma*, *Shuzhong Zhang*,
We will present an ADMM-like primal-dual approach to solve the nonconvex and nonsmooth multi-block optimization over Riemannian manifolds with linear constraints. Such optimization problems naturally arise from machine learning, statistical learning, compressive sensing, image processing, and tensor PCA, among others. We first introduce the optimality conditions for the afore-mentioned optimization models. And

then we show that the proposed algorithm enjoys an iteration complexity of $O(1/\epsilon^2)$ to reach an ϵ-stationary solution. Several variants of algorithm are also proposed to fit different situations. Finally, a few applications are provided to address the usefulness of the method.

Exploiting structure in constrained optimization

Specific Models, Algorithms, and Software
Learning - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 334
Organizer: Mihai Cucuringu, Alan Turing Institute-Oxford, GB

1 - Provably robust estimation of modulo 1 samples of a smooth function
Speaker: Hemant Tyagi, Alan Turing Institute, GB, talk 1121
Co-Authors: *Mihai Cucuringu*,
Consider an unknown smooth function $f : [0, 1]^d \rightarrow R$, and assume we are given n noisy mod 1 samples of f, i.e., $y_i = (f(x_i) + \eta_i)$ mod 1, for $x_i \in [0, 1]^d$, where η_i denotes the noise. Our goal is to recover smooth, robust estimates of the clean samples $f(x_i)$ mod 1. We formulate a natural approach for this problem, which works with angular embeddings of the noisy mod 1 samples over the unit circle, inspired by the angular synchronization framework. This leads to a smoothness regularized least-squares problem – a QCQP – where the variables are constrained to lie on the unit circle. Our proposed approach is based on solving its relaxation, which is a trust-region sub-problem and hence solvable efficiently. We provide theoretical guarantees demonstrating its robustness to noise for different noise models along with extensive simulations, and also provide a simple least-squares based solution for the unwrapping stage, that recovers the original samples of f (up to a global shift). It is shown to perform well at high levels of noise, when taking as input the denoised modulo 1 samples. Finally, we also consider two other approaches for denoising the modulo 1 samples that leverage tools from optimization on manifolds. For the 2D version of the problem, which has applications in radar interferometry (InSAR), we are able to solve instances of real-world data with a million sample points in under 10 seconds, on a personal laptop.
2 - Efficient DC Algorithm for constrained sparse optimization problems
Speaker: Akiko Takeda, The University of Tokyo, JP, talk 682
Co-Authors: *Katsuya Tono*, *Jun-ya Gotoh*, *Tianxiang Liu*, *Ting Kei Pong*,
Many applications such as in signal processing, machine learning and operations research seek sparse solutions by adopting the L0-norm constraint. We address the minimization of a smooth objective function under an L0-norm constraint and simple convex constraints. When the problem has no constraints except the L0-norm constraint, some efficient algorithms are available. However, when the problem has additional constraints, they often become inefficient because it is difficult to obtain closed-form solutions of the associated subproblems. We reformulate the problem by employing a new DC (difference of two convex functions) representation of the L0-norm constraint, so that DC algorithm can retain the efficiency by boiling down its subproblems to the projection operation onto a convex set. We will also discuss the extension of the approach to more general problems whose objective is the sum of a nonnegative smooth function and a bunch of nonnegative proper closed possibly nonsmooth functions (whose proximal mappings are easy to compute).
3 - Distributionally Ambiguous Optimization Techniques for Batch Bayesian Optimizati
Speaker: Nikitas Rontsis, University of Oxford, GB, talk 1259
Co-Authors: *Michael Osborne*, *Paul Goulart*,
We describe a novel, theoretically-grounded, acquisition function for Batch Bayesian optimization informed by insights from distributionally ambiguous optimization. Our acquisition function is a lower bound on the well-known Expected Improvement function, which requires evaluation of a Gaussian Expectation over a multivariate piecewise affine function, and it is computed by evaluating instead the best-case expectation over all probability distributions consistent with the same mean and variance as the original Gaussian distribution. Unlike alternative approaches, including Expected Improvement, our proposed acquisition function avoids multi-dimensional integrations entirely, and can be computed exactly – even on large batch sizes – as the solution of a tractable semidefinite programming problem. Our suggested acquisition function can also be optimized efficiently, since first and second derivative information can be calculated inexpensively as by-products of the acquisition function calculation itself. We derive various novel theorems that ground our work theoretically and we demonstrate superior performance via simple motivating examples, benchmark functions and real-world problems.
4 - On critical points of quadratic low-rank matrix optimization problems
Speaker: Andre Uschmajew, MPI MiS Leipzig, DE, talk 1377
Co-Authors: *Bart Vandereycken*,
The absence of spurious local minima in certain non-convex low-rank matrix recovery problems has been of recent interest as it indicates convergence of some optimization methods to the global optimum. One example is low-rank matrix sensing under restricted isometry properties. It can be formulated as minimization problem for a quadratic function on a low-rank matrix manifold, with a positive semidefinite Hessian which itself acts almost like an identity on low-rank matrices. We present an approach to show the absence of local minima for such type of quadratic minimization problems starting from the interesting fact that for the identity operator itself, that is, when just minimizing the Euclidean distance to a fixed low-rank matrix without noise, there are no critical points on the corresponding low-rank manifold at all besides the global minimum.

Scheduling and File Migration

Discrete Optimization & Integer Programming
APPROX - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Contributed Session 345
Chair: Asaf Levin, The Technion, IL

1 - Scheduling on Uniform Nonsimultaneous Parallel Machines
Speaker: Liliana Grigoriu, University of Siegen, DE, talk 1238
Co-Authors: *Donald Friesen*,
We consider the problem of scheduling on uniform nonsimultaneous machines, that is, machines with diverse processing speeds which may not start processing at the same time, with the purpose of minimizing the maximum completion time. We propose using a variant of the MULTIFIT algorithm, LMULTIFIT, which generates schedules which end within 1.382 times the optimal maximum completion time for the general problem, and within $\sqrt{6}/2$ times the optimal maximum completion time for problem instances with two machines. Both developments represent improvements over previous results such as a 5/3 worst-case approximation bound of the LPT algorithm when used to solve the general problem. The results are derived from MULTIFIT approximation bounds for scheduling on simultaneous uniform machines. We outline a proof that LMULTIFIT worst-case bounds for scheduling on simultaneous uniform machines are also LMULTIFIT worst-case approximation bounds for scheduling on nonsimultaneous uniform machines and show that worst-case approximation bounds of MULTIFIT variants for simultaneous uniform machines from previous literature also apply to LMULTIFIT. We present experiments that suggest that LMULTIFIT performs very well in practice, as it achieves average approximation factors of 1.03 or less when comparing to a lower bound for the maximum completion time of the optimal schedule, and that it is thus a viable option for addressing this problem in practice. We also show how a PTAS for scheduling on a constant number of uniform nonsimultaneous machines can be derived from previous results.

2 - On phase-based algorithms for online file migration
Speaker: Marcin Bienkowski, University of Wroclaw, PL, talk 1678
Co-Authors: *Jaroslaw Byrka*, *Marcin Mucha*,
We construct a deterministic 4-competitive algorithm for the online file migration problem, beating the currently best 20-year old, 4.086-competitive Move-To-Local-Min (MTLM) algorithm by Bartal, Charikar and Indyk (SODA 1997). Like MTLM, our algorithm also operates in phases, but it adapts their lengths dynamically depending on the geometry of requests seen so far. The improvement was obtained by carefully analyzing a linear model (factor-revealing LP) of a single phase of the algorithm. We also show that no fixed-length phase-based algorithm can beat the competitive ratio of 4.086. The results were presented at ICALP 2017.

3 - A unified framework for designing EPTAS's for load balancing on parallel machine
Speaker: Asaf Levin, The Technion, IL, talk 1255
Co-Authors: *Ishai Kones*,
We consider a general load balancing problem on parallel machines. Our machine environment in particular generalizes the standard models of identical machines, and the model of uniformly related machines, as well as machines with a constant number of types, and machines with activation costs. The objective functions that we consider contain in particular the makespan objective and the minimization of the ℓ_p-norm of the vector of loads of the machines both with possibly job rejection. We consider this general model and design an efficient polynomial time approximation scheme (EPTAS) that applies for all its previously studied special cases. This EPTAS improves the current best approximation scheme for some of these cases where only a polynomial time approximation scheme (PTAS) was known into an EPTAS.

Complexity of Randomized Algorithms

Continuous Optimization
RandomM - Mo 5:00pm-6:30pm, Format: 3x20 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 347
Organizer: Raghu Pasupathy, Purdue, US

1 - On the Convergence of SAGA-like Algorithms
Speaker: Martin Morin, Lund University, SE, talk 1285
Co-Authors: *Pontus Giselsson*,
Several methods have been developed in order to reduce the variance and speed up the convergence of the standard stochastic gradient method. Examples include SAGA, SVRG and Finito and they all havesimilar structure where they aggregate the previous gradients used. Although similarities exists, the respective convergence analyses were made on algorithm specific bases with no common approach. One attempt to perform a unified analysis of these algorithms is the SMART algorithm. By connecting the properties of the randomized gradients to standard deterministic operator properties such as monotonicity and cocoercivity, relatively simple proofs can be achieved. This talk will highlight these connections as well as extend the analysis to cover a broader family of algorithms, including the proximal variant of SAGA. Finally, we present novel results regarding sampling distribution selection in these types of algorithms.

2 - On the linear convergence of the projected stochastic gradient method
Speaker: Bang Vu, EPFL-Switzerland, CH, talk 264
Co-Authors: *Volkan Cevher*,
The strong growth condition (SGC) is known to be a sufficient condition for linear convergence of the projected stochastic gradient method using a constant step-size γ (PSGM-CS). In this paper, we prove that SGC is also a necessary condition for the linear convergence of PSGM-CS. Moreover, when SGC is violated up to a additive perturbation σ, we show that both PSGM-CS and the proximal stochastic gradient method exhibit linear convergence to a noise dominated region, whose distance to the optimal solution proportional to $\gamma\sigma$.

3 - The Complexity of Adaptive Sampling Accelerated Gradient Dsescent
Speaker: Raghu Pasupathy, Purdue, US, talk 247
Co-Authors: *David Newton*, *Farzad Yousefian*,
We consider the question of continuous stochastic optimization where the objective function is an expectation that can be observed only using an inexact oracle such as quasi-Monte Carlo or Monte Carlo. This question has recently drawn great attention due to its relevance in many machine learning and big data contexts such as classification, regression, and estimation in presence of a large dataset. For solving such problems, we present a variation of Nesterov's accelerated gradient descent that uses adaptive sampling. The salient

feature in the proposed iteration is the adaptive manner in which stochastic sampling is performed, exerting more oracle effort when algorithm iterates seem to be close to a stationary point and less when far away. We demonstrate convergence and characterize the work complexity of this algorithm for different combinations of smoothness and convexity stipulations on the objective function. For example, when the objective function is convex and smooth, the work complexity of the proposed algorithm is shown to be arbitrarily close to O(epsilon power -1 - mu power -1), where mu is the error decay rate (mu = 0.5 for Monte Carlo and mu=1-delta for quasi-Monte Carlo) associated with the inexact oracle that is in use.

Advances in Adjustable Robust Optimization

Optimization under Uncertainty
Robust - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 350
Organizer: Do Young Yoon, Stanford University, US

1 - Robust optimization for models with uncertain SOC and SDP constraints
Speaker: Dick den Hertog, Tilburg University, NL, talk 706
Co-Authors: *Jianzhe Zhen*, *Frans de Ruiter*,
In this presentation we consider uncertain second-order cone (SOC) and semidefinite programming (SDP) constraints with polyhedral uncertainty. We propose to reformulate an uncertain SOC or SDP constraint as a set of adjustable robust linear optimization constraints with an ellipsoidal or semidefinite representable uncertainty set, respectively. The resulting adjustable problem can then (approximately) be solved by using adjustable robust linear optimization techniques. For example, we show that if linear decision rules are used, then the final robust counterpart consists of SOC or SDP constraints, respectively, which have the same computational complexity as the nominal version with the original constraints. We also propose an efficient method to obtain good lower bounds, and extend our approach to other classes of robust optimization problems. Finally, we apply our approach to a robust regression problem and a robust sensor network problem. We use linear decision rules to solve the resulting adjustable robust linear optimization problems and the solutions found are optimal or near optimal.

2 - Approximation of uncertain convex inequalities
Speaker: Ernst Roos, Tilburg University, NL, talk 710
Co-Authors: *Dick den Hertog*, *Aharon Ben-Tal*,
Robust Optimization is a popular approach to treat uncertainty in optimization problems. Finding a computationally tractable formulation of the robust counterpart of an optimization problem is key in being able to apply this approach. Although techniques for finding a robust counterpart are available for many types of constraints, no general techniques exist for functions that are convex in the uncertain parameter. Such constraints are, however, common in, e.g., quadratic optimization and geometric programming problems. In this paper, we provide a systematic way to construct a safe approximation to the robust counterpart of a nonlinear uncertain inequality that is convex in the uncertain parameters for a polyhedral uncertainty set. We use duality theory as well as adjustable robust optimization techniques to obtain this approximation. We also propose a general purpose method to strengthen the obtained approximation by using nonlinear decision rules for the introduced auxiliary adjustable variables. We show the quality of the approximations by performing several numerical experiments.

3 - Monitoring with Limited Information
Speaker: Do Young Yoon, Stanford University, US, talk 954
Co-Authors: *Dan Iancu*, *Nikos Trichakis*,
We consider a complex system with a dynamic evolution characterized by state- and time-dependent uncertainty sets. The system's state can be observed by a decision maker (DM) at a limited number of monitoring times; any observation reduces the uncertainty concerning the future possible state values, and thus influences the system's evolution. The DM's goal is to select a policy for monitoring and stopping the system, based on all acquired information. We consider two versions of the problem – static and dynamic – depending on how the monitoring times are chosen. We show that, under mild conditions, the same worst-case reward is achievable under either static or dynamic monitoring. This allows recovering the optimal dynamic monitoring policy by resolving static versions of the problem. We discuss cases when the static problem becomes tractable, and highlight conditions when monitoring at equi-distant times is optimal. Lastly, we showcase our framework in the context of a healthcare problem (monitoring heart transplant patients for Cardiac Allograft Vasculopathy), where we design optimal monitoring policies that substantially improve over the status quo treatment recommendations.

Implementation of interior-point methods for large-scale problems and applications II

Specific Models, Algorithms, and Software
Algo - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 352
Organizer: Jordi Castro, Univ. Politècnica de Catalunya, ES

1 - On the implementation of the crossover algorithm
Speaker: Csaba Meszaros, FICO, GB, talk 992
At the end of a barrier optimization a crossover procedure is needed when a basic solution has to be computed. Albeit the crossover procedure has lower complexity than the barrier algorithm, sometimes it requires excessive computational work. In the presentation we outline our crossover implementation which exploits multithreading and special structures in the problem and demonstrate its effectiveness by numerical experiments.

2 - Interior point methods applied to context-free grammar parameter estimation
Speaker: Aurelio Oliveira, University of Campinas, BR, talk 1040
Co-Authors: *Sofia Lopez*,
This work deals with a probabilistic context-free grammar

model to represent a natural language such as English, French or Portuguese. The goal is to estimate the grammar parameters to recognize a sentence as belonging to the language. To achieve that, a corpus is used to obtain the language structure and to supply sentences used to find the optimal probabilities assigned to grammar rules. Such approach leads to a nonlinear optimization problem with linear constraints. It is a large-scale problem for natural languages. It is solved using a specialized primal dual interior point method. The objective function gradient and Hessian are computed using finite differences. The resulting augmented system is solved using preconditioned iterative methods. Numerical experiments with available English and Portuguese corpus are performed. The specialized interior point method obtain robust results solving all test instances. The iterations requirements for both: memory and time are very consuming. However, the method achieves convergence in few iterations which is related with problem size.

3 - A new specialized interior-point method for support vector machines

Speaker: Jordi Castro, Univ. Politècnica de Catalunya, ES, talk 81

Multiple variable splitting is a general technique to decompose problems through copies of variables and additional constraints equating their values. The resulting (and likely large) optimization problem can be solved with a specialized interior-point algorithm which exploits the problem structure and computes the Newton directions by direct and iterative solvers (i.e., Cholesky factorizations and preconditioned conjugate gradients). In this work this method is applied to the solution of real-world support vector machine (SVMs) instances, a binary classification technique from the machine learning field. This new approach is compared with state-of-the-art methods for SVMs, either based on interior-point algorithms (such as SVM-OOPS (Woodsend, Gondzio, 2011)) or specific algorithms for SVMs (such as libsvm (Chang, Lin 2011)). The computational results show that the new approach is competitive with previous interior-point methods and libsvm for linear SVMs.

Variational Analysis 4

Continuous Optimization

Variat - Mo 5:00pm-6:30pm, Format: 4x20 min

Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Invited Session 370

Organizer: Jo Brueggemann, Weierstrass Institute, DE

1 - Path-following method for a class of obstacle problems with integral constraints

Speaker: Jo Brueggemann, Weierstrass Institute, DE, talk 1397

Co-Authors: *Michael Hintermüller*, *Carlos Rautenberg*,

We consider a continuous model of two elastic membranes, enclosing a region of constant volume, that are allowed to be in contact and where external forces act in place. This problem can be formulated as a quasi-variational inequality (QVI) and existence of solutions can be established relying on fixed-point arguments. The quasi-variational problem is tackled via a sequential variational approach, building on the repeatedly solution of elliptic obstacle-type variational inequalities with additional integral constraints. The arising subproblems are approached in function space with a path-following semismooth Newton method and numerical tests are provided.

2 - Nonconvex integration using ϵ-subdifferentials

Speaker: Yboon García Ramos, Universidad del Pacífico, PE, talk 132

Co-Authors: *Abderrah Hantoute*, *Rafael Correa*,

We provide an integration criterion for nonconvex functions defined in locally convex spaces. We prove that an inclusion-type relationship between the ϵ-subdifferentials for small amount of ϵ of any two any functions is sufficient for the equality of the associated closed convex envelopes, up to an additive constant, and to a recession term relying on the asymptotic behavior of the functions. Another criterion of integration is proposed for convex functions, giving rise to weaker conditions using ϵ-subdifferentials, and to strong conclusions involving only the closed convex envelopes. We use these results to represent both the values of convex envelopes and their ϵ-subdifferentials by means of ϵ-subdifferentials of the original function. This theory also applies in the standard integration theory framework of proper and lower semi-continuous convex functions defined on Banach spaces, leading to a unifying and alternative proofs for the classical integration result of Rockafellar.

3 - A family of two-point stepsize gradient methods

Speaker: Yakui Huang, Hebei University of Technology, CN, talk 397

Co-Authors: *Yu-Hong Dai*, *Xin-Wei Liu*,

We propose a family of two-point stepsize gradient methods, which is a convex combination of the short Barzilai-Borwein (BB) stepsize and the long BB stepsize. It is shown that each stepsize in the family solves a least squares problem and hence possesses certain quasi-Newton property. The family also includes some other stepsizes as its special cases. We prove that the family of methods is R-superlinearly convergent for 2-dimensional strictly convex quadratics. Moreover, the family is R-linearly convergent for the n-dimensional case. Numerical results of the family with different settings are presented, which demonstrate that the proposed family is promising.

4 - Proximal alternating direction method of multipliers in the nonconvex setting

Speaker: Khoa Nguyen, University of Vienna, AT, talk 622

Co-Authors: *Radu Ioan Bot*,

We propose two numerical algorithms for minimizing the sum of a smooth function and the composition of a nonsmooth function with a linear operator in the fully nonconvex setting. The iterative schemes are formulated in the spirit of the proximal and, respectively, proximal linearized alternating direction method of multipliers. The proximal terms are introduced through variable metrics, which facilitates the derivation of proximal splitting algorithms for nonconvex complexly structured optimization problems as particular instances of the general schemes. Convergence of the iterates to a KKT point of the objective function is proved under mild conditions on the sequence of variable metrics and by assuming that a regularization of the associated augmented Lagrangian has the Kurdyka-Lojasiewicz property. If the augmented Lagrangian has the Lojasiewicz property, then convergence rates of both augmented Lagrangian and iterates are derived.

Learning and dynamic programming

Optimization under Uncertainty
Markov - Mo 5:00pm-6:00pm, Format: 2x30 min
Room: Salle 31 Building: B, Ground Floor, Zone: 5

Contributed Session 381
Chair: Boxiao Chen, University of Illinois Chicago, US

1 - A unifying computation of Whittle's Index for Markovian bandits
Speaker: Manu Gupta, IRIT, FR, talk 1355
Co-Authors: *Urtzi Ayesta*, *Ina Maria Verloop*,
The multi-armed restless bandit framework allows to model a wide variety of decision-making problems in areas as diverse as industrial engineering, computer communication, operations research, communication networks etc. In a seminal work, Whittle developed a methodology to derive well-performing (Whittle's) index policies that are obtained by solving a relaxed version of the original problem. However, the computation of Whittle's index itself is a difficult problem and hence researchers focused on calculation of Whittle's index problem-to-problem basis. Our main contribution is the derivation of a closed-form expression for Whittle's index when bandit has Markovian evolution, which is valid as long as the technical condition of indexability is satisfied. Our solution approach provides a unifying expression for Whittle's index, and as particular cases, we retrieve many known results from the literature including classical machine repairman problem, content delivery network etc.

2 - A verification theorem for indexability of real-state restless bandits
Speaker: Jose Nino-Mora, Carlos III University, Madrid, ES, talk 1070
Over the last decade researchers have identified a growing number of optimal dynamic sensor allocation problems that fit into the framework of the multiarmed restless bandit problem (MARBP) with real state bandits, which in principle allows to apply a powerful heuristic index policy proposed by Whittle (1988) for the general MARBP, a generally itnractable problem. Yet, to deploy such an approach a notoriously difficult technical roadblock needs to be overcome: the bandits in the model at hand must be proven to be indexable, i.e., to possess Whittle indices, and these must be computed. This paper presents sufficient conditions for indexability of general real-state discrete-time restless bandits (binary-action Markov decision processes) under the discounted optimality criterion, which are not based on dynamic programming and do not require establishing first optimality of threshold policies as in prevailing approaches. The main contribution is a verification theorem establishing that, if bandit performance metrics under threshold policies and an explicitly defined marginal productivity (MP) index satisfy three conditions, then the project is indexable with its Whittle index being given by the MP index, in a form implying optimality of threshold policies as a byproduct. The proof is based on partial conservation laws and infinite-dimensional linear programming duality. Further contributions include characterizations of the index as a Radon-Nikodym derivative and as a shadow price, and a recursive index-computing scheme. Applications of the theory will be discussed.

Structure from evidence

Specific Models, Algorithms, and Software
Sciences - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 386
Organizer: Peter Gritzmann, TU Munich, DE

1 - Mathematical Programming in Quantum Information and Computation
Speaker: Douglas Gonçalves, UFSC, BR, talk 786
Several essential tasks in Quantum Information and Computation, such as quantum state tomography and entanglement determination, may be posed as mathematical programming problems. Since the state of a quantum system may be represented by a positive semidefinite Hermitian matrix of trace one, it is natural to foresee the usefulness of semidefinite programming in this context. Some theoretical aspects of such problems will be presented along with mathematical programming formulations and methods based on semidefinite programming. We will also discuss the main challenges to scale such methods to larger quantum systems.

2 - Detection of Uninformed Experts
Speaker: Jorge Barreras, University of Pennsylvania, US, talk 1444
Testing the validity of claims made by self-proclaimed experts can be impossible when testing them in isolation, even with infinite observations at the disposal of the tester (Foster and Vohra ,1998, Olszewski and Sandroni ,2008). However, in a multiple expert setting it is possible to design a contract that only informed experts accept and uninformed experts reject. The tester can pit competing forecasts of future events against each other and take advantage of the uncertainty experts have about the other experts' knowledge. This contract will work even when there is only a single data point to evaluate. The presence of multiple experts brings strategical uncertainty to uninformed experts which can be exploited to design a contract that only informed experts would accept. Sandroni (2014) proposes contracts, based on scoring rules, that incentivize informed experts to reveal the truth and uninformed experts to 'do no harm'. Important progress was also made by Babaioff, Lambert et al.(2011) who used scoring rules that screened uninformed experts under certain non-convexity assumptions. I extend Sandroni (2014) in the following way; Alice offers a contract to a set of experts that determines money transfers based on their forecasted odds of a future state of Nature and the actual observation of such state. This contract specifies transfers proportional to scores on a Brier score (Brier, 1950). Such contract can be designed so that it is accepted by informed experts and gives incentives to revealing the true odds, but rejected by false experts.

3 - On constrained flow and multi assignment problems for plasma particle tracking
Speaker: Peter Gritzmann, TU Munich, DE, talk 1252
Co-Authors: *Andreas Alpers*,
We introduce and analyze certain constrained versions of min-cost-flow and multi assignment problems in order to address problems of particle tracking in plasma physics. More specifically, we consider the problem of reconstructing the paths of a set of points over time, where, at each of a finite set of moments in time the current positions of points in space

are only accessible through a small number of their X-rays. We present and analyze various different algorithmic models and practical algorithms for this basic problem in dynamic discrete tomography. Also, we determine the computational complexity of the underlying tasks and observe some quite surprising complexity jumps.

Combinatorial optimization and convexity

Discrete Optimization & Integer Programming
COMB - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

Contributed Session 424
Chair: Yu Yokoi, National Inst. of Informatics, JP

1 - Discrete convexity in binary VCSPs
Speaker: Yuni Iwamasa, University of Tokyo, JP, talk 1017
Co-Authors: *Kazuo Murota*, *Hiroshi Hirai*, *Standa Zivny*,
A binary VCSP is a general framework for the minimization problem of a function represented as the sum of unary and binary cost functions. An important line of VCSP research is to investigate what functions can be solved in polynomial time. Cooper–Živný showed that the only interesting tractable case is the one induced by the joint winner property (JWP). In this talk, we present the reason why JWP ensures polynomial time solvability via M-convexity, which is a generalization of matroids and one of the important convexity concepts in discrete convex analysis (DCA). Furthermore, by utilizing a DCA theory, we give a new tractable class of binary VCSPs beyond JWP. This is joint work with Hiroshi Hirai, Kazuo Murota, and Stanislav Živný.

2 - Low matrix completion by a majorized penalty approach
Speaker: Fei Wang, Royal Institute of Technology, SE, talk 1400
Co-Authors: *Anders Forsgren*, *Henry Wolkowicz*,
We study the problem of low rank matrix completion. We transform the problem into the problem of completing a semidefinite positive matrix. We then use a majorized penalty approach to penalize the rank function. The approach can recover cases where traditional convex relaxation (nuclear norm) could not recover.

3 - Abstract tropical linear programming
Speaker: Georg Loho, EPFL, CH, talk 1479
In this paper we develop a combinatorial abstraction of tropical linear programming. This generalizes the search for a feasible point of a system of min-plus-inequalities. The latter can be used to model scheduling with AND/OR-constraints. Furthermore, the feasibility problem is in NP and in co-NP but no polynomial time algorithm is known. We introduce signed tropical matroids based on the polyhedral properties of triangulations of the product of two simplices and the combinatorics of the associated set of bipartite graphs with an additional sign information. By exploiting the matching structure of the occuring bipartite graphs, we compose an algorithm to solve the feasibility problem in a signed tropical matroid. This is an analogue of oriented matroid programming. We show an upper bound of our feasibility algorithm applied to a system of min-plus-inequalities in terms of minimal integer vectors in cones associated to the system.

4 - List Supermodular Coloring
Speaker: Yu Yokoi, National Inst. of Informatics, JP, talk 973
Co-Authors: *Satoru Iwata*,
In 1995, Galvin provided an elegant proof for the list edge coloring conjecture for bipartite graphs, utilizing the stable matching theorem of Gale and Shapley. In this talk, we generalize Galvin's result to the setting of supermodular coloring, introduced by Schrijver, with the aid of the monochromatic path theorem of Sands, Sauer and Woodrow. Our result states that, for a pair of intersecting supermodular functions, there exists a list coloring dominating both of them if each element has a color list of length no less than the maximum values of the two functions.

Practical aspects of network optimization

Discrete Optimization & Integer Programming
COMB - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 41 Building: C, 3rd floor, Zone: 1

Contributed Session 427
Chair: Kai Hoppmann, Zuse Institute Berlin, DE

1 - Energy-Efficient in Multi-Hop Wireless Networks Problem
Speaker: Sonia Vanier, Université Panthéon-Sorbonne, FR, talk 1133
Energy-Efficient in Multi-Hop Wireless Networks Problem
Speaker: Sonia Vanier, Université Paris1 Panthéon-Sorbonne, FR.
Abstract: Energy-efficient designs are one of the most outstanding challenges in wireless communication networks. Saving energy in multi-hop wireless networks usually consists in maximizing the lifetime of the network. This can be done by using the minimum number of nodes to route the traffic and turning of the maximum number of nodes. Given a network G=(V,E) defined by a set of nodes V and a set of arcs E, each arc has a capacity. Let D denote the set of commodities. Each commodity has an origin "s", a destination "t" and a flow value to route. We would like to concurrently route every demand on a single path from "s" to "t" without violating the capacities and interference constraints. Interferences can be avoided if we can prohibit interfering nodes to transmit at the same time. If the distance between node "i" and node "j" is lower then the distance between "j" and any other node transmitting at the same time than "i", then we can consider a transmission from "i" to "j" as succeeded. This problem was studied in [1] using MILP and simulation methods. We present a new model and we propose a column generation approach to solve the problem. Then we introduce new classes of valid inequalities, and give separation algorithms for a branch-and-cut-and-price framework.

2 - Optimal division for the multi-member constituency system
Speaker: Keisuke Hotta, Bunkyo University, JP, talk 800
Co-Authors: *Toshio Nemoto*, *Junichiro Wada*,
We propose the optimization technique to solve the multi-member constituency system with an appropriate objective

function. This is an extended model of the single-seat constituency system. We can solve this model using some idea of the preprocessing and MIP solver. Let us introduce two case studies to use this technique. One is the electoral redistricting problems of the Prefectural assembly in Japan. There are 47 prefectures in Japan. Each prefecture has a parliament. In many prefectures, the maximum disparity of one vote is more than three times. The purpose of the problem is to show the minimum disparity ratio between values of votes in different constituencies of each prefecture. The purpose of the problem is to show the minimum disparity ratio between values of votes in different constituencies of each prefecture. The other is the apportionment problem of the electoral system in the House of Councillors in Japan. In that system, 73 members are apportioned to 47 constituencies in proportion to the population. However, since the ratio of the maximum population to the minimum population is more than 20 times, the disparity was nearly 5 times. Therefore, several constituencies are grouped together recently. We clarify the relationship between that and the disparity. We show several results with some objective function using Social Welfare Function.

3 - Maintenance Scheduling in a Railway Corridor
Speaker: Saman Eskandarzadeh, University of Newcastle, AU, talk 936
Co-Authors: *Thomas Kalinowski*, *Hamish Waterer*,
We investigate a planned maintenance and asset renewal scheduling problem on a railway corridor with train traffic in both directions. Potential train journeys are represented by train paths, where a train path is specified by a sequence of (location, time)-pairs. Necessary maintenance and renewal activities, or work, are specified by a release time, a deadline, a processing time and a location. Scheduling work at a particular time has the consequence that the train paths passing through the corresponding location while the work is carried out have to be cancelled. An instance of the problem is given by a set of train paths and a set of work activities, and the task is to schedule all the work such that the total number of cancelled paths is minimised. We show that the problem is NP-complete in general, but in two important special cases, the problem is polynomially solvable.

4 - Pushing a Network to its Limits - Finding Maximum Min-Cost-Flows
Speaker: Kai Hoppmann, Zuse Institute Berlin, DE, talk 594
Given a flow network together with lower and upper bounds on the in- and outflow at sources and sinks. The goal is to determine supplies and demands respecting these bounds, such that the optimal value of an induced Minimum Cost Flow Problem is maximized. In this talk, we discuss several theoretical properties of the problem and present a linear bilevel optimization formulation modeling it. This model is then applied to different representations of the underlying network. We report on the results of our computational experiments conducted on data from a real-world gas network. An application of the problem arises in the context of generating severe transport scenarios for gas transmission networks, so-called stress tests.

Modeling in NLP

Continuous Optimization
NLP - Mo 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 9 Building: N, 4th floor, Zone: 12

Contributed Session 433
Chair: Laura Balzano, Univ of Michigan, US

1 - Low Algebraic Dimension Matrix Completion
Speaker: Laura Balzano, Univ of Michigan, US, talk 1080
Co-Authors: *Greg Ongie*, *Daniel Pimentel-Alarcon*, *Rebecca Willett*, *Robert Nowak*,
Low rank matrix completion (LRMC) has received tremendous attention in recent years. The low rank assumption means that the columns (or rows) of the matrix to be completed are points on a low-dimensional linear variety. This work extends this thinking to cases where the columns are points on low-dimensional nonlinear algebraic varieties, a problem which we call Low Algebraic-Dimension Matrix Completion (LADMC). We discuss two optimization approaches to this problem, one kernelized algorithm and one that leverages existing LRMC techniques on a tensorized representation of the data. We also provide a formal mathematical justification for the success of our method and experimental results showing that the new approach outperforms existing state-of-the-art methods for matrix completion in many situations.

2 - DC programming algorithm for fully convex bilevel optimization
Speaker: Mirai Tanaka, ISM, JP, talk 1460
Co-Authors: *Alain Zemkoho*,
We consider an optimistic bilevel optimization problem where all the functions involved are fully convex and continuously differentiable. Then proceeding with the lower-level value function reformulation of the problem, we focus our attention on the related partially penalized problem connected to the well-known partial calmness concept. The latter problem is a special class of the difference of two convex functions (DC) programming problem. Hence, we design a DC algorithm tailored to the problem. Convergence results are studied and numerical experiments on existing and synthetic examples show that the method represents a promising approach for the aforementioned class of the optimistic bilevel optimization problem.

3 - An inertial proximal point methods for solving minimization problems
Speaker: Nuttapol Pakkaranang, KMUTT, TH, talk 829
Co-Authors: *Poom Kumam*, *Prasit Cholamjiak*,
In this paper, we are interested in the minimization problems in non-positive curvature metric spaces, namely CAT(0) spaces. For solving this problem, we propose an inertial proximal point algorithms involving iterative scheme. We also prove its strong convergence theorem. Moreover, we provide the numerical experiment of examples for supporting our main results.

Packing and Capacity Management

Specific Models, Algorithms, and Software
Logistics - Mo 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 16 Building: I, 2nd floor, Zone: 7

Contributed Session 452
Chair: Eugene Zak, Amazon, US

1 - Solving Irregular Strip Packing Problems with free rotations
Speaker: Marina Andretta, University of Sao Paulo, BR, talk 1326
Co-Authors: *Jeinny Peralta*, *Jose Oliveira*,
To solve an irregular strip packing problem is to position polygons in a fixed width and unlimited length strip, obeying polygon integrity containment constraints and non-overlapping constraints, in order to minimize the used length of the strip. To ensure non-overlapping, we use separation lines. Since we are considering free rotations of the polygons and separation lines, the mathematical model of the studied problem is nonlinear and we use the nonlinear programming solver IPOPT to solve it. Computational experiments were run using established benchmark instances and the results were compared with the ones obtained with other methodologies in the literature.
2 - A 3D-knapsack problem with truncated pyramids and static stability constraint
Speaker: Alexandre Le Jean, UGA Grenoble, Fives Syleps, FR, talk 1085
Co-Authors: *Olivier Briant*, *Berenger David*, *Nadia Brauner*, *Mircea Cocan*,
In the three-dimensional knapsack, a selection within a list of objects has to be placed in a container maximizing the used space, so that there is no overlapping and respecting additional constraints depending on the application. This problem has many applications in logistic. We consider wooden pallets as container and a constraint that is of importance and which has been dealt with by many authors is the stability. In our case, the objects are strongly heterogeneous and some are truncated pyramids. We propose a new stability constraint that is also designed for truncated pyramids. The solution method we propose is based on mixed integer programming. In the numerical experiments, for various existing stability constraints, we compare the space used and the practical stability, estimated with a physical engine.
3 - Minimization of sum of inverse sawtooth functions
Speaker: Eugene Zak, Amazon, US, talk 11
The problem is to minimize the highest peak of sum of inverse sawtooth functions. The decision variables are phase shifts of the inverse sawtooth functions. We formulated the original minimax problem as a MIP model, and implemented it in Xpress. We suggested a few model related cuts to improve the MIP performance. The problem has an important application in calculating the minimum multi-product storage capacity requirements at warehouses.

New models in robust optimization

Optimization under Uncertainty
Robust - Mo 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 37 Building: B, Intermediate, Zone: 4
Contributed Session 459
Chair: Juan Borrero, Oklahoma State University, US

1 - On using cardinality constrained uncertainty for objective coefficients
Speaker: Jaeyoong Lim, KAIST, KR, talk 1201
Co-Authors: *Sungsoo Park*,
Cardinality constrained uncertainty set, proposed by Bertsimas and Sim (2004), is an uncertainty set widely used in robust optimization. The uncertainty set can be used for both the constraints and the objective coefficients. However, when used for objective coefficients, it brings about some issues to be considered; that being a lack of invariant robust measure and non-monotonic relation between nominal objective performance and Γ. In this study, we address the issues in detail, and suggest a new robust model with slight change in the classical approach that does not suffer from the discussed issues.
2 - Robust optimization of PDE-constrained problems using second-order methods
Speaker: Philip Kolvenbach, TU Darmstadt, DE, talk 850
Co-Authors: *Stefan Ulbrich*,
We present an algorithm for the robust optimization of nonconvex PDE-constrained problems with ellipsoidal uncertainty sets. Given a program

$$\min_x \{ f_0(x,p) \ : \ f_i(x,p) \leq 0, \ i = 1,\ldots,n \}$$

that depends on uncertain parameters $p \in P$, we consider the robust counterpart formulation

$$\min_x \{ \phi_0(x) \ : \ \phi_i(x) \leq 0, \ i = 1,\ldots,n \}.$$

Here, $\phi_i(x) = \max_p \{ f_i(x,p) \ : \ p \in P \}$ are the worst-case functions of the uncertain objective and constraint functions f_i. The worst-case functions ϕ_i are locally Lipschitz continuous and regular in the sense of Clarke with readily available subgradient information, provided the maximization problems can be solved globally and efficiently. We solve the inner problems with a trust-region method and the outer problem with a BFGS-SQP method suitable for nonsmooth problems. We apply our method to the parametrized shape optimization of elastic bodies and present numerical results.
3 - Robust optimization with non-convex uncertainty sets
Speaker: Juan Borrero, Oklahoma State University, US, talk 758
Co-Authors: *Leonardo Lozano*,
We consider linear optimization problems where the cost vector is subject to uncertainty. Following the robust optimization paradigm, we assume that the decision-maker knows that the cost vector belongs to an uncertainty set. In contrast with the usual framework, we assume that this set is non-convex, specifically; we assume that the uncertainty set is given by a mixed-integer linear feasibility region. Such a larger class of sets allows modeling complex uncertain phenomena where there are logical, combinatorial, or disjunctive relationships between the uncertain events that generate the uncertain data. We show that optimizing over mixed-integer uncertainty sets greatly reduce the conservativeness of the optimal solutions when compared with a convex counterpart which cannot capture all the information of the problem at hand. However, such a reduction comes at the price of increasing the computational complexity of the problem. In particular, the problem is NP-complete and we develop exact iterative solution methods based on cutting plane and decomposition techniques that can solve many instances of the problem in a reasonable time.

Convergence and Approximation in Conic Programming

Continuous Optimization
SDP - Mo 5:00pm-6:30pm, Format: 3x30 min
Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

Contributed Session 465
Chair: Tamás Terlaky, Lehigh University, US

1 - Convergence Rate of Block Coordinate Ascent for Nonconvex Burer-Monteiro Method
Speaker: Nuri Vanli, MIT, US, talk 1499
Co-Authors: *Asu Ozdaglar*, *Pablo Parrilo*, *Murat Erdogdu*,
Semidefinite programming (SDP) with equality constraints arise in many optimization and machine learning problems, such as Max-Cut, community detection and robust PCA. Although SDPs can be solved to arbitrary precision in polynomial time, generic convex solvers do not scale well with the dimension of the problem. In order to address this issue, Burer and Monteiro proposed to reduce the dimension of the problem by appealing to a low-rank factorization, and solve the subsequent non-convex problem instead. It is well-understood that the resulting non-convex problem acts as a reliable surrogate to the original SDP, and can be efficiently solved using the block-coordinate maximization method. Despite its simplicity, remarkable success, and wide use in practice, the theoretical understanding of the convergence of this method is limited. We prove that the block-coordinate maximization algorithm applied to the non-convex Burer-Monteiro approach enjoys a global sublinear rate without any assumptions on the problem, and a local linear convergence rate despite no local maxima is locally strongly concave. We illustrate our results through examples and numerical experiments.
2 - Towards efficient approximation of p-cones
Speaker: Yuriy Zinchenko, U of Calgary and Gurobi LLC, CA, talk 919
Co-Authors: *Pooyan Shirvani*, *Liang Qihe*,
2-norm cone, a.k.a. the second-order cone (SOC), gained wide applicability in modern optimization. SOC may be effectively handled directly by interior-point methods as well as can be well approximated with polyhedra. Specifically, Ben-Tal and Nemirovski constructed an elegant 'optimal' efficient approximation scheme where the number of required linear inequalities grows only logarithmically with respect to the desired approximation precision. In contrast, the situation with SOC extensions to p-norm cones remained dramatically different: despite applications being present, our capacity to handle these cones is somewhat limited. Neither there are dimension-invariant self-concordant barriers known for such cones, nor has one been able to approximate these cones efficiently. In this work, we describe a few novel approaches aimed at constructing good approximations to p-cones, and provide evidence that indeed an efficient polyhedral approximation may be within reach for such cones.
3 - Quadratic convergence to the optimal solution of second-order conic optimization
Speaker: Tamás Terlaky, Lehigh University, US, talk 952
Co-Authors: *Ali Mohammad-Nezhad*,
In this paper, we establish the quadratic convergence of Newton's method to the unique maximally complementary optimal solution of second-order conic optimization, when strict complementarity fails. Only very few approaches have been proposed to remedy the failure of strict complementarity, mostly based on nonsmooth analysis of the optimality conditions. Our local convergence result depends on the optimal partition of the problem, which can be identifi ed from a bounded sequence of interior solutions. We provide a theoretical complexity bound for identifying the quadratic convergence region of Newton's method from the trajectory of central solutions.

Algorithms for matching markets

Discrete Optimization & Integer Programming
APPROX - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 467
Organizer: Amin Saberi, Stanford University, US

1 - Concise Bidding Through Dependent Randomized Rounding
Speaker: Arash Asadpour, NYU Stern, US, talk 1670
Co-Authors: *Hossein Bateni*, *Vahab Mirrokni*, *Kshipra Bhawalkar*,
A major challenge faced by marketers attempting to optimize their advertising campaigns is to deal with budget constraints. The problem is even harder in the face of multidimensional budget constraints, particularly in the presence of many decision variables involved and the interplay among the decision variables through such constraints. In this talk, we introduce concise bidding strategies help advertisers deal with this challenge by introducing fewer variables to act on. We define the problem of finding optimal concise bidding strategies for advertising campaigns with multiple budget constraints. We show how a 0.539-approximation algorithm can be obtained via dependent LP rounding techniques concerning bipartite matchings which can be of independent interest. From a practical point of view, in addition to being able to deal with multi-dimensional budget constraints, our results do not assume any specific payment scheme and can be applied on pay-per-click, pay-per-impression, or pay-per- conversion models. Also, no assumption about the concavity of value or cost functions is made.
2 - Robust Repeated Auctions under Heterogeneous Buyer Behavior
Speaker: Balasubraman Sivan, Google Research, US, talk 1672
Co-Authors: *Shipra Agrawal*, *Constantinos Daskalakis*, *Vahab Mirrokni*,
We study revenue optimization in a repeated auction between a single seller and a single buyer. Traditionally, the design of repeated auctions requires strong modeling assumptions about the bidder behavior, such as it being myopic, infinite lookahead, or some specific form of learning behavior. Is it possible to design mechanisms which are simultaneously optimal against a multitude of possible buyer behaviors? We answer this question by designing a simple state-based mechanism that is simultaneously approximately optimal against a k-lookahead buyer for all k, a buyer who is a no-regret learner, and a buyer who is a policy-regret learner. Against each type of buyer our mechanism attains a constant fraction of the optimal revenue attainable against that type of buyer. We complement our positive results with almost tight impossibility results, showing that the revenue approximation

tradeoffs achieved by our mechanism for different lookahead attitudes are near-optimal.

3 - Proportional Allocation: Simple, Distributed, and Diverse Matching w High Entropy

Speaker: Vahab Mirrokni, Google Research, US, talk 1675

Co-Authors: *Shipra Agrawal*, *Morteza Zadimoghaddam*,

Inspired by many applications of bipartite matching in online advertising and machine learning, we study a simple and natural iterative proportional allocation algorithm: Maintain a priority score beta(a) for each node a on one side of the bipartition, initialized as beta(a) = 1. Iteratively allocate the nodes i on the other side to eligible nodes in A in proportion of their priority scores. After each round, for each node a, decrease or increase the score a based on whether it is over-or under-allocated. Our first result is that this simple, distributed algorithm converges to a (1 epsilon)-approximate fractional b-matching solution in O(log square n) rounds. We also extend the proportional allocation algorithm and convergence results to the maximum weighted matching problem, and show that the algorithm can be naturally tuned to produce maximum matching with high entropy. High entropy, in turn, implies additional desirable properties of this matching, e.g., it satisfies certain diversity and fairness (aka anonymity) properties that are desirable in a variety of applications in online advertising and machine learning.

4 - Matching in dynamic environments

Speaker: Amin Saberi, Stanford University, US, talk 1669

The theory of matching with its roots in the work of mathematical giants like Euler and Kirchhoff has played a central and catalytic role in combinatorial optimization for decades. More recently, the growth of online marketplaces for allocating advertisements, rides, or other goods and services has led to new interest and progress in this area. I will start the talk by giving a few examples from various industries on how building on and advancing this theory has led to increase in efficiency and and survey a few models, algorithms, and open problems.

Sparsity, variable selection and efficient algorithms

Specific Models, Algorithms, and Software

Learning - Mo 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 22 Building: G, 2nd floor, Zone: 6

Contributed Session 475

Chair: Alex Sholokhov, MIPT, RU

1 - Distributed algorithms for statistical learning with structured sparsity

Speaker: Sam Tajbakhsh, Ohio State University, US, talk 1626

Co-Authors: *Dewei Zhang*,

Sparsity-inducing penalties are commonly used in statistical learning for variable selection. While these penalties help to obtain a sparse solution, they cannot guarantee specific sparsity structures. In some problems, however, there exist logical sparsity relations between variables or groups of variables that are known a priori. Being able to generate such structures helps to obtain more interpretable models. Our study focuses on hierarchical sparsity structures that can be represented as Directed Acyclic Graphs (DAG). Designed penalty functions exploit group overlaps to induce solutions with desired hierarchical structures. These overlaps, however, complicate the problem from the optimization perspective. In this talk, we will present new distributed algorithms that can solve the underlying optimization problems in parallel with theoretical convergence guarantees. Some numerical results supporting the proposed algorithms will be provided.

2 - Sparse regression: Scalable algorithms and empirical performance

Speaker: Jean Pauphilet, MIT, US, talk 1139

Co-Authors: *Dimitris Bertsimas*, *Bart Van Parys*,

In this work, we address the problem of sparse linear and logistic regression from a discrete optimization perspective. We formulate the problem as a convex integer optimization problem and solve it efficiently using a cutting-plane algorithm. We also propose a fast sub-gradient algorithm to solve its Boolean relaxation and provide high-quality approximate solutions. We compare our approach with three state-of-the-art methods, namely ℓ_1 regularization and two methods with non-convex penalties (SCAD and MCP), with an application-oriented eye: We demonstrate empirically how noise and correlation impact both the accuracy - the number of correct features selected - and the false detection - the number of incorrect features selected - for all five methods. A property that a selection method is expected to exhibit is a two-fold convergence, namely the accuracy and false detection rate should converge to 1 and 0, respectively, as the sample size increases. Empirically, only the integer optimization formulation and its Boolean relaxation exhibit these two properties consistently in various regimes of noise and correlation. In addition, apart from the integer optimization approach which requires a substantial, yet often affordable, computational time, all methods terminate in times comparable with the glmnet package for Lasso. Jointly considered, accuracy, false detection and computational time provide a comprehensive assessment of each feature selection method and shed light on alternatives to the Lasso-based heuristic which are not as popular in practice yet.

3 - Sparsified Huge-Scale Optimization for Regularized Regression Problems

Speaker: Alex Sholokhov, MIPT, RU, talk 1523

Co-Authors: *Yury Maximov*,

Recent years the interest in huge-scale optimization has been increasing as big datasets emerge in the variety of fields. Classical ML algorithms tend to be ineffective in case of big datasets while using knowledge of its structure may significantly boost the convergence of learning algorithms. In this talk, I will consider the huge-scale regularized least-squares regression problems on big sparsified data and show how the sparsity' structure can be utilized to improve both algorithm's theoretical convergence bounds and its practical convergence speed. On the basis of these ideas we propose a modification of Conditional Gradient Descent method for large-scale regression problems and demonstrate its remarkable performance in comparison to state-of-the-art algorithms.

4 - Forward stepwise variable selection based on relative weights

Speaker: Zixin Shen, National Taiwan University, TW, talk 995

Co-Authors: *Argon Chen*,

We consider the problem of selecting a subset of important variables from a finite set of variables. This variable selection problem is essentially a combinatorial optimization problem usually solved by heuristic approaches in the literature. Least square optimization approaches with sparse penalty, such as LASSO and Elastic Net, are now widely used for variable selection. However, when a group of highly correlated variables have comparable importances, suffering from the multicollinearity problem in regression above approaches tend to select one or very few variables from the group. To address this problem, the relative weight was proposed to effectively evaluate the correlated variables' contributions using a set of uncorrelated surrogate variables most alike to the original variables. In this research, we propose a new forward stepwise variable selection algorithm based on the relative weight. Simulation and real cases show that the proposed algorithm selects variables more effectively in comparison with other conventional approaches.

Differentiability, convexity, and modeling in stochastic optimization

Optimization under Uncertainty
Stoch - Mo 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 30 Building: B, Ground Floor, Zone: 5
Contributed Session 493
Chair: Kai Spuerkel, University of Duisburg-Essen, DE

1 - Stochastic optimization with probabilistic/robust (probust) constraints
Speaker: Holger Heitsch, Weierstrass Institute, DE, talk 1554
Stochastic optimization approaches are frequently used to model practical decision processes over time and under uncertainty, e.g., in finance, production, energy and logistics. In that context, we represent a new class of optimization models involving a mix of nonlinear probabilistic and robust constraints. Algorithmic aspects as well as applications to energy management, in particular, gas transportation networks, are in the focus of attention by this talk.
2 - Subdifferential characterization of probability functions
Speaker: Pedro Perez-Aros, University of O'higgins, CL, talk 907
Co-Authors: *René Henrion*, *Abderrah Hantoute*,
This work provides formulae for the subdifferential of the probability function

$$\varphi(x) = \mathbb{P}(g(x,\xi) \le 0),$$

where $(\Omega, \mathcal{A}, \mathbb{P})$ is a probability space, ξ is an m-dimensional gaussian random vector, $g : X \times \mathbb{R}^m \to \mathbb{R}$ is locally Lipschitz and convex in the second variable and X is a separable reflexive Banach space. Applications for this class of functions can be found in water management, telecommunications, electricity network expansion, mineral blending, chemical engineering, etc, where the constraint $\mathbb{P}(g(x,\xi) \le 0) \ge p$ expresses that a decision vector x is feasible if and only if the random inequality $g(x,\xi) \le 0$ is satisfied with probability at least p.
3 - Strong Convexity in Stochastic Programming with Deviation Risk Measures
Speaker: Kai Spuerkel, University of Duisburg-Essen, DE, talk 1666
Co-Authors: *Ruediger Schultz*, *Matthias Claus*,
Deviation risk measures are a widely used tool in stochastic optimization to quantify variability of risk. Some of these, as the upper-semideviation and the expected excess, can be represented as convex integral functionals and exhibit structural properties similar to the expectation functional. We will present results regarding strong convexity of such deviation risk measures including verifiable conditions in terms of model data, extending results on risk neutral stochastic programs. While being a desirable property of objective functions anyway, strong convexity also plays a role in stability of optimal solutions to a given stochastic program wrt. perturbations of the underlying probability measure.

Data Mining

Discrete Optimization & Integer Programming
IPpractice - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1
Contributed Session 504
Chair: Marcus Poggi, PUC-Rio Informatica, BR

1 - A weighting local search for huge assignment problems in item recommendation
Speaker: Takahiro Kan, Osaka University, JP, talk 810
Co-Authors: *Shunji Umetani*, *Hiroshi Morita*,
We consider large-scale assignment problems arising from recent item recommendation systems. This problem asks an assignment of items to customers that maximizes gross profit while satisfying the budget constraint and the lower limits of expected gain for each item. It can be formulated as the binary integer program (BIP) with billions of variables. We develop a weighting local search algorithm (WLS) that repeats a local search algorithm while adaptively updating penalty weights of constraints. However, we often encounter huge instances for which we are unable to obtain good feasible solutions by WLS within a reasonable computation time. To improve the efficiency of WLS, we introduce a random sampling of neighbor solutions instead of the complete search for the neighborhood. According to computational experiments on huge instances of a real application, we observe that the proposed algorithm much improves the efficiency of WLS for the instances.
2 - Exact Clustering via Integer Programming and Maximum Satisfiability
Speaker: Atsushi Miyauchi, RIKEN AIP, JP, talk 1209
Co-Authors: *Tomohiro Sonobe*, *Noriyoshi Sukegawa*,
We consider the following general graph clustering problem: given a complete undirected graph $G = (V, E, c)$ with an edge weight function $c : E \to \mathbb{Q}$, we are asked to find a partition C of V that maximizes the sum of edge weights within the clusters in C. Owing to its high generality, this problem has a wide variety of real-world applications, including correlation clustering, group technology, and community detection. In this study, we investigate the design of mathematical programming formulations and constraint satisfaction formulations for the problem. First, we present a novel integer linear programming (ILP) formulation that has far fewer constraints than the standard ILP formulation by Groetschel and Wakabayashi (1989). Second, we propose an ILP-based exact algorithm that is usually faster than just solving our above ILP formulation. Third, we present maximum satisfi-

ability (MaxSAT) counterparts of both our ILP formulation and ILP-based exact algorithm. Computational experiments demonstrate that our proposed approaches are highly effective in terms of both memory efficiency and computation time.

3 - The best subset selection problem in regression

Speaker: Dennis Kreber, Trier University, DE, talk 996

We consider a linear regression model $y = X\beta + r$. Finding a β such that the residual sum of squares is minimal is a standard approach and a well studied method used for prediction. However, to avoid over- or underfitting a careful choice of relevant predictors for the response variable is required. Since carrying out this manually is overwhelmingly complex we consider an algorithmic approach. One of the main approaches to filter non-predictive variables is requiring the coefficients β to be sparse, i.e., demanding that β has a limited number of non-zero entries. In contrast to common approaches we are using a hard constraint to limit the number of non-zero regression coefficients, which gives us a discrete optimization problem. Bertsimas et al. (Best subset selection via a modern optimization lens, The Annals of Statistics, 2016) highlighted the importance of this problem and were able to solve large-sized instances in a viable time frame by using elaborated MIP techniques. Prior to their research the subset selection regression problem has been considered computationally intractable. We prove some interesting structural features of such a formulation. Further, we derive an equivalent formulation of the sparse regression problem, which leads to beneficial properties, like an improved coefficient bound and a better approximation quality of a warm start heuristic.

4 - Cut and Column Generation for Process Discovery

Speaker: Marcus Poggi, PUC-Rio Informatica, BR, talk 1475

Co-Authors: *Georges Spyrides*, *Beatriz Santiago*, *Helio Lopes*,

Process Discovery aims at finding a process model from an event log of a business process. Petri nets are a choice for formalising a process model. One is interested in finding a Petri net which, when simulated, produces a log that corresponds to the original event log, or minimizes a metric between them. Given a set S of elements, each representing a process activity, an event log is a set $L = \{\sigma_1, ..., \sigma_k\}$ where σ_q represents a sequence of activities, called traces, that occur in the process. A Petri net is a bi-partite graph with directed arcs connecting transitions(activities) and places. van der Werf et al. 2008 presents an ILP that finds one place and its arcs to and from activities. This formulation has one constraint for each prefix of each trace. Practical instances have thousands of traces and dozens of activities. A Petri net solution for the Process Discovery problem is then obtained by solving a sequence of ILPs. Recently, Spyrides et al. (2018) proposes an ILP that finds all places and arcs of the Petri net. It allows considering global properties such as token balance and cohesion among places. The main drawback of this approach is how to scale to practical instances. Therefore, we devise a cut and column generation approach. The master problem considers the global properties of the Petri net, the column generation sub-problem, similar to the ILP proposed in van der Werf et al. 2008, obtains candidate places and arcs. Variants of the model are tested for solution quality on instances of the Process Discovery Contest @BPM2017.

IP Practice II

Discrete Optimization & Integer Programming

IPpractice - Mo 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 36 Building: B, Intermediate, Zone: 4

Contributed Session 508

Chair: Petra Bartmeyer, Unicamp, BR

1 - Application of the SSSDP method to combinatorial optimisation problems

Speaker: Gaël Guillot, Université de Bordeaux, FR, talk 1617

Co-Authors: *François Clautiaux*, *Boris Detienne*,

Successive Sublimation Dynamic Programming (SSDP) is a method proposed by Ibaraki in 1987 based on dynamic programming. This method iteratively solves a sequence of relaxed problems, using the information learned at each iteration to filter out some decision variables until convergence is reached. In this talk, we study several ingredients of the method (lagrangian filtering, choices of relaxations) and their effectiveness against hard combinatorial problems from the literature. Our conclusions are supported by computational experiments.

2 - A Parallel Branch and Bound with DC Algorithm for Mixed Integer Optimization

Speaker: Yi-Shuai Niu, Shanghai Jiao Tong University, CN, talk 182

In this paper, we design a hybrid algorithm based on a PBandB (Parallel Branch and Bound) framework combining with DC (Difference of Convex functions) programming techniques for globally solving mixed-integer optimization problem. The PB and B procedure consists of exploring and solving a number of node problems simultaneously in order to speed up the convergence of Branch and Bound. Several DC programming formulations for mixed-integer optimization problem are investigated. An efficient local DC programming algorithm - DCA is used to solve the equivalent DC programs. DCA helps to find a good upper bound solution quickly, and restarting DCA in PB and B helps to update the incumbent solution more effectively. Preliminary numerical results show good performance of our approach comparing with some existing methods.

3 - Two-dimensional bin packing problem with defects on bins

Speaker: Quentin Viaud, Saint-Gobain Recherche, FR, talk 1538

Co-Authors: *François Clautiaux*, *Ruslan Sadykov*, *Francois Vanderbeck*,

We consider an industrial application of a two-dimensional bin packing problem with defects on bins. From technical constraints, the cutting process is 4-stage and restricted to exact guillotine cuts, while piece rotation is allowed. We propose to solve this problem in two ways. First, a diving heuristic is used to solve the problem without defect consideration. This heuristic is based on column generation with pricing problems solved with dynamic programming. The solution is then repaired to be feasible regarding defects. The second retained method is to modify the diving heuristic to directly handle defects on bins. We compare experimentally our different methods for solving this problem.

4 - A new approach to relax the binary variables on binary quadratic problems

Speaker: Petra Bartmeyer, Unicamp, BR, talk 32

Co-Authors: *Christiano Lyra*,
This talk proposes a new strategy to convert a quadratic unconstrained binary optimization problem (QUBO) into a quadratic formulation with continuous variables and a single quadratic constraint. New variable $y_i \in [0,1]$ and terms $(x_i - y_i)^2$ are created for each variable $x_i \in \{0,1\}$ of the QUBO; x_i is relaxed to $x_i \in [0,1]$. The single constraint includes all the terms $(x_i - y_i)^2$, packed as $\sum_{i=1}^{n}(x_i - y_i)^2 = n$. The correctness of the equivalent problem is discussed. The shaping of an equivalent continuous problem with a single constraint is the main advantage of this formulation with respect to the previous approaches, which required a larger number of constraints. Furthermore, the computational experiments show that problems with up to 2500 variables can be solved with processing times under 500 seconds to achieve an average gap under 1

Manufacturing

Specific Models, Algorithms, and Software
Scheduling - Mo 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 530
Chair: Younsoo Lee, Seoul National University, KR

1 - Detailed production planning models for semiconductor manufacturing with profit
Speaker: Sébastien Beraudy, Ecole des Mines de St Etienne, FR, talk 1335
Co-Authors: *Nabil Absi*, *Stéphane Dauzère-Pérès*,
Semiconductor manufacturing facilities (fabs) probably include the most complex manufacturing processes, with hundreds of products, each requiring hundreds of operations on hundreds heterogeneous machines. Moreover, a product is processed in the same workshops dozens of times in its route. This leads to congestions in the facility and to cycle times of two to three months. Capturing all these characteristics in production planning is not an easy task. The current literature focuses more on modeling congestion effects efficiently than on the objective function, which usually aims at minimizing costs. However, fabs are not only cost-driven; they have to maintain a high productivity level and maximize profits while satisfying known demands. In this work, we investigate linear programming models with new objective functions, and in particular profit maximization integrating the notion of Net Present Value. Our models are first validated on small instances, and then tested on large industrials instances.

2 - Scheduling in the Photolithography Bay
Speaker: Teun Janssen, TU Delft, NL, talk 1474
Co-Authors: *Leo van Iersel*, *Jan Driessen*, *Thomas Bosman*, *Stéphane Dauzère-Pérès*, *Claude Yugma*,
Photolithography is a process to transfer the geometric pattern of a chip-design onto a wafer. This is done by putting light through a reticle (or mask) onto the production wafer. This reticle contains the geometrical pattern of the computer chip. In European factories, the photolithography bay contains many different machines and the products are very diverse. Furthermore, there is only one reticle of every kind in the whole factory, thus products that share a reticle cannot be produced at the same time. This translates to a previously unstudied optimization problem, which is a variant of scheduling with resource constraints. More precisely, it can be modelled as scheduling on parallel machines where every job needs exactly one resource while minimizing the total completion time. We present several theoretical as well as practical results. In particular, we show that the popular shortest-processing-time-first (SPT) rule does not always lead to an optimal solution, but does give a 2-approximation algorithm. In addition, we show that in any optimal solution, jobs that use the same resource are always scheduled in SPT order. While we show several NP-hardness results for related problems, the NP-harness of the original problem remains open. Finally, we show several heuristic approaches that efficiently solve the problems in practice (on unrelated machines).

3 - Column generation and fix-and-optimize for the lot-sizing with remanufacturing
Speaker: Hugo Harry Kramer, Universidade Federal Paraíba, BR, talk 616
Co-Authors: *Jesus Cunha*, *Rafael Melo*,
We propose an effective mixed integer programming matheuristic for the multi-item capacitated lot-sizing problem with remanufacturing. This NP-hard problem consists in determining an optimal plan for the production and remanufacturing of multiple items in order to satisfy their deterministic dynamic demands over a discrete time horizon while taking into account both production and remanufacturing capacities. We propose a column generation rounding heuristic with an LP/MIP repairing mechanism as a constructive approach. We also apply a fix-and-optimize local search over the solutions obtained by the constructive heuristic. Computational results show that our approach could find, within reasonable time, improvements over the best known solutions in the literature for 69.72 percent of the instances. Besides, our solutions are at least as good as the best known in the literature for 86.85 percent of the instances. On top of that, our approach is very robust in a way that all solutions are within 5.54 percent of optimality.

4 - On the discrete lot-sizing and scheduling problem with sequence-dependent setup
Speaker: Younsoo Lee, Seoul National University, KR, talk 803
Co-Authors: *Kyungsik Lee*,
In this study, we consider a production planning problem arising in real-world high-technology industry, which can be formulated as a variant of the discrete lot-sizing and scheduling problem with sequence-dependent setup and minimum/maximum production run limit (DLSPSM). After briefly analyzing the computational complexity of the problem and some easily solvable cases, we propose an extended formulation for the DLSPSM which is based on a network structure. The tightness of the extended formulation is demonstrated by both theoretical analysis and computational experiments. We also propose a relax-and-fix heuristic based on the proposed extended formulation with some computational results.

Stochastic and Nonlinear Optimization I

Continuous Optimization
NLP - Tu 8:30am-10:30am, Format: 4x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

Invited Session 47

Organizer: Jorge Nocedal, Northwestern University, US

1 - A Progressive Batching L-BFGS Method for Machine Learning

Speaker: Raghu Bollapragada, Northwestern University, US, talk 564

Co-Authors: *Jorge Nocedal*, *Hao-Jun Shi*, *Dheevatsa Mudigere*, *Ping Tak Tang*,

We present a new version of the L-BFGS algorithm for machine learning that combines three basic components - progressive batching, a stochastic line search, and stable quasi-Newton updating. The motivation for this approach is to combine the early efficiency and good generalization properties of the SGD method and the fast convergence, stability and parallelization opportunities offered by large batches. We illustrate the performance of the method on logistic regression and deep neural network models.

2 - Convexity "à la carte"

Speaker: Leon Bottou, Facebook, US, talk 591

Co-Authors: *Martin Arjovsky*, *David Lopez-Paz*, *Maxime Oquab*,

Instead of defining a parametrized density function $p_\theta(x)$, an implicit generative model describes how to produce samples of the distribution P_θ by pushing samples z drawn from a known distribution through a parametrized generator function $G_\theta(z)$. Training such a model then consists in minimizing a distance $D(Q, P_\theta)$ where Q is the distribution of the examples on the basis of samples of Q (the examples) and samples of P_θ (the generated samples). When the distance D can be expressed as a maximization problem

$$D(Q,P) = \max_{(f,g)\in\mathcal{Q}} E_{x\sim Q}[f(x)] - E_{x\sim P}[g(x)]$$

for some well chosen set $\mathcal{Q}$ of critic functions, this leads to a saddle point problem that is typical of Generative Adversarial Networks. Many such distances exists. They can induce very different geometries on the space of probability distributions at large. The set of probability distributions represented by a parametrized generator function may have convexity properties in the induced geometry despite the fact that the parametrization is nonlinear and non-convex. When this is the case, we can study the convergence to the global minimum regardless of the non-convexity of the parametrization. However, non-Euclidian and non-Riemannian geometry can be full of surprises.

3 - On variance reduction for stochastic optimization with multiplicative noise

Speaker: Philip Thompson, CREST-ENSAE, FR, talk 1147

Co-Authors: *Alejandro Jofre*,

We propose dynamic sampled stochastic approximation methods for regularized stochastic convex optimization problems with a heavy-tailed distribution with finite second moments. Typically, it is assumed an oracle with an upper bound σ^2 on its variance (OUBV). Differently, we assume an oracle with multiplicative noise, where the variance may not be uniformly bounded over the feasible set. This includes the case of linear regression where the covariance matrix is affected by noise. With respect to tolerance, our methods achieve optimal iteration complexity and (near) optimal oracle complexity on the smooth convex and smooth strongly-convex classes improving upon Ghadimi and Lan [Math. Program., 156:59-99, 2016] and Byrd et al. [Math. Program., 134:127-155, 2012] where it is assumed an OUBV. Our methods possess a variance localization property: our bounds depend only on local variances $\sigma(x^*)^2$ at solutions x^* and the per unit distance multiplicative variance σ_L^2 (typically of the order of the Lipschitz constant). Moreover, we show there exist policies such that our bounds resemble, up to numerical constants, those obtained in the mentioned papers if it was assumed an OUBV but with the replacement $\sigma^2 := \sigma(x^*)^2$ in terms of variance at solutions. Our bounds are thus sharper since typically $\max\{\sigma(x^*)^2, \sigma_L^2\} \ll \sigma^2$. Philip Thompson was supported by Center of Mathematical Modelling of Uni.de Chile, Chile and Fondation Mathematique Jacques Hadamard at CREST-ENSAE, France (under contract with the Ecole Polytechnique).

4 - Characterizing Worst-Case Complexity of Algorithms for Nonconvex Optimization

Speaker: Frank Curtis, Lehigh University, US, talk 434

Co-Authors: *Daniel Robinson*,

In this talk, we question the idea of using a single number to characterize the worst-case complexity of an algorithm for solving nonconvex optimization problems. Characterizing complexity in this manner leads to worst-case behavior being dictated by pedagogical functions that are quite distinct from those seen in typical practice. We propose a new strategy for characterizing algorithms that attempts to better represent algorithmic behavior in real-world settings. This is done by partitioning the search space according to the lowest order for which a simple derivative-based step would yield a sufficient reduction.

Bayesian and Randomized Optimization II

Continuous Optimization

DerFree - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 79

Chair: Youssef Diouane, ISAE-SUPAERO, FR

1 - Adaptive modeling strategy for high-dimensional constrained global optimization

Speaker: Nathalie Bartoli, ONERA, FR, talk 1296

Co-Authors: *Thierry Lefebvre*, *Sylvain Dubreuil*, *Rémy Priem*, *Joaquim Martins*, *Joseph Morlier*,

Surrogate models are often used to reduce the cost of design optimization problems that involve computationally costly models such as computational fluid dynamics simulations. However, the number of evaluations required by surrogate models usually scales poorly with the number of design variables, and there is a need for better constraint handling. To address this issue, we develop a surrogate-based gradient-free optimization algorithm that can handle cases where the function evaluations are expensive, the dimensionality is high, and the optimization is subject to nonlinear constraints. This new algorithm—super efficient global optimization coupled with mixture of experts (SEGOMOE)—can tackle complex design constrained optimization problems through the use of an enrichment strategy approach based on mixture of experts coupled to adaptive surrogate models. The performance of this approach, including a new enrichment criterion, is evaluated for analytical examples, as well as for a multimodal aerodynamic shape constrained optimization problem (ADODG 6). Our results show that the method is cost-effective and that the optimum is much less dependent on the starting point than conventional gradient-based optimization.

2 - Modeling an Augmented Lagrangian for Blackbox Constrained Optimization

Speaker: Robert Gramacy, Virginia Tech, US, talk 276

Constrained blackbox optimization is a difficult problem, with most approaches coming from the mathematical programming literature. The statistical literature is sparse, especially in addressing problems with nontrivial constraints. This situation is unfortunate because statistical methods have many attractive properties: global scope, handling noisy objectives, sensitivity analysis, and so forth. To narrow that gap, we propose a combination of response surface modeling, expected improvement, and the augmented Lagrangian numerical optimization framework. This hybrid approach allows the statistical model to think globally and the augmented Lagrangian to act locally. We focus on problems where the constraints are the primary bottleneck, requiring expensive simulation to evaluate and substantial modeling effort to map out. In that context, our hybridization presents a simple yet effective solution that allows existing objective-oriented statistical approaches, like those based on Gaussian process surrogates and expected improvement heuristics, to be applied to the constrained setting with minor modification. This work is motivated by a challenging, real-data benchmark problem from hydrology where, even with a simple linear objective function, learning a nontrivial valid region complicates the search for a global minimum.

3 - Bayesian optimization under mixed constraints

Speaker: Victor Picheny, INRA, FR, talk 536

Co-Authors: *Robert Gramacy*, *Stefan Wild*, *Sébastien Le Digabel*,

This talk extends the joint use of augmented Lagrangian (AL) and Gaussian process (GP) surrogates for Bayesian Optimization (BO) to tackle problems with mixed (equality and inequality) constraints. Here we introduce an alternative slack variable AL, and show that in this formulation treatment of mixed constraints is facilitated. We additionally show how the acquisition function (expected improvement), previously relying on Monte Carlo evaluation, enjoys a degree of analytical tractability under this new AL formulation, and thus may be evaluated quickly and accurately with library routines. We demonstrate how such approach adapts well to several situations, including cheap or expensive objectives, a mixture of cheap and expensive constraints, and the case of correlated GP surrogates for the constraints. We finally show several mixed constraint examples on which our new slack "ALBO" compares favorably to conventional alternatives.

4 - Bayesian Optimization Guided by Max-values

Speaker: Zi Wang, MIT, US, talk 637

Co-Authors: *Stefanie Jegelka*,

Bayesian optimization (BO) has taken a decades-long journey, resulting in various approaches for selecting new query points to optimize an unknown target function: from optimizing the probability of improvement to querying information gain. Both performance and robustness of BO methods have significantly improved over the years, but little is understood about connections between different methods. We take a detour to explore the usage of maximum values of target functions in the design of novel BO approaches, and make two main contributions: First, our findings bridge missing pieces that reveal connections between entropy search methods, upper confidence bounds and probability of improvement. By exploiting these connections, we establish theoretical regret bounds for variants of entropy search and probability of improvement guided by max-values. Second, we obtain a much more efficient version of popular entropy search methods that maintains the good empirical performance. We demonstrate computational efficiency and effectiveness of BO approaches guided by max-values on a variety of low and high-dimensional tasks both in machine learning and simulated robot control.

Algebraic and geometric aspects of semidefinite programming

Continuous Optimization

SDP - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle 20 Building: G, 1st floor, Zone: 6

Invited Session 85

Organizer: Hamza Fawzi, University of Cambridge, GB

1 - Certificates of polynomial nonnegativity via hyperbolic optimization

Speaker: James Saunderson, Monash University, AU, talk 1680

I will discuss a new approach to certifying the nonnegativity of homogeneous multivariate polynomials that is based on the theory of hyperbolic polynomials. Moreover, the search for these certificates of nonnegativity can be automated by solving a hyperbolic optimization problem. The main technical fact that enables these nonnegativity certificates is a polynomial parameterization (up to closure) of the dual cone of a hyperbolicity cone, a construction essentially due to Kummer, Plaumann, and Vinzant. This talk presents the basic idea of such hyperbolic certificates of nonnegativity, and discusses the relationship between sums of squares and polynomials with hyperbolic certificates of nonnegativity.

2 - Log-barrier interior point methods are not strongly polynomial

Speaker: Xavier Allamigeon, INRIA and Ecole Polytechnique, FR, talk 372

Co-Authors: *Pascal Benchimol*, *Stephane Gaubert*, *Michael Joswig*,

We prove that primal-dual log-barrier interior point methods are not strongly polynomial, by constructing a family of linear programs with $3r + 1$ inequalities in dimension $2r$ for which the number of iterations performed is in $\Omega(2^r)$. The total curvature of the central path of these linear programs is also exponential in r, disproving a continuous analogue of the Hirsch conjecture proposed by Deza, Terlaky and Zinchenko. Our method is to tropicalize the central path in linear programming. The tropical central path is the piecewise-linear limit of the central paths of parameterized families of classical linear programs viewed through logarithmic glasses. This allows us to provide combinatorial lower bounds for the number of iterations and the total curvature, in a general setting. (Joint work with P. Benchimol, S. Gaubert, and M. Joswig)

3 - Slack ideals of polytopes

Speaker: Amy Wiebe, University of Washington, US, talk 713

Co-Authors: *João Gouveia*, *Antonio Macchia*, *Rekha Thomas*,
In this talk we discuss a new tool for studying the realization spaces of polytopes, namely the slack ideal associated to the polytope. These ideals were first introduced to study PSD rank of polytopes, and their structure also encodes other important polytopal properties, gives us a new way to understand important concepts such as projective uniqueness, and suggests connections with the study of other algebraic and combinatorial objects (toric ideals and graphs, for example).

4 - Measuring Optimality Gap in Conic Programming Approximations with Gaussian Width
Speaker: Dogyoon Song, MIT, US, talk 703
Co-Authors: *Pablo Parrilo*, *Christos Thrampoulidis*,
It is a common practice to approximate hard optimization problems with simpler convex programs for the purpose of computational efficiency. However, this often introduces a nontrivial optimality gap between the true optimum and the approximate values. We evaluate the quality of approximations by studying the Gaussian width of the underlying convex cones as a generic measure to evaluate the optimality gap. Specifically, we consider two canonical examples: (a) approximation of the positive semidefinite (PSD) cone $\mathcal{S}_+^n$ by the (scaled) diagonally dominant (DD) cone (DD^n (SDD^n); and (b) the sequence of hyperbolic cones, $\mathbb{R}_+^{n,(k)}$, which are the derivative relaxations of the nonnegative orthant. We show that there is a significant gap between the width of PSD cone and (S)DD cone ($\Theta(n^2)$ vs $\Theta(n \log n)$). On the other hand, (perhaps, surprisingly) the width of the hyperbolic cones remains almost invariant in the linear regime of relaxation ($k = \alpha n$ for $\alpha < 1$).

Theory and algorithms in conic linear programming 1

Continuous Optimization
SDP - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

Invited Session 88
Organizer: Gabor Pataki, UNC Chapel Hill, US

1 - Low-Rank Matrix Completion (LRMC) using Nuclear Norm (NN) with Facial Reduction
Speaker: Henry Wolkowicz, University of Waterloo, CA, talk 480
Minimization of the NN is often used as a surrogate, convex relaxation, for solving LRMC problems. The minimum NN problem can be solved as a trace minimization semidefinite program (SDP). The SDP and its dual are regular in the sense that they both satisfy strict feasibility. FR has been successful in regularizing many problems where strict feasibility fails, e.g., SDP relaxations of discrete optimization problems such as QAP, GP, as well as sensor network localization. Here we take advantage of the structure at optimality for the NN minimization and show that even though strict feasibility holds, the FR framework can be successfully applied to obtain a proper face that contains the optimal set. This can dramatically reduce the size of the final NN problem while guaranteeing a low-rank solution. We include numerical tests for both exact and noisy cases and extensions to robust principal component analysis.

2 - Solving conic systems via projection and rescaling
Speaker: Negar Soheili, Univ. of Illinois at Chicago, US, talk 744
Co-Authors: *Javier Pena*,
We propose a projection and rescaling algorithm for finding the most interior solution to the pair of conic feasibility problems find $x \in L \cap \Omega$ and find $\hat{x} \in L^\perp \cap \Omega$, where L, $L^\perp$ and Ω are respectively a linear subspace, the orthogonal complement, and the interior of a symmetric cone in a finite-dimensional vector space V. Our algorithm is inspired by previous work on rescaled versions of the perceptron algorithm and by Chubanov's projection-based method for linear feasibility problems. As in these predecessors, each main iteration of our algorithm combines a basic procedure involving low-cost operations with a periodic rescaling step. We provide a set of numerical experiments that study the performance of our algorithm on synthetic problem instances. Our computational experiments provide promising evidence of the effectiveness of the projection and rescaling algorithm.

3 - Projection and presolve in MOSEK: exponential and power cones
Speaker: Henrik Friberg, MOSEK, DK, talk 508
The major new feature in MOSEK version 9 is the support for exponential cones and power cones. This talk examines three closely related questions of interest to the analysis of new cones of any kind: How to measure conic constraint violations? How to project points onto these cones? How to find separating hyperplanes for these cones? As shown, all three questions can be answered systematically and reduce to univariate root-finding problems in case of the exponential and power cone. This establish a complexity-wise difference between separation and maximal separation. Various other issues, results and open questions related to presolve are surveyed.

4 - TOTAL DUAL INTEGRALITY FOR CONVEX, SEMIDEFINITE, AND EXTENDED FORMULATIONS
Speaker: Levent Tuncel, University of Waterloo, CA, talk 707
Co-Authors: *Marcel de Carli Silva*,
We propose a notion of total dual integrality for SDPs that generalizes the notion for LPs, by relying on an "integrality constraint" for SDPs that is primal-dual symmetric. A key ingredient for the theory is a generalization to compact convex sets of a result of Hoffman for polytopes, fundamental for generalizing the polyhedral notion of total dual integrality introduced by Edmonds and Giles. We study the corresponding theory applied to SDP formulations for stable sets in graphs using the Lovasz theta function and show that total dual integrality in this case corresponds to the underlying graph being perfect. We also relate dual integrality of an SDP formulation for the maximum cut problem to bipartite graphs. Total dual integrality for extended formulations naturally comes into play in this context.

Advances in Bundle Methods for Convex Optimization

Continuous Optimization
NonSmooth - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle LC4 Building: L, Intermediate 1, Zone: 9

Invited Session 93

Organizer: Christoph Helmberg, TU Chemnitz, DE

1 - An Asynchronous Parallel Bundle Method Based on Inexact Oracles
Speaker: Frank Fischer, Universität Kassel, DE, talk 715
Bundle methods are a powerful tool for solving large scale non-smooth convex optimization problems. Such problems naturally arise in Lagrangian relaxation approaches of large combinatorial optimization problems. One main advantage is that if the problem is composed as a sum of many independent functions, the function evaluation in each iteration can be done in parallel utilizing modern parallel hardware. However, often the subproblems are differently difficult and the synchronous nature of bundle methods causes the most difficult subproblems to dominate the overall running time. Different approaches to reduce the computation time of these subproblems have been proposed, e.g. inexact oracles or skipping the evaluation of some oracles in some iterations. However, all of these approaches possess the same synchronous nature. In this talk we present a new algorithm that performs all function evaluations asynchronously. We show how the theory of inexact bundle method can be used to interpret asynchronous function evaluations as inexact oracles to prove global convergence.

2 - Fully Incremental Bundle Methods: (Un)cooperative (Un)faithful Oracles and Upper
Speaker: Antonio Frangioni, Università di Pisa, IT, talk 56
Co-Authors: *Wim van Ackooij*,
We propose a family of proximal bundle methods for minimizing sum-structured convex nondifferentiable functions. Focus of our work is to minimize the effort for computing the function, by both allowing each component of the function to be evaluated inexactly, and allowing as many components as possible not to be evaluated at all. In contrast with previous approaches in the literature, we skip oracle calls entirely (for some of the component functions) not only at “null steps” but also at “serious steps”. This requires defining upper models of the functions that allow to estimate function values at points where the oracle has not been called, which in turns requires oracles which also produce upper estimates on the function values, and a Lipschitz continuity assumption. In exchange, the methods provide the oracles with more information about when the function computation can be interrupted, possibly diminishing their cost, provide explicit and reliable a-posteriori estimates of the quality of the obtained solutions, and work with all possible combinations of different assumptions on how the oracles deal with not being able to compute the function with arbitrary accuracy. In particular, we define two entirely new notions of "noise reduction step", and we show under which conditions on the oracle any one of them (and their combination) is needed. We also discuss the introduction of constraints (or, more generally, of easy components) and use of (partly) aggregated models.

3 - The Bundle Method for Getting an Improved SDP Relaxation of the Stability Number
Speaker: Elisabeth Gaar, AAU Klagenfurt, AT, talk 269
Co-Authors: *Franz Rendl*,
The Lovasz theta function is an upper bound on the stability number of a graph, which can be computed in polynomial time as semidefinite program (SDP). One possibility to further improve this upper bound is to include so called exact subgraph constraints (ESC) for many small subgraphs into the SDP. For a certain subgraph the ESC ensures that the submatrix of the calculation of the Lovasz theta function corresponding to the subgraph is contained in the convex hull of all stable set matrices of the subgraph. However, solving the resulting SDP is very time-consuming with off-the-shelf solvers, hence it requires alternative solution methods to calculate this improved upper bound. After reformulation, the bundle method with easy sum components (a specialized version of the bundle method) can be applied in a very natural way and yields significantly faster running times. We will discuss some details of the bundle method we use.

4 - A Dynamic Scaling Approach for Bundle Methods in Convex Optimization
Speaker: Christoph Helmberg, TU Chemnitz, DE, talk 145
Co-Authors: *Alois Pichler*,
A canonical bundle method for convex optimization generates the next candidate point by minimizing a quadratic subproblem. Typically, this consists of a piecewise linear cutting model of the convex function formed from collected subgradient information and a quadratic proximal term keeping the candidate close to the current center of stability. For convergence a minimal cutting model consisting of a so called aggregate (cutting plane) and the latest subgradient inequality suffices. This allows to trade quality of the model against solution time of the subproblem. We propose a systematic approach for including subgradient information in the proximal term in order to support reduced size models. In the smooth case this term should mimic the Hessian and we highlight some theoretical connections in this respect. The practical benefits of the approach will be illustrated by numerical experiments on a class of large scale instances from practice using the callable library ConicBundle.

Machine learning and sparse optimisation

Continuous Optimization
NLP - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 109
Organizer: Coralia Cartis, University of Oxford, GB

1 - Condition numbers and weak average-case complexity in optimization
Speaker: Martin Lotz, The University of Manchester, GB, talk 957
Co-Authors: *Dennis Amelunxen*, *Jake Walvin*,
A common weakness of the complexity analysis of numerical optimization algorithms, even when considering average-case or smoothed analysis, is the discrepancy between observed behavior and provable bounds. We use the framework of weak average-case complexity analysis to derive performance bounds for numerical problems that are close to their observed behavior. One application is to condition number bounds for the performance of convex regularization methods using composite regularizers, such as in total variation or analysis l1-regularization. We also discuss other recent applications of this analysis to problems in computational semi-algebraic geometry.

2 - A Long (Random) Walk Solves All Your (Linear) Problems

Speaker: Armin Eftekhari, Alan Turing Institute, GB, talk 1199
Co-Authors: *Martin Lotz*, *Peter Richtarik*,
We present a new and nearly-optimal stochastic algorithm for minimizing a linear objective function over a convex body. At every feasible iteration, the algorithm chooses a direction randomly and, if it reduces the objective function, moves along this random direction until it reaches the boundary of the convex body. Perhaps surprisingly, this algorithm converges linearly and with high probability to a minimizer, with a rate of convergence that depends inversely on the dimension of the convex body. More specifically, this simple stochastic algorithm achieves the same rate of convergence as deterministic but computationally expensive cutting-planes algorithms. As an application, consider the well-known Basis Pursuit (BP) program for finding the sparsest solution of a system of linear equations, which arises in various problems, including compressive sensing in signal processing and feature selection in high-dimensional statistics. We apply this algorithm to the dual of BP, which is an (often low-dimensional) linear program. Lastly, we design a family of such stochastic algorithms and study their convergence with the aid of powerful tools from integral geometry and probability theory.

3 - Manifold lifting: problems and methods
Speaker: Florentin Goyens, Oxford University, GB, talk 1182
Co-Authors: *Armin Eftekhari*, *Coralia Cartis*, *Greg Ongie*,
The goal of our project is to complete a partially observed matrix whose columns obey a nonlinear structure. Such matrices are in general full rank, but it is often possible to exhibit a low rank structure when the data is lifted to a higher dimensional space of features. Previous works in this direction include (Ongie et al 2017). This lifting procedure is performed using a kernel operator. The presence of a nonlinear kernel makes it impossible to write the problem using common matrix completion formulations. In this talk, we aim to find the best formulation of this problem as a nonconvex optimisation problem, as well as using, wherever possible, existing approaches from matrix completion theory and methods. Optimization on manifolds, alternative minimization algorithms and methods that solve a sequence of matrix completion

4 - Sparse non-negative super-resolution: simplified and stabilized
Speaker: Jared Tanner, University of Oxford, GB, talk 1462
Co-Authors: *Armin Eftekhari*, *Andrew Thompson*, *Bogdan Toader*, *Hemant Tyagi*,
Super-resolution is a technique by which one seeks to overcome the inherent accuracy of a measurement device by exploiting further information. Applications are very broad, but in particular these methods have been used to great effect in modern microscopy methods and underpin recent Nobel prizes in chemistry. This topic has received a renewed theoretical interest starting in approximately 2013 where notions from compressed sensing were extended to this continuous setting. The simplest model is to consider a one dimensional discrete measure $\mu = \sum_{j=1}^{k} \alpha_j \delta_{t_j}$ which models k discrete objects at unknown locations t_j and unknown amplitudes α_j (typically with non-negative amplitudes).The measurement device can be viewed as a burring operator, where each discrete spike is instead replaced a function $\psi(s, t_j)$ such as a Gaussian $\exp(-\sigma|s - t_j|)$, in which case one can make measurements of the form $y(s) = \psi(s, t) \star \mu = \sum_{j=1}^{k} \alpha_j \psi(s, t_j)$. Typically one measures $m > 2k + 1$ discrete values; that is $y(s_i)$ for $i = 1, \ldots, m$. The aim is then to recover the $2k$ parameters $t_{j}{}_{j=1}^{k}$ and $\alpha_{j}{}_{j=1}^{k}$ from the m samples and knowledge of $\psi(s, t)$. In this talk we extend recent results by Schiebinger, Robava, and Recht to show that the the $2k$ parameters are uniquely determined by their $2k + 1$ samples, and that any solution consistent with the measurement within τ is proportionally consistent with the original measure

Nonlinear Optimization with Uncertain Constraints

Optimization under Uncertainty
Robust - Tu 9:00am-10:30am, Format: 3x30 min
Room: Salle 37 Building: B, Intermediate, Zone: 4

Invited Session 110
Organizer: Charlie Vanaret, Argonne National Laboratory, US

1 - Nonlinear programming reformulations of chance constraints (Part 2)
Speaker: Andreas Waechter, Northwestern University, US, talk 1427
Co-Authors: *Alejandra Pena-Ordieres*, *Jim Luedtke*,
This is the second of two talks on a new method for solving nonlinear continuous optimization problems with chance constraints. In this part, we extend our reformulation to joint chance constraints. We propose an exact penalty function for the resulting optimization problem and use it to design an Sl1QP-type trust-region method. A tailored algorithm for the solution of the associated QP subproblems is presented. We discuss theoretical convergence properties and demonstrate the efficiency of the method in numerical experiments.

2 - Nonlinear programming reformulations of chance constraints (Part 1)
Speaker: Alejandra Pena-Ordieres, Northwestern University, US, talk 1441
Co-Authors: *Andreas Waechter*, *Jim Luedtke*,
This is the first of two talks on a new method for solving nonlinear continuous optimization problems with chance constraints. In this part, we consider single chance constraints and introduce reformulations of the probabilistic constraints based on quantile functions. These are approximated using sample average approximation and smoothed to make them differentiable. We examine the theoretical and practical statistical guarantees of the approximation. In numerical experiments we demonstrate that the resulting nonlinear programming formulation can be handled by standard nonlinear programming solvers and that it scales well both in terms of the number of samples and the number of decision variables.

3 - Sequential Linearization for Nonlinear Robust Optimization
Speaker: Sven Leyffer, Argonne National Laboratory, US, talk 1071
Many optimization problems involve uncertain data, or decision variables that cannot be implemented exactly. Problems of this type can be formulated as robust optimization problems, a class of optimization problems under uncertainty. We present a new algorithmic approach that solves general nonlinear robust optimization approaches by a sequential lin-

earization method, resulting in tractable subproblems. We discuss the theoretical properties of the sequential linearization method, and present some preliminary numerical results.

Algorithms for stochastic games : new approaches

Optimization under Uncertainty
Markov - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 31 Building: B, Ground Floor, Zone: 5

Invited Session 137
Organizer: Hugo Gimbert, CNRS, LABRI, Universite de Bor, FR

1 - Quasi-polynomial algorithms for solving parity games
Speaker: Marcin Jurdzinski, University of Warwick, GB, talk 1042
Co-Authors: *Ranko Lazic*,
Parity games play a fundamental role in automata theory, logic, and their applications to verification and synthesis. For example, solving parity games is polynomial-time equivalent to to the modal mu-calculus model checking and to testing emptiness of tree automata. The quest for a polynomial-time algorithm for solving parity games has not only brought diverse algorithmic techniques to the theory and practice of verification and synthesis, but it has also contributed to resolving long-standing open questions in other research areas, for example the complexity of policy iteration in Markov Decision Processes and of randomized simplex pivoting rules in Linear Programming. I will present new algorithmic techniques that have sprung after the first quasi-polynomial algorithm for solving parity games was given by Calude et al. in 2017, such as ordered tree coding, universal trees, succinct progress measures, and separating automata, and I will discuss their provable limitations in the ongoing quest for a polynomial-time algorithm.

2 - One-Counter Stochastic Games with Zero-Reachability Objectives
Speaker: Antonin Kucera, Masaryk University, CZ, talk 1330
One-counter stochastic games are stochastic games over finite graphs where each transitions modifies an integer counter by a fixed value in -1,0,1. Starting in a given initial vertex with a given initial counter value, Player I aims at reaching a a configuration with zero counter (as quickly as possible), while Player II aims at the opposite. In the talk we present basic results about one-counter games and explain the prominent role of martingales in developing algorithms for approximating the equilibrium value in these games.

3 - Around tropically convex constraint satisfaction problems.
Speaker: Marcello Mamino, Università di Pisa, IT, talk 1410
Co-Authors: *Manuel Bodirsky*,
The constraint satisfaction problem (CSP) of a class of sets (called relations) is the computational task of deciding whether a given finite intersection of such relations is empty. For instance the linear programming feasibility problem is the CSP of linear half-spaces. A piecewise linear relation is max-closed if it is preserved by taking the component-wise maximum, and it is tropically convex if it is additionally closed under translations along the diagonal. We prove that the CSP of tropically convex piecewise linear relations is in NP intersected co-NP. This result is obtained through a duality for open tropically convex relations, which comes as a consequence of the memoryless determinacy of stochastic mean payoff games, coupled with a syntactic characterization of max-closed relations. Finally, we will discuss recent advancements regarding the tractability of CSPs sub-classes of all max-closed relations.

4 - The condition number of stochastic mean payoff games
Speaker: Mateusz Skomra, Ecole Polytechnique and INRIA, FR, talk 1371
Co-Authors: *Xavier Allamigeon*, *Stephane Gaubert*, *Ricardo Katz*,
Recently, it has been shown that one can solve generic nonarchimedean semidefinite feasibility problems by means of stochastic game algorithms. This relies on tropical geometry. In this talk, we introduce a condition number for nonarchimedean feasibility problems, defined as the maximal radius of a ball in Hilbert's projective metric that is included in the (primal or dual) feasible set. We show that this conditioning controls the number of value iterations needed to decide whether a mean payoff game is winning. In particular, we obtain a pseudopolynomial bound for the complexity of value iteration provided that the number of random positions is fixed. This is joint work with X. Allamigeon, S. Gaubert, and R. D. Katz.

Machine Learning for Optimization

Discrete Optimization & Integer Programming
IPpractice - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Invited Session 138
Organizer: Bistra Dilkina, Univ of Southern California, US

1 - Machine Learning for Branch and Bound
Speaker: Bistra Dilkina, Univ of Southern California, US, talk 1090
Branch and Bound solvers for Mixed Integer Programs (MIP) such as CPLEX, Gurobi and SCIP are used daily across different domains and industries to find solutions with optimality guarantees for NP-hard combinatorial problems. In order to improve the state of the art in such solvers, we propose a data-driven machine-learning approach to MIP solving. Leveraging the plethora of rich and useful data generated during the solving process, we aim to improve some of the heuristic solver components, which so far have been based mostly on mathematical and algorithm engineering insights. We illustrate the potential for ML in MIP on two tasks: branching variable selection and primal heuristic selection, both crucial components of the branch-and-bound algorithm. We show that our novel approaches can significantly improve the performance of a solver on both heterogeneous benchmark instances as well as homogeneous families of instances.

2 - Learning when to use a decomposition
Speaker: Markus Kruber, RWTH Aachen University, DE, talk 1142
Co-Authors: *Marco Lübbecke*, *Axel Parmentier*,
Applying a Dantzig-Wolfe decomposition to a mixed-integer program (MIP) aims at exploiting an embedded model struc-

ture and can lead to significantly stronger reformulations of the MIP. Recently, automating the process and embedding it in standard MIP solvers have been proposed, with the detection of a decomposable model structure as key element. If the detected structure reflects the (usually unknown) actual structure of the MIP well, the solver may be much faster on the reformulated model than on the original. Otherwise, the solver may completely fail. We propose a supervised learning approach to decide whether or not a reformulation should be applied, and which decomposition to choose when several are possible. Preliminary numerical experiments with a MIP solver equipped with this knowledge show a significant performance improvement on structured instances, with little deterioration on others.

3 - Learning Combinatorial Optimization Algorithms Over Graphs

Speaker: Elias Khalil, Georgia Tech, US, talk 1083

Co-Authors: *Hanjun Dai*, *Yuyu Zhang*, *Bistra Dilkina*, *Le Song*,

The design of good heuristics or approximation algorithms for NP-hard combinatorial optimization problems often requires significant specialized knowledge and trial-and-error. Can we automate this challenging, tedious process, and learn the algorithms instead? In many real-world applications, it is typically the case that the same optimization problem is solved again and again on a regular basis, maintaining the same problem structure but differing in the data. This provides an opportunity for learning heuristic algorithms that exploit the structure of such recurring problems. We propose a unique combination of reinforcement learning and graph embedding to address this challenge. The learned greedy policy behaves like a meta-algorithm that incrementally constructs a solution, and the action is determined by the output of a graph embedding network capturing the current state of the solution. Our framework can be applied to a diverse range of optimization problems over graphs, and learns effective algorithms for the Minimum Vertex Cover, Maximum Cut and Traveling Salesman problems.

4 - Learning Discrete Optimization

Speaker: Andrea Lodi, Polytechnique Montreal, CA, talk 1034

In this talk, I explain my point of view as a Mathematical Optimizer – especially concerned with discrete (integer) decisions – on Big Data. I advocate a tight integration of Machine Learning and Mathematical Optimization (among others) to deal with the challenges of decision making in Data Science. Finally, I discuss in details some applications that highly benefited from such an integration with both Machine Learning techniques applied to Mixed-Integer Programming and vice versa, namely Integer Programming techniques applied to Learning.

Nonlinear Optimization and Variational Inequalities V

Continuous Optimization

Variat - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 145

Organizer: Xin Liu, Chinese Academy of Sciences, CN

1 - Lower-order regularization method for group sparse optimization with application

Speaker: Yaohua Hu, Shenzhen University, CN, talk 84

Co-Authors: *Chong Li*, *Kaiwen Meng*, *Jing Qin*, *Xiaoqi Yang*,

The lower-order regularization problem has been widely studied for finding sparse solutions of linear inverse problems and gained successful applications in various mathematics and applied science fields. In this talk, we will present the lower-order regularization method for (group) sparse optimization problem in three aspects: theory, algorithm and application. In the theoretical aspect, by introducing a notion of restricted eigenvalue condition, we will establish an oracle property and a global recovery bound for the lower-order regularization problem. In the algorithmic aspect, we will apply the well-known proximal gradient method to solve the lower-order regularization problem, and establish the linear convergence rate of the proximal gradient method for solving the lower-order regularization problem under a simple assumption. Finally, in the aspect of application, we apply the lower-order group sparse regularization method to solve two important problems in systems biology: gene transcriptional regulation and cell fate conversion.

2 - Solving Constrained TV2L1-L2 MRI Signal Reconstruction via an Efficient ADMM

Speaker: Tingting Wu, NJUPT, CN, talk 64

Co-Authors: *Z.W. Wang*, *Z.M. Jin*, *J. Zhang*,

High order total variation (TV^2) and ℓ_1 (TV2L1) based model has its advantage over the TVL1 for its ability in avoiding the staircase; and a constrained model has its advantage over its unconstrained counterpart for its simplicity in estimating the parameters. In this paper, we consider solving the TV2L1 based magnetic resonance imaging (MRI) signal reconstruction problem by an efficient alternating direction method of multipliers. By sufficiently utilizing the problem's special structure, we manage to make all subproblems either possess closed-form solutions or can be solved via Fast Fourier Transforms (FFTs), which makes the cost per iteration is very low. Experimental results for MRI reconstruction are presented to illustrate the new model and algorithm. Comparisons with its recent unconstrained counterpart are also reported.

3 - On solving saddle-point problems and non-linear monotone equations

Speaker: Oleg Burdakov, Linkoeping University, SE, talk 1258

Problem of finding saddle points for strictly convex-concave functions is considered. We present pseudo-orthogonal direction algorithms for solving this problem. They are extensions of some conjugate direction algorithms known in unconstrained optimization. They converge to saddle points in a finite number of steps for quadratic functions. In the non-quadratic case, the asymptotic rate of their convergence is quadratic. Extensions to non-linear monotone equations are discussed. Preliminary results of numerical experiments are presented.

4 - A first-order method for semidefinite stochastic variational inequality problems

Speaker: Javad Feizollahi, Georgia State University, US, talk 698

Co-Authors: *Nahidsadat Majlesinasab*, *Farzad Yousefian*,

Motivated by multi-user non-cooperative Nash games in stochastic regimes, we consider stochastic variational inequality problems (SVI) on positive semidefinite matrix spaces. Much of the interest in the literature of variational inequality (VI) has focused on addressing VIs on vector spaces. Yet, there is not enough guidance on solution methods for addressing SVIs on semidefinite matrix spaces. Motivated by this gap, we develop a stochastic mirror descent method. This method is first-order in the sense that it only requires a gradient-type of update at each iteration. Our contribution is three-fold: (i) we show that the iterate generated by the algorithm converges to a weak solution of the SVI; (ii) moreover, we derive a convergence rate in terms of the expected value of a suitably defined gap function; (iii) we implement the developed method for solving a multiple-input multiple-output multi-cell cellular wireless network composed of seven hexagonal cells and present the numerical experiments supporting the convergence of the proposed method.

Optmization Algorithms and Variational Inequalites I

Continuous Optimization

Variat - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Invited Session 148

Organizer: Bo Jiang, Nanjing Normal University, CN

1 - Smoothing quadratic regularization method for the hemivariational inequalities

Speaker: Yu-Hong Dai, Chinese Academy of Sciences, CN, talk 799

Co-Authors: *Yanfang Zhang*, *Weimin Han*,

In this talk, we employ the smoothing quadratic regularization method to solve the hemivariational equalities (HVI). The hemivariatonal inequalty is a class of nonsmooth and nonconvex optimization problem, which is constrained by box constraints. The objective function of the problem has a dominated quadratic part. Hence, we employ the smoothing quadratic regularization method to solve it. The hemivariational inequalities coming from the nonsmooth mechanics of solid, especially in nonmonotone contact problems can be formulated as this kind of optimization problems. For this algorithm, the closed form solution is not expensive to calculate at each iteration. The convergence results of this algorithm are shown, and the worst case complexity for reaching an ϵ Clarke stationary point is also given.

2 - ADMM for Optimization Problems Involving Nonconvex Functions

Speaker: Deren Han, Nanjing Normal University, CN, talk 438

The efficiency of the classic alternating direction method of multipliers has been exhibited by various applications for large scale separable optimization problems, both for convex objective functions and for nonconvex objective functions. While there are a lot of convergence analysis for the convex case, the nonconvex case is still an open problem and the research for this case is in its infancy. In this talk, we consider two classes of optimization problems involving nonconvex functions. The first case is the "strongly+weakly" convex model and the second on is the general nonconvex model. For both cases, by using different analysis techniques, we prove the global convergence of the algorithms, and under some further conditions on the problem's data, we also analyze the convergence rate.

3 - ADMM-based methods for monotone inverse variational inequalities

Speaker: Xingju Cai, Nanjing Normal University, CN, talk 418

Inverse variational inequalities have broad applications in various disciplines, and there are already some methods which based on proximal point method or projection type methods to solve it. In this paper, we discuss a class of inverse variational inequality which has separable structure, thus we fi rst propose a method based on alternating direction method of multipliers (ADMM) that only needs functional values for given variables in the solution process, and its convergence is established. A linearized variant is proposed to make the subproblem can be easily solved. Further, we give a numerical example to show the efficiency of the new method.

4 - Vector Transport-Free SVRG with General Retraction for Riemannian Optimization

Speaker: Bo Jiang, Nanjing Normal University, CN, talk 320

Co-Authors: *Shiqian Ma*, *Anthony So*, *Shuzhong Zhang*,

The empirical risk minimization over Riemannian manifold has wide applications in machine learning area. In this talk, we propose a vector transport-free stochastic variance reduced gradient (SVRG) method with general retraction for empirical risk minimization over Riemannian manifold. Existing SVRG methods on manifold usually consider a specific retraction operation, and involve additional computational costs such as parallel transport or vector transport. The vector transport-free SVRG with general retraction we propose in this paper handles general retraction operations, and do not need additional computational costs mentioned above. As a result, we name our algorithm S-SVRG, where the first S means simple. We analyze the iteration complexity of S-SVRG for obtaining an ϵ-stationary point and its local linear convergence by assuming the Łojasiewicz inequality, which naturally holds for PCA and holds with high probability for matrix completion problem. We also incorporate the Barzilai-Borwein step size and design a very practical S-SVRG-BB method. Numerical results on PCA and matrix completion problems are reported to demonstrate the efficiency of our methods. This is a joint work with Shiqian Ma, Anthony Man-Cho So and Shuzhong Zhang.

Larges Scale and Distributed Optimization

Continuous Optimization

RandomM - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 214

Organizer: Ermin Wei, Northwestern University, US

1 - On Linear Convergence for Douglas-Rachford splitting and ADMM

Speaker: Pontus Giselsson, Lund University, SE, talk 291

Several local and global linear convergence rate results for the alternating direction method of multipliers (ADMM) have appeared in the literature over the last couple of years. Many of these are derived under strong monotonicity, Lipschitz continuity, and/or cocoercivity assumptions, and focus on the convex optimization setting. It is well known that ADMM is obtained by applying the Douglas-Rachford algorithm to a Fenchel dual problem formulation. In this talk, we show that the linear convergence results for ADMM follow from our results on contraction factors for the Douglas-Rachford operator under smoothness and strong monotonicity assumptions. Our analysis improves on previous analyses in three aspects 1) the contraction factors are provably sharp 2) the results hold in more general Hilbert space settings 3) the proofs are more compact as they are based on operator theory.

2 - Block-Iterative and Asynchronous Projective Splitting for Monotone Operators

Speaker: Jonathan Eckstein, Rutgers University, US, talk 240
Co-Authors: *Patrick Johnstone*, *Jean-Paul Watson*,
Recent advances in the theory of projective splitting algorithms for monotone inclusion problems (including convex optimization) have shown that the methods can be implemented in a block-iterative and asynchronous manner. “Block iterative” means that only a subset of operators need be considered at each iteration. We describe the key ideas behind the convergence mechanism of these methods and how they can be used to derive an algorithm that resemble the multi-block ADMM but can be operated asynchronously with almost no stepsize restrictions. Various techniques can be used to accelerate this class of method, including using an auxiliary primal-dual scaling factor and activating operators in a greedy manner. We discuss these techniques and their impact on the performance of various applications, such as data fitting and multistage stochastic programming. It is also possible to incorporate forward steps into this class of algorithms, a topic that will be explored in greater detail in a presentation by Patrick Johnstone.

3 - Achieving Geometric Convergence for Distributed Asynchronous Optimization

Speaker: Gesualdo Scutari, Purdue University, US, talk 634
Co-Authors: *Ye Tian*, *Ying Sun*,
Can one obtain a geometrically convergent algorithm for distributed asynchronous multi-agent optimization? This paper provides a positive answer to this open question. The proposed algorithm solves multi-agent (convex and nonconvex) optimization over static digraphs and is fully asynchronous, in the following sense: i) agents can update their local variables as well as communicate with their neighbors at any time, without any form of coordination; and ii) they can perform their local computations using (possibly) delayed, out-of-sync information from the other agents. Delays need not obey any specific profile, and can also be time-varying (but bounded). The algorithm builds on a tracking mechanism that is robust against asynchrony (in the above sense) whose goal is to estimate locally the average of agents’ gradients. Moreover, it employs either a fixed step-size or diminishing, uncoordinated, ones. When applied to strongly convex functions, we prove that it converges at an R-linear (geometric) convergence rate as long as the step size is less than a specific bound. A sublinear convergence rate is proved, when nonconvex problems and/or diminishing, uncoordinated, step-sizes are considered. Preliminary numerical results demonstrate the efficacy of the proposed algorithm and validate our theoretical findings.

4 - Asynchronous Distributed Network Newton Method

Speaker: Ermin Wei, Northwestern University, US, talk 209
Co-Authors: *Fatemeh Mansoori*,
The problem of minimizing a sum of local convex objective functions over a networked system captures many important applications and has received much attention in the distributed optimization field. Most of existing work focuses on development of fast distributed algorithms under the presence of a central clock. The only known algorithms with convergence guarantees for this setup in asynchronous setup could achieve either sublinear rate under totally asynchronous setting or linear rate under partially asynchronous setting (with bounded delay). In this work, we built upon existing literature to develop and analyze an asynchronous Newton based approach for solving a penalized version of the problem. We show that this algorithm converges almost surely and has superlinear rate in expectation. Numerical studies confirm superior performance against other existing asynchronous methods.

Extended formulations

Discrete Optimization & Integer Programming
IPtheory - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 219
Organizer: Stefan Weltge, Technical University of Munich, DE

1 - Balas formulation for the union of polytopes is optimal

Speaker: Michele Conforti, University of Padova, IT, talk 567
Co-Authors: *Marco Di Summa*, *Yuri Faenza*,
A celebrated theorem of Balas gives a linear mixed-integer formulation for the union of two nonempty polytopes whose relaxation gives the convex hull of this union. The number of inequalities in Balas formulation is linear in the number of inequalities that describe the two polytopes and the number of variables is doubled. We show that this is best possible: in every dimension there exist two nonempty polytopes such that if a formulation for the convex hull of their union has a number of inequalities that is polynomial in the number of inequalities that describe the two polytopes, then the number of additional variables is at least linear in the dimension of the polytopes. This result essentially carries over if one wants to approximate the convex hull of the union of two polytopes and also in the more restrictive setting of lift-and-project.

2 - Strengthening Convex Relaxations of 0/1-Sets Using Boolean Formulas

Speaker: Tony Huynh, Université Libre de Bruxelles, BE, talk 78
Co-Authors: *Samuel Fiorini*, *Stefan Weltge*,
In convex integer programming, various procedures have been developed to strengthen convex relaxations of sets of integer points. On the one hand, there exist several general-purpose methods that strengthen relaxations without specific knowledge of the set S of feasible integer points, such as popular linear programming or semi-definite programming hierarchies. On the other hand, various methods have been designed for obtaining strengthened relaxations for very specific sets S that arise in combinatorial optimization. We propose a new efficient method that interpolates between these two approaches. Our procedure strengthens any convex set containing a set

S of 0/1-points by exploiting certain additional information about S. Namely, the required extra information will be in the form of a Boolean formula defining the target set S. The aim of this work is to analyze various aspects regarding the strength of our procedure. As one result, interpreting an iterated application of our procedure as a hierarchy, our findings simplify, improve, and extend previous results by Bienstock and Zuckerberg on covering problems.

3 - Lower Bounds for Approximating the Matching Polytope

Speaker: Makrand Sinha, University of Washington, US, talk 95

We prove that any extended formulation that approximates the matching polytope on n-vertex graphs up to a factor of $(1+\epsilon)$ for any $2/n \leq \epsilon \leq 1$ must have at least $\binom{n}{\alpha/\epsilon}$ inequalities where $0 < \alpha < 1$ is an absolute constant. This is tight as exhibited by the $(1+\epsilon)$ approximating linear program obtained by dropping the odd set constraints of size larger than $O(1/\epsilon)$ from the description of the matching polytope. Previously, a tight lower bound of $2^{\Omega(n)}$ was only known for $\epsilon = O(1/n)$ (Rothvoss STOC' 14, Braun and Pokutta, IEEE Trans. Information Theory '15) whereas for $2/n \leq \epsilon \leq 1$, the best lower bound was $2^{\Omega(1/\epsilon)}$ (Rothvoss STOC' 14). The key new ingredient in our proof is a close connection to the nonnegative rank of a lopsided version of the unique disjointness matrix.

4 - Lifting Linear Extension Complexity Bounds to the Mixed-Integer Setting

Speaker: Stefan Weltge, Technical University of Munich, DE, talk 59

Co-Authors: *Alfonso Cevallos*, *Rico Zenklusen*,

Mixed-integer mathematical programs are ubiquitous in Operations Research and related fields. However, there is still very little known about what can be expressed by compact mixed-integer programs with few integer variables. We provide a general framework for lifting inapproximability results for linear extended formulations to the mixed-integer setting, and obtain almost tight lower bounds on the number of integer variables needed to describe a variety of classical combinatorial optimization problems. Among the implications we obtain, we show that any mixed-integer extended formulation of sub-exponential size for the matching polytope, cut polytope, or dominant of the odd-cut polytope, needs $\Omega(n/\log n)$ many integer variables, where n is the number of vertices of the underlying graph. Moreover, we can show that these bounds are optimal up to a logarithmic factor. Our results build upon a new decomposition technique that, for any convex set C, allows for approximating any mixed-integer description of C by the intersection of C with the union of a small number of affine subspaces.

Optimization Methods for PDE Constrained Problems

Continuous Optimization

Control - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Invited Session 221

Organizer: Michael Ulbrich, Technical University of Munich, DE

1 - An affine covariant composite step method with inexact step computations

Speaker: Anton Schiela, Uni Bayreuth, DE, talk 1253

Co-Authors: *Manuel Schaller*,

We present a composite step method, designed for the solution of nonlinear PDE constrained optimization problems. As a distinguishing feature, the globalization mechanism depends on primal quantities only which facilitates the incorporation of known analytic problem structure. For the computation of the steps we employ a projected cg method, equipped with a block triangular constraint preconditioner. For efficiency reasons, steps are computed inexactly. We discuss criteria for the required accuracy and present the numerical performance of the overall method.

2 - Optimal Control under Uncertainty: Adaptive Solution with Low-rank Tensors

Speaker: Sebastian Garreis, Technical University of Munich, DE, talk 1062

Co-Authors: *Michael Ulbrich*,

In this talk, an adaptive, inexact optimization method for solving PDE-constrained optimal control problems under uncertainty with control constraints is presented. The considered class of semilinear, elliptic PDEs is formulated in a suitable tensor Banach space and is discretized by a stochastic Galerkin scheme with a full tensor product basis. To avoid the curse of dimensionality the respective tensor coefficients are represented in a low-rank format (Tensor Train or Hierarchical Tucker). Thus, the developed methods are tailored to the usage of low-rank tensor arithmetics, which only offer a limited set of operations and require truncation (rounding) in between to avoid infeasible rank growth. A trust-region framework is used to control all occurring errors in order to achieve global convergence of the algorithm. In particular, an a posteriori error estimation technique allows to control and balance the discretization error contributions and the error caused by the low-rank tensor solver in the forward and adjoint PDE solves. Numerical results show how the algorithm adapts to the problem data.

3 - On the optimal control of quasi-variational inequalities

Speaker: Carlos Rautenberg, HU Berlin - WIAS, DE, talk 980

Co-Authors: *Amal Alphonse*, *Michael Hintermüller*,

A novel class of optimal control problems for elliptic quasi-variational inequalities (QVIs) is considered. Such problems arise in diverse applications involving compliant obstacles and the main goal here is to control the solution set of the QVI. In particular, we develop stability results of the solution set and establish well-posedness of the optimization problems. Additionally, we consider appropriate directional differentiability concepts in this multivalued solution case, and further characterize the directional derivatives. We finalize the talk with a range numerical tests.

4 - Inexact bundle methods for nonconvex problems in Hilbert space with applications

Speaker: Michael Ulbrich, Technical University of Munich, DE, talk 1265

Co-Authors: *Lukas Hertlein*,

Motivated by optimal control problems for elliptic variational inequalities we develop an inexact bundle method for nonsmooth nonconvex optimization on a closed convex feasible set in a Hilbert space. The proposed method requires only approximate (i.e., inexact) evaluations of the cost function and of an element of Clarke's generalized differential. The algorithm allows for incorporating curvature information and aggregation techniques can be used to ensure that the cutting plane subproblems can be solved efficiently. A global convergence theory in a suitable infinite-dimensional Hilbert space setting is presented. We discuss the application of our framework to optimal control of the obstacle problem and present preliminary numerical results.

Streaming

Discrete Optimization & Integer Programming
APPROX - Tu 8:30am-10:30am, Format: 4x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1
Invited Session 228
Organizer: Michael Kapralov, EPFL, CH

1 - Counting subgraphs in graph streams
Speaker: Eric Price, UT Austin, US, talk 1560
Co-Authors: *John Kallaugher*,
We study the problem of estimating the number of triangles in a graph stream. No streaming algorithm can get sublinear space on all graphs, so methods in this area bound the space in terms of parameters of the input graph such as the maximum number of triangles sharing a single edge. We give a sampling algorithm that is additionally parameterized by the maximum number of triangles sharing a single vertex. Our bound matches the best known turnstile results in all graphs, and gets better performance on simple graphs like $G(n, p)$ or a set of independent triangles. We complement the upper bound with a lower bound showing that no sampling algorithm can do better on those graphs by more than a log factor. In particular, any insertion stream algorithm must use $\sqrt{T}$ space when all the triangles share a common vertex, and any sampling algorithm must take $T^{1/3}$ samples when all the triangles are independent. We also give an "instance-optimal" lower bound that applies to all graph classes, showing our algorithm is optimal up to logarithmic factors.

2 - Sublinear Time Low Rank Approximation of Positive Semidefinite Matrices
Speaker: David Woodruff, CMU, US, talk 1417
We show how to compute a *relative-error* low-rank approximation to any positive semidefinite (PSD) matrix in *sublinear time*, i.e., for any $n \times n$ PSD matrix A, in $\tilde{O}(n \cdot poly(k/\epsilon))$ time we output a rank-k matrix B, in factored form, for which $\|A - B\|_F^2 \leq (1 + \epsilon)\|A - A_k\|_F^2$, where A_k is the best rank-k approximation to A. When k and $1/\epsilon$ are not too large compared to the sparsity of A, our algorithm does not need to read all entries of the matrix. Hence, we significantly improve upon previous $nnz(A)$ time algorithms based on oblivious subspace embeddings, and bypass an $nnz(A)$ time lower bound for general matrices (where $nnz(A)$ denotes the number of non-zero entries in the matrix). We prove time lower bounds for low-rank approximation of PSD matrices, showing that our algorithm is close to optimal. Finally, we extend our techniques to give sublinear time algorithms for low-rank approximation of A in the (often stronger) spectral norm metric norm(A-B) square and for ridge regression on PSD matrices. Based on joint work with Cameron Musco

3 - Estimating Graph Parameters from Random Order Streams
Speaker: Pan Peng, The University of Sheffield, GB, talk 1247
Co-Authors: *Christian Sohler*,
We develop a new algorithmic technique that allows to transfer some constant time approximation algorithms for general graphs into random order streaming algorithms. We illustrate our technique by showing that in random order streams, one can approximate the number of connected components of the input graph G with an additive error of ϵn; $(1+\epsilon)$-approximate the weight of the minimum spanning tree of an input graph with bounded maximum edge weight; and $(1+\epsilon)$-approximate the size of a maximum independent set in planar graphs, with constant space complexity that only depends on ϵ and is independent of the size of the input graph.

4 - $(1 + \Omega(1))$-Approximation to MAX-CUT Requires Linear Space
Speaker: Michael Kapralov, EPFL, CH, talk 1496
Co-Authors: *Sanjeev Khanna*, *Madhu Sudan*, *Ameya Velingker*,
We consider the problem of estimating the value of MAX-CUT in a graph in the streaming model of computation. We show that there exists a constant $\epsilon_* > 0$ such that any randomized streaming algorithm that computes a $(1 + \epsilon_*)$-approximation to MAX-CUT requires $\Omega(n)$ space on an n vertex graph. By contrast, there are algorithms that produce a $(1 + \epsilon)$-approximation in space $O(n/\epsilon^2)$ for every $\epsilon > 0$. Our result is the first linear space lower bound for the task of approximating the max cut value and partially answers an open question from the literature. The prior state of the art ruled out $(2 - \epsilon)$-approximation in $\tilde{O}(\sqrt{n})$ space or $(1 + \epsilon)$-approximation in $n^{1-O(\epsilon)}$ space, for any $\epsilon > 0$. We achieve the result by a delicate choice of distributions on instances as well as a novel use of the convolution theorem from Fourier analysis combined with graph-theoretic considerations to analyze the communication complexity.

Addressing problems with complex geometries

Continuous Optimization
NonSmooth - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 8 Building: N, 4th floor, Zone: 12
Invited Session 229
Organizer: Edouard Pauwels, Université Toulouse 3, FR

1 - Sensitivity analysis for mirror-stratifiable convex functions
Speaker: Jerome Malick, CNRS, FR, talk 562
The class of mirror-stratifiable convex functions encompasses all regularizers routinely used in signal processing and machine learning, including l1-norm and nuclear norm for instance. The strong geometric structure of these functions leads to a simple but powerful sensitivity theory, allowing us to study stability of solutions of optimization problems to small perturbations, as well as and activity identification of first-order proximal algorithms. In contrast with existing results, our results do not require any non-degeneracy conditions and can thus be applied to ill-posed inverse problems. Joint work with Jalal Fadili and Gabriel Peyré.

2 - An accelerated proximal method for minimizing compositions of convex functions
Speaker: Courtney Paquette, Lehigh University, US, talk 903
Co-Authors: *Dmitriy Drusvyatskiy*, *Damek Davis*,
I will describe an accelerated algorithm for minimizing compositions of finite-valued convex functions with smooth mappings. When applied to optimization problems having an additive composite form, the algorithm reduces to the method of Ghadimi and Lan. The method both realizes the best known complexity bound in optimality conditions for nonconvex problems with bounded domain, and achieves an accelerated rate under standard convexity assumptions. A natural convexity parameter of the composition quantifies the transition between the two modes of convergence. I will illustrate our techniques on real phase retrieval and covariance estimation problems. I end by analyzing the effect of inexact proximal subproblem solves on global performance – an essential feature of the composite setting – and compare the resulting scheme with algorithms based on smoothing.

3 - How to perturb semi-algebraic problems to ensure constraint qualification?
Speaker: Antoine Hochart, Universidad Adolfo Ibáñez, CL, talk 554
Co-Authors: *Jerome Bolte*, *Edouard Pauwels*,
In this talk, we consider inequality constraint sets defined by a finite family of semi-algebraic/definable functions and we study constraint qualification for perturbations of this set. We show that uniform perturbations by adding a positive constant ϵ to the right-hand side of the constraints ensure that any point within the feasible set satisfies Mangasarian-Fromovitz constraint qualification (MFCQ). This striking result can be seen as a reinforced Sard's theorem, and provides a simple protocol to build sequences of "regular" problems approximating arbitrary semi-algebraic/definable problems. In a second step, we discuss the case of singular perturbations, for which there is a failure of MFCQ at some point in the feasible set. When the constraints are polynomial functions, we provide a bound on the number of singularities by using the Milnor-Thom theorem. Examples show that the order of magnitude of our exponential bound is relevant. Possible extensions are discussed.

4 - The multiproximal linearization method for convex composite problems
Speaker: Edouard Pauwels, Université Toulouse 3, FR, talk 142
Co-Authors: *Jerome Bolte*, *Zheng Zheng Chen*,
Composite minimization involves a collection of smooth functions which are aggregated in a nonsmooth manner. In the convex setting, we design an algorithm by linearizing each smooth component in accordance with its main curvature. The resulting method, called the Multiprox method, consists in solving successively simple problems (e.g. constrained quadratic problems) which can also feature some proximal operators. To study the complexity and the convergence of this method we are led to prove a new type of qualification condition and to understand the impact of multipliers on the complexity bounds. We obtain explicit complexity results of the form O(1/k) involving new types of constant terms. A distinctive feature of our approach is to be able to cope with oracles featuring moving constraints. Our method is flexible enough to include the moving balls method, the proximal Gauss-Newton's method, or the forward-backward splitting, for which we recover known complexity results or establish new ones. We show through several numerical experiments how the use of multiple proximal terms can be decisive for problems with complex geometries.

MIP under Uncertainty 1

Discrete Optimization & Integer Programming
IPtheory - Tu 9:00am-10:30am, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 231
Organizer: Fatma Kilinc-Karzan, Carnegie Mellon University, US

1 - Distributionally Robust Combinatorial Optimization
Speaker: Shabbir Ahmed, Georgia Tech, US, talk 1562
Co-Authors: *Ruiwei Jiang*, *Mohit Singh*,
We study distributionally robust analogs of combinatorial optimization problem with uncertain objective coefficients. We provide equivalent deterministic reformulations of such problems under several types of ambiguity sets, and discuss corresponding solution approaches.

2 - Risk-Averse Set Covering Problems
Speaker: Simge Kucukyavuz, University of Washington, US, talk 927
Co-Authors: *Hao-Hsiang Wu*,
We consider probabilistic set covering problems with two risk models: value-at-risk and conditional value-at-risk. Suppose that we have an oracle that computes the risk efficiently for a given solution. Using this oracle, we propose a method for solving the risk-averse set covering problems exactly. We also give compact mixed-integer programming formulations for a special case. We give valid inequalities that strengthen the formulations. We report our computational experience with the proposed methods on a probabilistic set covering problem that admits an efficient risk oracle.

3 - Mixed-Integer Recourse via Prioritization
Speaker: Ruiwei Jiang, University of Michigan, US, talk 1189
Co-Authors: *Yuanyuan Guo*,
Based on the expansion planning problem in electricity transmission systems, we study adaptive stochastic and robust optimization models with mixed-integer recourse. Using the concept of prioritization, we obtain conservative approximations of such models that are more computationally effective and facilitate decomposition algorithms. We report and discuss numerical case studies.

LP, Mixed Integer Convex Programming and Decomposition

Specific Models, Algorithms, and Software
Algo - Tu 8:30am-10:30am, Format: 4x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 236
Organizer: Thorsten Koch, ZIB and TU Berlin, DE

1 - Optimising over Gradient-Boosted Regression Trees with Convex Penalty Functions

Speaker: Miten Mistry, Imperial College London, GB, talk 643
Co-Authors: *Ruth Misener*, *Robert Lee*, *Dimitrios Letsios*, *Gerhard Krennrich*,
Machine-learned decision trees can effectively represent the sparse, high-dimensional and noisy nature of data from experiments. Incorporating these machine-learned, discrete functions into an optimisation problem is difficult. Furthermore, due to costly experiments, we may mistrust the learned function in regions lacking training data. We study a large-scale, industrially-relevant mixed-integer convex optimisation problem involving: (i) pre-trained gradient-boosted regression trees (GBTs), (ii) penalty functions maintaining closeness to training points, and (iii) penalties enforcing constraints. We develop a heuristic method leveraging GBT independence properties. We also present a branch-and-bound algorithm that, by relaxing linking constraints, utilises the strength of convex and mixed-integer linear optimisation separately on the penalties and GBTs respectively. To handle the GBTs, we present a bounding method and derive branching priorities that aid bound refinement by fixing discrete variables. We strong branch by leveraging cheap convex solves that induce infeasibility. Numerical tests on Kaggle benchmarks and an industrial instance from BASF show the effectiveness of using our GBT bounding and branch priorities.

2 - An advanced initialization procedure for the simplex algorithm
Speaker: Nikolaos Ploskas, Carnegie Mellon University, US, talk 88
Co-Authors: *Nikolaos Sahinidis*, *Nikolaos Samaras*,
This paper addresses the computation of an initial basis for the simplex algorithm for linear programming. We propose six algorithms for constructing an initial basis that is sparse and will reduce the fill-in and computational effort during LU factorization and updates. The algorithms rely on triangulation and fill-reducing ordering techniques that are applied prior to LU factorization. Over a set of 62 large benchmarks, the best proposed algorithm produces remarkably sparse starting bases, and results in 7 percent and 6 percent average reduction of the execution time of CPLEX's primal and dual simplex algorithm, respectively. We also present results for very large and degenerate linear programming problems for which our best proposed algorithm leads CPLEX's primal and dual simplex algorithm to perform an order of magnitude faster than the CPLEX default crash procedures.

3 - Experiments with a general Benders' decomposition framework for SCIP
Speaker: Stephen Maher, Lancaster University, GB, talk 330
Benders' decomposition is a popular mathematical programming technique that is frequently being implemented within general purpose solvers. These general frameworks provide new opportunities for the development of general enhancements for the Benders' decomposition algorithm. While the enhancement of Benders' decomposition has been a topic of much interest, there has been little progress in the generalisation of these techniques for use within mathematical programming solvers. SCIP has been extended to include a general Benders' decomposition framework in order to exploit the tighter integration with a mathematical programming solver and achieve algorithmic performance improvements. The general Benders' decomposition framework has been used to evaluate the performance gains achieved through improved use of primal heuristics and cut generation techniques. The results demonstrate the benefits from implementing a general Benders' decomposition framework within a state-of-the-art mathematical programming solver.

4 - Progress in the Branch-Price-and-Cut Solver GCG
Speaker: Christian Puchert, RWTH Aachen University, DE, talk 1349
Co-Authors: *Marco Lübbecke*, *Michael Bastubbe*, *Jonas Witt*, *Stephen Maher*,
GCG, an extension to the well-known SCIP, is a solver for mixed-integer linear programs. It implements a Dantzig-Wolfe (or similar) reformulation and a full-featured branch-price-and-cut algorithm. Information on how the reformulation should be performed can be given by the user in various ways. However, GCG can and usually does detect a model structure suited for reformulation all by itself. We report on recent developments that lead to the upcoming release 3.0. This includes a completely re-designed structure detection, new cutting planes, and experimental features like deciding whether a reformulation should be applied at all and a Benders decomposition extension. Moreover, it features a newly designed pricing mechanism. We show computational experiments and some use cases in which we applied GCG.

Matching games and beyond

Discrete Optimization & Integer Programming
COMB - Tu 8:30am-10:30am, Format: 4x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2
Invited Session 241
Organizer: Jochen Koenemann, University of Waterloo, CA

1 - Stabilizing Weighted Graphs
Speaker: Zhuan Khye Koh, University of Waterloo, CA, talk 207
Co-Authors: *Laura Sanità*,
An edge-weighted graph G = (V,E) is called stable if the value of a maximum-weight matching equals the value of a maximum-weight fractional matching. Stable graphs play an important role in some interesting game theory problems, such as network bargaining games and cooperative matching games, because they characterize instances which admit stable outcomes. Motivated by this, in the last few years many researchers have investigated the algorithmic problem of turning a given graph into a stable one, via edge- and vertex-removal operations. However, all the algorithmic results developed in the literature so far only hold for unweighted instances, i.e., assuming unit weights on the edges of G. We give the first polynomial-time algorithm to find a minimum cardinality subset of vertices whose removal from G yields a stable graph, for any weighted graph G. The algorithm is combinatorial and exploits new structural properties of basic fractional matchings, which are of independent interest. In contrast, we show that the problem of finding a minimum cardinality subset of edges whose removal from a weighted graph G yields a stable graph, does not admit any constant-factor approximation algorithm, unless P = NP. In this setting, we develop an $O(\Delta)$-approximation algorithm for the problem, where Δ is the maximum degree of a node in G.

2 - Computing the Nucleolus of Weighted Cooperative Matching Games in Poly Time

Speaker: Justin Toth, University of Waterloo, CA, talk 135
Co-Authors: *Jochen Koenemann*, *Kanstantsin Pashkovich*,
The nucleolus is an important solution concept in cooperative game theory, and matching games are a fundamental class of cooperative games on graphs. In such games, the value of a coalition of nodes (players) is determined by solving a maximum weight matching problem on the corresponding induced subgraph. We provide an efficient algorithm for computing the nucleolus for an instance of a weighted cooperative matching game. This resolves a long-standing open question of [Kern and Paulusma, Mathematics of Operations Research, 2003]

3 - New and simple algorithms for stable flow problems
Speaker: Jannik Matuschke, Technische Universität München, DE, talk 1493
Co-Authors: *Agnes Cseh*,
Stable flows generalize the well-known concept of stable matchings to markets in which transactions may involve several agents, forwarding flow from one to another. An instance of the problem consists of a capacitated network, in which vertices express their preferences over their incident edges. A flow is stable if there is no group of vertices that all could benefit from rerouting the flow along a walk. Fleiner established existence of stable flows in any network via reduction to the stable allocation problem. We present an augmenting-path algorithm for computing a stable flow, the first algorithm that achieves polynomial running time for this problem without using stable allocation as a black-box subroutine. We further consider the problem of finding a stable flow such that the flow value on every edge is within a given interval. For this problem, we present an elegant graph transformation that leads to a simple and fast algorithm and that can also be used to find a solution to the stable marriage problem with forced and forbidden edges. Finally, we also present simplifications and hardness results for the stable multicommodity flow model introduced by Király and Pap.

4 - The complexity of cake cutting with unequal shares
Speaker: Agnes Cseh, Hungarian Academy of Sciences, HU, talk 217
Co-Authors: *Tamás Fleiner*,
We investigate the problem of proportional cake cutting with unequal shares. In this setting, each player is entitled to receive a predetermined portion of the cake. The efficiency of a protocol is measured by the number of queries asked from players. Our contribution is twofold. First we present a protocol that delivers a proportional solution in less queries than all known algorithms. We then show that our protocol is the fastest possible by giving an asymptotically matching lower bound.

Equilibrium Computation in Congestion Games

Discrete Optimization & Integer Programming
COMB - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 41 Building: C, 3rd floor, Zone: 1

Invited Session 242
Organizer: Umang Bhaskar, TIFR, IN

1 - Multiplicative Weights Update with Constant Step-Size in Congestion Games
Speaker: Ioannis Panageas, MIT, US, talk 675
Co-Authors: *Gerasimos Palaiopanos*, *Georgios Piliouras*,
The Multiplicative Weights Update (MWU) method is a ubiquitous meta-algorithm that works as follows: A distribution is maintained on a certain set, and at each step the probability assigned to action γ is multiplied by $(1 - \epsilon C(\gamma)) > 0$ where $C(\gamma)$ is the "cost" of action γ and then rescaled to ensure that the new values form a distribution. We analyze MWU in congestion games where agents use arbitrary admissible constants as learning rates ϵ and prove convergence to exact Nash equilibria. Interestingly, this convergence result does not carry over to the nearly homologous MWU variant where at each step the probability assigned to action γ is multiplied by $(1 - \epsilon)^{C(\gamma)}$ even for the simplest case of two-agent, two-strategy load balancing games, where such dynamics can provably lead to limit cycles or even chaotic behavior.

2 - Equilibrium Computation in Resource Allocation Games
Speaker: Tobias Harks, Augsburg University, DE, talk 948
Co-Authors: *Veerle Timmermans*,
We study the equilibrium computation problem for two classical resource allocation games: atomic splittable congestion games and multimarket Cournot oligopolies. Our main result is a new combinatorial polynomial time algorithm computing an exact equilibrium for such games with affine cost cost/price functions.

3 - Computing Efficient Nash Equilibria in Congestion Games
Speaker: Guido Schäfer, CWI, NL, talk 773
Co-Authors: *Pieter Kleer*,
Congestion games constitute an important class of games which capture many applications in network routing, resource allocation and scheduling. In a seminal paper, Rosenthal (1973) established the existence of pure Nash equilibria in congestion games by exhibiting an exact potential function whose local minima coincide with the set of pure Nash equilibria of the game. This correspondence has helped to shed light on several important aspects of congestion games; in particular, it is exploited crucially to show that finding pure Nash equilibria is a computationally hard problem in general. We investigate structural properties which allow us to efficiently compute global minima of Rosenthal's potential function. To this aim, we use a polyhedral description to represent the strategy sets of the players and identify two general properties which are sufficient for our results to go through. In addition, we show that the resulting Nash equilibria provide attractive social cost approximation guarantees. Our contributions thus provide an efficient equilibrium selection algorithm which computes an approximately optimal Nash equilibrium for a large class of polytopal congestion games.

4 - Equilibrium Computation in Atomic Splittable Routing Games with Convex Costs
Speaker: Umang Bhaskar, TIFR, IN, talk 944
Co-Authors: *Phani Lolakapuri*,
We present polynomial-time algorithms as well as hardness results for equilibrium computation in atomic splittable routing games with convex cost functions. These games model traffic in freight transportation, market oligopolies, data networks, and various other applications. An atomic splittable routing game is played on a network where the edges have traffic-dependent cost functions, and player strategies correspond to flows in the network. A player can thus split it's

traffic arbitrarily among different paths. While many properties of equilibria in these games have been studied, efficient algorithms for equilibrium computation are known for only two cases: if cost functions are affine, or if players are symmetric. Neither of these conditions is met in most practical applications. We present two algorithms for routing games with general convex cost functions on parallel links. The first algorithm is exponential in the number of players, while the second is exponential in the number of edges; thus if either of these is small, we get a polynomial-time algorithm. These are the first algorithms for these games with convex cost functions. We further give evidence that in general networks equilibrium computation may be hard, showing that given input C it is NP-hard to decide if there exists an equilibrium where every player has cost at most C.

Risk-averse stochastic programming

Optimization under Uncertainty
Stoch - Tu 8:30am-10:30am, Format: 4x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 252
Organizer: Andrzej Ruszczynski, Rutgers University, US

1 - Asymptotics of stochastic optimization problems with composite risk functionals
Speaker: Darinka Dentcheva, Stevens Institute of Technolog, US, talk 600
Co-Authors: *Andrzej Ruszczynski*, *Gregory Stock*,
We discuss composite risk functionals and their statistical estimation. The analysis is motivated by measures of risk, however, the structure of a composite functional is very general. We analyse the asymptotic behavior of the optimal value and the optimal solutions of stochastic optimization problems involving such composite risk functionals. Specific application illustrate the results.

2 - Multi-objective risk-averse two-stage stochastic programming problems
Speaker: Ozlem Cavus, Bilkent University, TR, talk 148
Co-Authors: *Cagin Ararat*, *Irfan Mahmutogullari*,
We consider a multi-objective risk-averse two-stage stochastic programming problem with a multivariate convex risk measure. We suggest a convex vector optimization formulation with set-valued constraints and propose an extended version of Benson's algorithm to solve this problem. Using Lagrangian duality, we develop scenario-wise decomposition methods to solve the two scalarization problems appearing in Benson's algorithm. Then, we propose a procedure to recover the primal solutions of these scalarization problems from the solutions of their Lagrangian dual problems. Finally, we test our algorithms on a multi-asset portfolio optimization problem under transaction costs.

3 - Distributionally robust stochastic programming
Speaker: Alexander Shapiro, Ga Tech Institution, US, talk 1677
In this talk we address various approaches to formulations of distributionally robust stochastic programs. We consider a relation to risk averse stochastic optimization and extensions to a multistage setting. In particular we discuss a question of time consistency and its relation to an interchangeability principle.

4 - Risk Disintegration with Application to Partially Observable Systems
Speaker: Andrzej Ruszczynski, Rutgers University, US, talk 249
Co-Authors: *Darinka Dentcheva*,
We introduce the concept of a risk form, which is a real functional on the product of two spaces: the space of measurable functions and the space of measures. We generalize the Kusuoka representation to this setting. Then we prove a risk disintegration formula and apply the theory to two-stage stochastic programming problems with partial information and decision-dependent observation distribution.

Approximation Algorithms for Clustering

Discrete Optimization & Integer Programming
APPROX - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4

Invited Session 256
Organizer: Chaitanya Swamy, University of Waterloo, CA

1 - Better Guarantees for k-Means Problem using Primal-Dual Algorithms
Speaker: Sara Ahmadian, University of Waterloo, CA, talk 1515
Co-Authors: *Ola Svensson*, *Ashkan Norouzi Fard*, *Justin Ward*,
Clustering is a classic topic in optimization with k-means being one of the most fundamental such problems. For more than a decade the best-known approximation algorithm for this classical problem was a $9+\epsilon$ approximation algorithm based on a simple local search which was known to be tight. In this talk, I will present our improved approximation algorithm for the k-means problem. First, I will present the algorithm which is based on primal-dual approach inspired by the famous Jain-Vazirani algorithm for k-median. Then, I will present the high-level idea behind the improved analysis and show how to exploit the geometric structure of k-means and (2) satisfy the hard constraint on the number of clusters without deteriorating the approximation guarantee. This result is a 6.357-approximation algorithm with respect to the standard LP relaxation.

2 - On the Local Structure of Stable Clustering Instances
Speaker: Chris Schwiegelshohn, Sapienza, University of Rome, IT, talk 1325
Co-Authors: *Vincent Cohen-Addad*,
As an optimization problem, clustering exhibits a striking phenomenon: It is generally regarded as easy in practice, while theory classifies it among the computationally intractable problems. To address this dichotomy, research has identified a number of conditions a data set must satisfy for a clustering to be (1) easily computable and (2) meaningful. In this talk we show that all previously proposed notions of struturedness of a data set are fundamentally local properties, i.e. the global optimum is in well defined sense close to a local optimum. As a corollary, this implies that the Local Search heuristic has strong performance guarantees for both the tasks of recovering the underlying optimal clustering and obtaining a clustering of small cost.

3 - Approximation Bounds for Hierarchical Clustering
Speaker: Benjamin Moseley, Carnegie Mellon University, US, talk 1648
Co-Authors: *Joshua Wang*,
Hierarchical clustering is a data analysis method that has been used for decades. Despite its widespread use, the method has an underdeveloped analytical foundation. Having a well understood foundation would both support the currently used methods and help guide future improvements. This talk gives an analytic framework to better understand observations seen in practice. This talk considers the dual of a problem framework for hierarchical clustering introduced by Dasgupta [Dasgupta STOC 2016]. The main result is that one of the most popular algorithms used in practice, average linkage agglomerative clustering, has a small constant approximation ratio for this objective. This talk gives some of the first work to establish guarantees on widely used hierarchical algorithms for a natural objective function. This objective and analysis give insight into what popular algorithms are optimizing and when they will perform well. This work was presented at NIPS 2017.

4 - Unifying k-Median and k-Center: Approximation Algorithms for Ordered k-Median
Speaker: Chaitanya Swamy, University of Waterloo, CA, talk 1364
Co-Authors: *Deeparnab Chakrabarty*,
We consider a generalization of k-median and k-center, called the ordered k-median problem. In this problem, we are given a metric space $(D, \{c_{ij}\})$ with $n = |D|$ points, and a non-increasing, nonnegative weight vector w, and the goal is to open k centers and assign each point each point $j \in D$ to a center so as to minimize $w_1 \cdot$(largest assignment cost) + $w_2 \cdot$(second-largest assignment cost) + $\ldots$ + $w_n \cdot$(n-th largest assignment cost). We give an $(18 + \epsilon)$-approximation algorithm for this problem. For the special case of $\{0, 1\}$-weights, which models the problem of minimizing the *ell* largest assignment costs that is interesting in and of by itself, we devise two algorithms. We devise a $(12 + \epsilon)$-approximation algorithm based on Lagrangian relaxation and the primal-dual schema, which extends easily to the general weighted-setting; when combined with an enumeration procedure, this yields our 18-approximation for general weights. Second, we provide a novel reduction to the (standard) k-median problem, showing that LP-relative guarantees for k-median translate to guarantees for the ordered k-median problem; this yields a simple $(8.5 + \epsilon)$-approximation algorithm for $\{0, 1\}$ weights. Our algorithms are derived using a novel LP-relaxation that we propose for the problem, which leverages a key insight to circumvent the issue that the natural LP-relaxation has large integrality gap. These constitute the first constant-factor approximation guarantees for ordered k-median, for both $\{0, 1\}$- and general-weights.

Graphical Optimization Model 1
Discrete Optimization & Integer Programming
CP - Tu 8:30am-10:30am, Format: 4x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1
Invited Session 295
Organizer: Joris Kinable, Eindhoven University, NL

1 - On the integrated last mile transportation problem
Speaker: David Bergman, University of Connecticut, US, talk 920
Co-Authors: *Arvind Raghunathan*, *John Hooker*, *Shingo Kobori*, *Thiago Serra*,
In this talk, we introduce the problem of scheduling passengers jointly on mass transportation and last-mile transportation services, where passengers share a car, van, or autonomous pod of limited capacity in the last mile portion of their trips. The problem we study balances minimizing travel time and the number of trips taken by the last-mile vehicles. We show how a restricted version of the problem remains NP-hard, and devise a decision diagram-based decomposition model that is used to solve instances orders-of-magnitude faster than other methods appearing in the literature.

2 - Cut Generation for Integer (Non-)Linear Programming via Decision Diagrams
Speaker: Willem-Jan van Hoeve, Carnegie Mellon University, US, talk 1317
Co-Authors: *Christian Tjandraatmadja*, *Danial Davarnia*,
In recent years, decision diagrams (DDs) have successfully been applied to represent and solve discrete optimization problems. In this talk we discuss how DDs can be used to generate valid inequalities for integer programming problems. For a given integer program, we first construct a relaxed DD that represents an over-approximation of the solution space. We then define a cut-generating linear program to separate a given point that does not belong to the interior of the convex hull defined by the DD solutions. We first apply our DD-generated cuts to improve the root node bound of integer linear programs. Then we extend our approach to an outer approximation framework for separable integer non-linear programming. Computational experiments show substantial optimality gap improvement over traditional cutting plane methods.

3 - Hybrid Optimization Methods for Time-Dependent Sequencing Problems
Speaker: Joris Kinable, Eindhoven University, NL, talk 1161
Co-Authors: *Andre Cire*, *Willem-Jan van Hoeve*,
In the class of Time-Dependent Sequencing problems, the setup time between a pair of activities depends on the order in which the activities are scheduled or, when treated from a routing perspective, the travel time between a pair of cities depends on the order the cities are visited. Often, real-world scheduling problems exhibit a large number of side constraints such as precedence relations, time windows or time-lags between the activities. Developing dedicated solution procedures for each of these variants is both notoriously hard, and time consuming. Generic solution approaches on the other hand, purely based on for example Mixed Integer (MIP) or Constraint Programming (CP) cannot deal with these problems efficiently. We propose a generic CP solution approach strengthened with both continuous and discrete relaxations to solve Time-Dependent Sequencing problems. Experimental results indicate significant performance improvements over dedicated MIP or CP approaches.

4 - Compact Representation of Near-Optimal Integer Programming Solutions
Speaker: John Hooker, Carnegie Mellon Univ, US, talk 763
Co-Authors: *Thiago Serra*,
It is often useful in practice to explore near-optimal solutions of an integer programming problem. We show how all solutions within a given tolerance of the optimal value can be

efficiently and compactly represented in a weighted decision diagram, once the optimal value is known. The structure of the decision diagram facilitates rapid processing of a wide range of queries about the near-optimal solution space. We describe a "sound reduction" operation that, when applied repeatedly in any order, yields a smallest possible diagram that is suitable for storing all near-optimal solutions for a given problem instance.

Algorithmic Game Theory I

Optimization under Uncertainty
Game - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 30 Building: B, Ground Floor, Zone: 5
Invited Session 311
Organizer: Luce Brotcorne, inria, FR

1 - Solving Strong Stackelberg Equilibrium in Stochastic Games
Speaker: Victor Bucarey, Universidad de Chile, CL, talk 1611
Co-Authors: *Fernando Ordoñez*, *Alain Jean-Marie*, *Eugenio Della Vecchia*,
In this work we face the problem of computing a strong Stackelberg equilibrium (SSE) in a stochastic game (SG). Given a set of states we model a two player perfect information dynamic where one of them, called Leaderc or player A, observes the current state and decides, possible up to probability distribution f, between a set of available actions. Then other player, called Follower or player B, observes the strategy of player A and plays his best response noted by g. We show that Value Iteration and Policy Iteration algorithms converges to stationary policies that form the unique SSE for a family of games where the value functions for the follower does not play any role in the best response functional. We called to this type of games Myopic Follower Strategy games. Two important cases are when the discount factor for the follower is equal to zero, or the transition probabilities between states do not depend on the follower actions. We show via counterexample Dynamic Programming algorithms not always converge to an algorithm. In this counterexample we show that there are multiple equilibrium. Finally, we study security games, where a defender and an attacker choose where to protect some targets and which target to attack respectively. Payoff matrices in every state depend only if the targets are protected or not. Computationally we show that for this type of games Value Iteration and Policy Iteration procedures converge always to a SSE.

2 - Models for the single-minded bundle pricing problem
Speaker: Fränk Plein, Université Libre de Bruxelles, BE, talk 515
Co-Authors: *Sourour Elloumi*, *Martine Labbé*,
We develop mathematical formulations for a problem in product pricing called single-minded bundle pricing problem (SMBPP). Each client is represented by a subset of products (bundle) and the maximum price he is willing to pay (budget). The total bundle price is obtained by summing the prices of the individual products. The client is single-minded in the sense that he buys his bundle if and only if the total bundle price is no higher than his budget. Assuming that the supply for each product is unlimited, the objective is to maximise the total profit obtained from selling the bundles to the clients. We first present a very intuitive mixed-integer non-linear program (MINLP) using non-negative price variables and binary buying decisions. Introducing additional variables for the revenue obtained from each client, we apply two different linearisations in order to obtain mixed-integer linear programs (MILP). We conduct a polyhedral study of their feasible domains and establish a hierarchy between both models. Furthermore, we use an RLT-like approach applied to the initial MINLP to derive valid inequalities. After linearisation, these inequalities combined with the previously strongest formulation lead to an extended MILP which significantly improves the linear relaxation gap. We support our theoretical results with computational experiments. On a set of generated instances, we compare the performance of the MILP with respect to their linear relaxation gap and computation time.

3 - Branch-and-cut algorithm for the Rank Pricing problem
Speaker: Concepcion Dominguez, Inria, FR, talk 1643
Co-Authors: *Martine Labbé*, *Alfredo Marín*, *Carmen Galé*, *Herminia Calvete*,
Pricing optimization problems aim at determining the prices of a series of products in order to maximize the revenue of a company. These problems have a hierarchical structure with a first optimization problem given by the company, which aims at maximizing its profit, and a subset of the constraints that force the solution to be optimal to another optimization problem, which is minimizing the customers' purchasing cost, hence they are bilevel problems. In our problem, customers are interested in several products and they intend to purchase at most one of them according to a selection rule. These are known as unit-demand customers, and their purchase decision is modelled by means of a budget, since they will only buy a product provided that they can afford it. The Rank Pricing Problem arises when the selection rule of the customers depends on their preferences, that is, when customers rank the items and purchase the highest-ranked one which fits their budget. The Rank Pricing problem is introduced as a bilevel problem, and an analysis of its properties leads us to develop two mixed-integer single level formulations to tackle it. Valid inequalities are proposed taking advantage of the fact that a subset of its constraints constitutes a special case of the Set Packing Problem, and others are presented as a result of an analysis of its structure. A computational study is also included.

4 - A matheuristic for the bilevel 0-1 public-private partnership problem
Speaker: Yury Kochetov, Institute of Mathematics, RU, talk 499
Co-Authors: *Alexander Zyryanov*, *Sergey Lavlinskii*,
We present a new bi-level linear integer programming model for the strategic planning of the public-private partnership. In this model, we need to select and schedule some ecological, infrastructure, and production projects within a finite planning horizon. Two players, the leader (government) and the follower (private companies) make own decisions sequentially under the budget constraints. The players try to maximize own total profits. We claim that this bi-level problem is Σ_2^p-hard in cooperative and non-cooperative cases. To find near-optimal solution, we design a stochastic tabu search metaheuristic according to the upper level variables. The optimal solution for the lower level is obtained by CPLEX software. To reduce the running time, we use randomized

flip and move neighborhoods. To evaluate the neighboring solutions, we solve the lower level problem approximately. Computational results for real world instances for the Transbaikalian polymetal fields and comparison with a matheuristic based on the high point reformulation are discussed.

Optimization in Statistical Learning

Specific Models, Algorithms, and Software
Learning - Tu 8:30am-10:30am, Format: 4x30 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 326
Organizer: Quentin Berthet, University of Cambridge, GB

1 - Near-linear time approximation algorithms for optimal transport
Speaker: Jonathan Weed, MIT, US, talk 1602
Co-Authors: *Jason Altschuler*, *Philippe Rigollet*,
Computing optimal transport distances is a fundamental problem in machine learning, statistics, and computer vision. Large-scale computation of these distances requires extremely fast, practical algorithms with rigorous guarantees. In this work, we establish that this task can be accomplished in near-linear time by a simple iterative algorithm. This algorithm is based on entropic regularization, which also improves the problem's statistical stability.

2 - Sharp Oracle Inequalities for nonconvex regularized M-estimators
Speaker: Andreas Elsener, ETH Zurich, CH, talk 1561
Co-Authors: *Sara van de Geer*,
Many methods in statistics and machine learning rely on nonconvex loss functions. Due to the high-dimensional nature of the data one often adds a (norm) penalty to the empirical loss. As a matter of fact, it is mostly not possible to compute the global optimum of these functions. Algorithms such as (coordinate) gradient descent and its variants are guaranteed to output stationary points. Theoretical understanding of the statistical properties of these points is therefore indispensable. We present a general framework to derive sharp oracle inequalities for stationary points of regularized empirical risk minimization. The general framework is applied to sparse Principal Component Analysis, sparse errors-in-variables and robust regression.

3 - Sharpness, Restart and Compressed Sensing Performance
Speaker: Alexandre d Aspremont, CNRS - ENS, FR, talk 590
Co-Authors: *Vincent Roulet*, *Nicolas Boumal*,
We show that several classical quantities controlling compressed sensing performance directly match parameters controlling algorithmic complexity. We first describe linearly convergent restart schemes on first-order methods using a sharpness assumption. The Lojasievicz inequality shows that sharpness bounds on the minimum of convex optimization problems hold almost generically. Here, we show that sharpness directly controls the performance of restart schemes. For sparse recovery problems, sharpness at the optimum can be written as a condition number, given by the ratio between true signal sparsity and the largest signal size that can be recovered by the observation matrix. Overall, this means that in compressed sensing problems, a single parameter directly controls both computational complexity and recovery performance.

4 - Towards a deeper understanding of generalization for kernel learning
Speaker: Fan Yang, UC Berkeley, US, talk 1597
Co-Authors: *Martin Wainwright*, *Yuting Wei*, *Raaz Dwivedi*,
Regularization is a standard method in machine learning to prevent overfitting by explicitly or implicitly limiting the size of the underlying function space. Based on empirical observations, recent work however has questioned the common understanding in learning theory which correlates the ability to generalize with the expressivity of the function space. In this talk we focus on Reproducing Kernel Hilbert Spaces (RKHS) and explore the relation between overfitting and two crucial quantities (both characterizing the RKHS) in more depth: the Hilbert norm of the resulting estimators and localized Gaussian complexities. We show how these quantities, now standard in the analysis of penalized estimators, can be used to prove optimal statistical convergence results for algorithmic regularization such as early stopping of boosting and related gradient-type algorithms. Using the new insights, optimal stopping rules can be obtained for a broad class of loss functions (including L2-boost, LogitBoost and AdaBoost, among others).

Statistics meets optimization: going beyond convexity

Specific Models, Algorithms, and Software
Learning - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 337
Organizer: John Duchi, Stanford University, US

1 - Learning ReLUs and over-parameterized neural networks via gradient descent
Speaker: Mahdi Soltanolkotabi, USC, US, talk 1580
Many problems of contemporary interest in signal processing and machine learning involve highly nonconvex optimization problems. While nonconvex problems are known to be intractable in general, simple local search heuristics such as (stochastic) gradient descent are often surprisingly effective at finding global optima on real or randomly generated data. In this talk, I will discuss some results explaining the success of these heuristics. I will discuss results regarding learning the optimal weights of the shallowest of neural networks consisting of a single Rectified Linear Unit (ReLU). I will discuss this problem in the high-dimensional regime where the number of observations are fewer than the ReLU weights. I will show that projected gradient descent on a natural least-squares objective, when initialized at zero, converges at a linear rate to globally optimal weights with a number of samples that is optimal up to numerical constants. I will then discuss how this result can be generalized to over-parameterized one-hidden layer neural networks.

2 - When are nonconvex optimization problems not scary?
Speaker: Ju Sun, Stanford University, US, talk 953
Co-Authors: *Qing Qu*, *John Wright*, *Yu Bai*, *David Barmherzig*, *Emmanuel Candes*,

Many problems arising from applications can be naturally formulated as optimization problems, most nonconvex. For nonconvex problems, obtaining a local minimizer is computationally hard in theory, never mind the global minimizer. In practice, however, simple numerical methods often work surprisingly well in finding high-quality solutions for specific problems. In this talk, I will describe our recent effort in bridging the mysterious theory-practice gap for nonconvex optimization. I will highlight a family of nonconvex problems that can be solved to global optimality using simple numerical methods, independent of initialization. This family has the characteristic global structure that (1) all local minimizers are global, and (2) all saddle points have directional negative curvatures. Problems lying in this family cover various applications across machine learning, signal processing, scientific imaging, and more. I will focus on two examples we worked out: learning sparsifying bases for massive data and recovery of complex signals from phaseless measurements. In both examples, benign global structures allow us to derive geometric insights and computational results that are inaccessible from previous methods. In contrast, alternative approaches to solving nonconvex problems often entail either expensive convex relaxation (e.g., solving large-scale semidefinite programs) or delicate problem-specific initializations. Toward the end, I will discuss open problems to be tackled to enrich and complete this framework.

3 - Solving composite optimization problems, with applications to phase retrieval an
Speaker: John Duchi, Stanford University, US, talk 1157
Co-Authors: *Feng Ruan*,
We consider minimization of stochastic functionals that are compositions of a (potentially) non-smooth convex function h and smooth function c. We develop two stochastic methods–a stochastic prox-linear algorithm and a stochastic (generalized) sub-gradient procedure–and prove that, under mild technical conditions, each converges to first-order stationary points of the stochastic objective. Additionally, we analyze this problem class in the context of phase retrieval and other nonlinear modeling problems, showing that we can solve these problems (even with faulty measurements) with extremely high probability under appropriate random measurement models. We provide substantial experiments investigating our methods, indicating the practical effectiveness of the procedures.

4 - Optimal iterative thresholding algorithms for sparse optimization
Speaker: Rina Barber, University of Chicago, US, talk 1644
Co-Authors: *Haoyang Liu*,
Iterative thresholding algorithms seek to optimize a differentiable objective function over a sparsity or rank constraint by alternating between gradient steps, and thresholding steps that enforce the constraint. This work examines the choice of the thresholding operator, and asks whether it is possible to achieve stronger guarantees than what is possible with hard thresholding. We develop the notion of relative concavity of a thresholding operator, a quantity that characterize the convergence performance of any thresholding operator on the target optimization problem. This framework motivates the construction of a new method, the reciprocal thresholding operator, that is better able to escape from local minima without introducing too much shrinkage bias.

Interval Global Optimization

Specific Models, Algorithms, and Software Sciences - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 339
Organizer: Frederic Messine, LAPLACE-ENSEEIHT-INPT, FR

1 - Nonlinear Symbolic Transformations for Simplifying Functions – Interval Methods
Speaker: Tibor Csendes, University of Szeged, HU, talk 1420
Co-Authors: *Elvira Antal*,
For interval arithmetic based reliable computation the expression of the function to be optimized can be critical. We have an automatic algorithm based on symbolic calculation to simplify nonlinear functions. The talk will give detailed results on the effect of this presolving technique on the efficiency of an interval arithmetic based branch-and-bound algorithm. Although we still have a long way to go, the first numbers are encouraging.

2 - An Interval Branch and Bound Algorithm for Parameter Estimation
Speaker: Bertrand Neveu, Ecole des Ponts, FR, talk 1454
Co-Authors: *Pascal Monasse*, *Martin de la Gorce*, *Gilles Trombettoni*,
The parameter estimation problem is a challenging problem in engineering sciences consisting in computing the parameters of a parametric model that fit observed data. The system is defined by unknown parameters and sometimes internal constraints. The observed data provide constraints on the parameters. The parameter estimation problem is particularly difficult when some observation constraints correspond to outliers and/or the constraints are non convex. For dealing with outliers, the RANSAC randomized algorithm is efficient, but non deterministic, and must be specialized for every problem. In this work, we propose a generic interval branch and bound algorithm that produces a model maximizing the number of observation constraints satisfied within a given tolerance. This tool is inspired by the IbexOpt Branch and Bound algorithm for constrained global optimization (NLP) and is endowed with an improved version of a relaxed intersection operator applied to the observations. Experiments on two different computer vision problems (shape detection and stereovision) have validated the approach.

3 - Interval Branch-and-Bound Algorithm for semi-infinite programming
Speaker: Dominique Monnet, ENSTA Bretagne, FR, talk 1530
Co-Authors: *Jordan Ninin*, *Benoit Clement*,
Abstract: Semi-infinite programming is known to be NP-hard: $\min_{x\in\mathbb{X}} f(x) s.t. g(x,y) \forall y \in \mathbb{Y}$. Most of methods focus on the convex-concave particular case. Interval-analysis-based approach enables to find the global minimum in the general case. The quantified constraints can be dealt with in a guaranteed way, and the convergence towards the global minimum is ensured. However, the complexity of Branch-and-Bound algorithm based on Interval Analysis is exponential with respect to the number of variables. In order to shorten the convergence time of such algorithm, heuristics can be used without losing the global optimum. Those heuristics are based both on the monotonicity of inclusion function, as defined by interval

arithmetic, and the reformulation of the quantified constraint as a maximization problem. This last reformulation imposes to include a Branch-and-Bound algorithm at each iteration of a Branch-and-Bound algorithm with hot start. The tuning of those Branch-and-Bound will be detailed as well as a fast technique to find feasible solutions.

4 - Reliable convex relaxation techniques for interval global optimization codes

Speaker: Frederic Messine, LAPLACE-ENSEEIHT-INPT, FR, talk 1374

Co-Authors: *Gilles Trombettoni*,

In order to obtain reliable deterministic global optima, all the computed bounds have to be certified in a way that no numerical error due to floating-point operations can involve a wrong solution. Interval arithmetic Branch and Bound algorithms which are developed since the 80th own this property of reliability. However, some new accelerating techniques such as convex relaxation techniques, should be added in order to improve the convergence of those reliable global optimization algorithms. This implies that these new subroutines must keep the property of reliability. In this work, we will show that a floating-point solution obtained by solving a relaxed convex program can be corrected in order to certify that this floating point lower bound is reliable and then lower than the real global optimum.

Path and tree problems

Specific Models, Algorithms, and Software

Network - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 360

Chair: Arthur Delarue, MIT, US

1 - Approximate Shortest Paths and Transshipment in Distributed and Streaming Models

Speaker: Andreas Karrenbauer, MPI for Informatics, DE, talk 1382

Co-Authors: *Ruben Becker*, *Christoph Lenzen*, *Sebastian Krinninger*,

Single-source shortest paths (SSSP) is a fundamental and well-studied problem in computer science. Thanks to sophisticated algorithms and data structures, it has been known for a long time how to obtain (near-)optimal running time in the RAM model. This is not the case in non-centralized models of computation, which become more and more relevant in a big-data world. Despite certain progress for exact SSSP algorithms, there remain large gaps to the strongest known lower bounds. We make a qualitative algorithmic improvement for $(1+\varepsilon)$-approximate SSSP in the CONGEST model: we solve the problem in $(\sqrt{n}+D)\cdot\left(\frac{\log n}{\varepsilon}\right)^{O(1)}$ communication rounds. We thus narrow the gap between upper and lower bound significantly and additionally improve the dependence on ε. Our new approach achieves its superior running time by leveraging techniques from continuous optimization. In fact, we approximate the shortest transshipment problem, which is a generalization of SSSP, by a gradient descent to minimize a smooth relaxation of the infinity-norm using spanners to compute good directions for the updates. Our method is widely applicable among a plurality of non-centralized models of computation. We obtain the first non-trivial algorithms for approximate undirected shortest transshipment in the broadcast CONGEST, broadcast congested clique, and multipass streaming models. Moreover, our approximate SSSP algorithms are the first to be provably optimal up to polylogarithmic factors.

2 - Exact IP-based approaches for the longest induced path problem.

Speaker: Dmytro Matsypura, The University of Sydney, AU, talk 290

Co-Authors: *Alexander Veremyev*, *Oleg Prokopyev*, *Eduardo Pasiliao*,

Graph diameter, which is defined as the longest shortest path in the graph, is often used to quantify graph communication properties. In particular, it provides a very intuitive measure of the worst-case pairwise distance. However, in many practical settings where vertices can either fail or be overloaded, or destroyed by an adversary and thus, cannot be used in any communication or transportation path, it is natural to consider a more general measure of worst-case distance. One such measure is the longest induced path. The longest induced path problem is defined as the problem of finding a subgraph of largest cardinality such that this subgraph is a simple path. In contrast to the polynomially computable graph diameter, this problem is NP-hard. In this paper, we focus on exact solution approaches for the problem based on integer programming (IP) techniques. We first propose three conceptually different IP models and study their basic properties. To improve the performance of standard IP solvers, we propose an exact iterative algorithm, which solves a sequence of smaller IPs in order to obtain an optimal solution for the original problem. In addition, we develop a heuristic capable of finding induced paths in larger networks. Finally, we conduct an extensive computational study to evaluate the performance of the proposed solution methods.

3 - Adding Edges of Short Lengths Incident with the Root to Complete K-ary Tree

Speaker: Kiyoshi Sawada, Univ. of Mktg. - Distr. Sci., JP, talk 1521

We have proposed a model of adding relations between the top and members with the same level in a pyramid organization structure such that the communication of information between every member in the organization becomes the most efficient. This model is expressed as all relations have the same length. However, we should consider that adding relations differ from those of original organization structure in length. This study proposes a model of adding edges with short lengths between the root and all nodes with the same depth N in a complete K-ary tree of height H. The lengths of adding edges are L which is less than 1 while those of edges of complete K-ary tree are 1. An optimal depth N is obtained by maximizing the total shortening distance which is the sum of shortened lengths of shortest paths between every pair of all nodes by adding edges.

4 - Travel Time Estimation in the Age of Big Data

Speaker: Arthur Delarue, MIT, US, talk 784

Co-Authors: *Dimitris Bertsimas*, *Patrick Jaillet*, *Sebastien Martin*,

Twenty-first century urban planners have identified the understanding of complex city traffic patterns as a major priority, leading to a sharp increase in the amount and the diversity of traffic data being collected. For instance, taxi companies in an increasing number of major cities have started record-ing metadata for every individual car ride. In this paper, we show that we can leverage network optimization insights to extract accurate travel time estimations from such origin-destination data, using information from a large number of taxi trips to reconstruct the traffic patterns in an entire city on a variety of timescales. We develop a method that tractably exploits origin-destination data, and draws from its optimization framework the flexibility needed to take advantage of other sources of traffic information. Using synthetic data, we establish the robustness of our algorithm to high variance data, and the interpretability of its results. We then use hundreds of thousands of taxi travel times observations in Manhattan to show that our algorithm can provide insights about urban traffic patterns on different scales and accurate travel time estimations throughout the network.

Unconstrained Optimization

Continuous Optimization
NLP - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle KC7 Building: K, Intermediate 2, Zone: 10

Contributed Session 401
Chair: Ekkehard Sachs, Trier University, DE

1 - SYMMBK algorithm applied to Newton-Krylov methods for unconstrained optimization
Speaker: Andrea Caliciotti, University of Rome La Sapienza, IT, talk 1315
Co-Authors: *Giovanni Fasano*, *Florian Potra*, *Massimo Roma*,
In this work, we deal with Newton-Krylov methods for solving large scale (possibly nonconvex) unconstrained optimization problems. In particular, we consider the use of SYMMBK algorithm for solving the Newton equation, at each (outer) iteration of the method. SYMMBK uses the Bunch and Kaufman factorization of the Lanczos tridiagonal matrix and it can provide conjugate directions, both in the case of 1 by 1 and 2 by 2 pivoting steps. We focus on theoretical properties in order to ensure that the search directions generated by SYMMBK method are gradient-related. In this regard, gradient-related algorithms share a number of their convergence properties with the steepest-descent method. Moreover, in case at the current iteration a linesearch procedure is performed, it is required the search direction and the steepest-descent to be bounded away from orthogonality.
2 - Regularizing trust-region methods for ill-posed nonlinear least-squares problems
Speaker: Elisa Riccietti, IRIT, FR, talk 557
Co-Authors: *Stefania Bellavia*, *Benedetta Morini*,
It is well known that inverse problems typically lead to mathematical models that are ill-posed. This means especially that their solution is unstable under data perturbations. Numerical methods that can cope with these problems are so-called regularization methods. We consider procedures in the class of trust-region methods, and we propose a trust-region approach that ensures regularizing properties and is so suitable to solve ill-posed nonlinear systems and nonlinear least-squares problems. We provide a trust region radius choice ensuring regularizing properties and giving rise to a procedure that has the potential to approach a solution of the unperturbed problem, even in case of noisy data. We show the results of some numerical tests performed on systems arising from the discretization of Fredholm equations of the first kind and on ill-posed data-fitting problems.
3 - Approximate Inverse Preconditioning for Newton-Krylov methods
Speaker: Massimo Roma, SAPIENZA Universita' di Roma, IT, talk 1164
Co-Authors: *Mehiddin Al-Baali*, *Andrea Caliciotti*, *Giovanni Fasano*,
In this work, we deal with a class of approximate inverse preconditioners, based on Krylov-subspace methods, for the solution of large indefinite linear systems, or a sequence of such systems. The main interest is the application to truncated Newton methods for the solution of large scale (nonconvex) unconstrained optimization problems, where a sequence of possibly indefinite linear systems (the Newton equations) is required to solve. The preconditioners are iteratively constructed by gaining information as by-product of the Krylov method adopted. In particular, we propose the use of the SYMMBK method, which is specifically suited for large indefinite linear systems. The SYMMBK method is based on the Lanczos algorithm and represents an alternative solver with respect to the usual Conjugate Gradient method, when tackling indefinite problems. This led to a significant improvement of the resulting method both in terms of efficiency and robustness, as showed by the results of an extensive numerical experience reported.
4 - Second Order Adjoints
Speaker: Ekkehard Sachs, Trier University, DE, talk 1378
Co-Authors: *Noemi Petra*,
Second order adjoints play an important role in an efficient implementation of fast optimization algorithms. They surfaced over the past decades in various applications under different names. In this talk we take a general viewpoint and derive them in a fairly abstract setting. We show how they can be used in an efficient implementation of Newton's method as an alternative to inexact Newton-Krylov methods. We point out various applications such as optimal control, PDE constrained optimization and machine learning.

Robust Optimization and Operations Mangement

Optimization under Uncertainty
Robust - Tu 9:00am-10:30am, Format: 3x30 min
Room: Salle 33 Building: B, Ground Floor, Zone: 5

Invited Session 410
Organizer: Chaithanya Bandi, Northwestern University, US

1 - Robustness of Static Pricing Policies in the Face of Strategic Customers
Speaker: Nikos Trichakis, MIT, US, talk 1186
Co-Authors: *Yiwei Chen*,
We study canonical network revenue management problems and consider utility-maximizing customers who strategize over their purchasing decisions. Under a large class of utility functions, we show that static prices are asymptotically optimal in a fluid-type regime. We discuss extensions wherein we enrich the customers' strategic actions by allowing choice over the offered products. To analyze them, we use a novel

decomposition approach in a mechanism design setting to deal with customers' multi-dimensional private information. We derive an upper bound to the optimal revenues and use it to establish a constant factor guarantee for static pricing.

2 - Prior-Independent Optimal Auctions

Speaker: Omar Besbes, Columbia University, US, talk 1214
Co-Authors: *Amine Allouah*,
Auctions are widely used in practice. While also extensively studied in the literature, most of the developments rely on significant assumptions about common knowledge on the seller and buyers' sides. In this work, we study the design of optimal prior-independent selling mechanisms. In particular, the seller faces buyers whose values are drawn from an unknown distribution, and only knows that the distribution belongs to a particular class. We analyze a competitive ratio objective, in which the seller attempts to optimize the worst-case fraction of revenues garnered compared to those of an oracle with knowledge of the distribution. Our results are along two dimensions. We first characterize the structure of optimal mechanisms. Leveraging such structure, we then establish tight lower and upper bounds on performance, leading to a crisp characterization of optimal performance for a spectrum of families of distributions. In particular, our results imply that a second price auction is an optimal mechanism when the seller only knows that the distribution of buyers has a monotone increasing hazard rate. Furthermore, a second price auction is near-optimal when the class of admissible distributions is that of those with increasing virtual values (aka regular).

3 - Design and Control of Multi-class Queueing Networks via Robust Optimization

Speaker: Chaithanya Bandi, Northwestern University, US, talk 739
Co-Authors: *Itai Gurvich*,
We consider the problem of design and control of open multiclass queueing networks under parameter uncertainty. In particular, we seek the property of global stability which ensures that a network is stable for any work conserving policy provided the natural load condition is met for each server. In general, restrictions on the vector of mean service times must be imposed for a network to be globally stable. Characterizing these conditions is a difficult task and results are known for specific networks and fully-understood only for 2-station networks. We propose here a new route into this problem by making connections with the field of robust optimization. In particular, we present computationally tractable optimization formulations to verify if a given queueing network is globally stable. We do this in two ways: 1) Using sufficiency conditions on the reflection matrix, where we obtain convex semidefinite programming formulation, and 2) Using more exact conditions by linking the stability of a queueing network to the stability of a linear complementarity problem. Using this analysis, we also present a solution to the problem of designing globally stable networks by using a modular approach. In particular, we seek to identify assembly (LEGO) operations, such as pooling of networks, and assembly rules-of-thumb that, when followed, crate a globally stable network from globally stable building blocks.

Facility Location

Specific Models, Algorithms, and Software
Logistics - Tu 9:00am-10:30am, Format: 3x30 min
Room: Salle 16 Building: I, 2nd floor, Zone: 7

Contributed Session 414
Chair: Ivan Contreras, Concordia University, CA

1 - Exact solution of single source quadratic capacitated location problems

Speaker: Ivan Contreras, Concordia University, CA, talk 1506
In this talk we present an exact solution algorithm for a general class of single source quadratic capacitated facility location problems. The quadratic term represents the flow cost associated with the interaction of customers' assignments to facilities. This class of problems arise in the design of hub-and-spoke networks in transportation and telecommunications systems. We first use the well-known reformulation-linearization technique (RLT) to linearize the quadratic term of the objective function and then project out all auxiliary variables of the RLT using Benders decomposition. We develop a branch-and-cut algorithm to solve the resulting Benders reformulation. This algorithm is enhanced with several algorithmic features such as efficient separation procedures to generate non-dominated Benders cuts, reduction tests, a partial enumeration phase, and a matheuristic. Results of extensive computational experiments show that this algorithm is capable of optimally solving uncapacitated and capacitated instances with up to 300 nodes. To the best of our knowledge, this as the largest instances ever solved for this challenging class of discrete location problems.

2 - Optimal multi-facility location for competing firms under quantity competition

Speaker: Blas Pelegrin, Universidad de Murcia, ES, talk 187
Co-Authors: *Pascual Fernández*, *M. Dolores García Pérez*,
We study a location problem for competing firms that sell an homogeneous product to the customers located at the nodes of a transportation network. The firms compete on product quantity and will chose the Cournot quantities after establishing their facilities. Such quantities depend on the facilities locations of the firms and will be delivered from the facilities to the customers. Delivered cost includes both mill price and transportation cost. The price of the product at each node is given by a linear function of the total amount of product delivered to that node. The profit each firm obtains from each node results to be a quadratic function of the Cournot quantities delivered to that node. For profit maximization, it is proved that optimal facility locations can be found at the nodes. This makes the facility location problem to be a combinatorial optimization problem. The objective function can be expressed by a quadratic function of delivered cost from the cheapest facility to each node. Then we show a Mixed Integer Linear Programming formulation to obtain the best facility locations for any firm assuming that the other firms have their facility locations already fixed. The proposed formulation can be used to solve large size problems as it is shown by an illustrative example. It can also be used to find location Nash equilibria for the competing firms. A study for different scenarios with 1049 demand nodes and 142 nodes as location candidates is presented and conclusions are drawn from a sensitivity analysis.

3 - A new formulation for the Hamiltonian p-median problem

Speaker: Daniel Santos, CMAF-CIO, FCUL, PT, talk 822

Co-Authors: *Luís Gouveia*, *Tolga Bektas*,
This talk concerns the Hamiltonian p-median problem defined on a directed graph, which consists of finding p mutually disjoint circuits of minimum total cost, such that each node of the graph is included in one of the circuits. Earlier formulations are based on viewing the problem as resulting from the intersection of two subproblems. The first subproblem states that at most p circuits are required, that are usually modeled by using subtour elimination constraints. The second subproblem states that at least p circuits are required, for which in this talk an explicit connection is made to the so-called path elimination constraints that arise in multi-depot/location-routing problems. A new extended formulation is proposed that builds on this connection, that allows the derivation of a stronger set of subtour elimination constraints for the first subproblem, and implies a stronger set of path elimination constraints for the second subproblem. The proposed model is solved by using a branch-and-cut algorithm.

Exact approaches for problems over lattices and graphs

Discrete Optimization & Integer Programming
COMB - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Contributed Session 425
Chair: Daniele Catanzaro, CORE - UCL, BE

1 - Why is maximum clique often easy in practice?
Speaker: Austin Buchanan, Oklahoma State University, US, talk 279
Co-Authors: *Jose Walteros*,
Recently, researchers have developed algorithms for solving the maximum clique problem that run rather quickly for million-node real-life graphs despite the computational intractability of the problem in the worst case. A natural explanation for the success of these approaches on real-life graphs is their sparsity, allowing one to safely delete many low-degree vertices in a preprocessing step. Related ideas lead to algorithms that solve the problem in time polynomial in the size of the graph, but exponential in the graph's degeneracy d (a measure of sparsity). This is encouraging given that d is orders of magnitude smaller than the number n of nodes on most real-life graphs. However, given that these algorithms run in time exponential in d and the fact that d is often in the hundreds on these "easy" instances, this explanation for their easiness is somewhat unsatisfying. This paper provides an alternative explanation based on the empirically observed proximity of the clique number ω to the graph's degeneracy d. Namely, we develop an algorithm for the maximum clique problem that runs in time polynomial in the graph's size, but exponential in the difference $d - \omega$. When this difference is a constant, the running time is $O(dm) = O(m^{1.5})$. Since 70 percent of common test instances have $d - \omega \leq 3$, our implementation performs rather well and is competitive with previous approaches. It uses existing kernelization and fpt algorithms for vertex cover as subroutines.
2 - Scheduling for Last-Mile Food Delivery
Speaker: Matteo Cosmi, Roma Tre University, IT, talk 1408
Co-Authors: *Gianpaolo Oriolo*, *Veronica Piccialli*, *Simone Terranova*, *Paolo Ventura*,
The demand of food delivery services has increased extremely fast in the last few years. In this setting, customers requests are usually defined by a list of items that have to be collected from a specified restaurant and delivered at a given time to a certain address. The service administrator has to assign the orders to a fleet of movers so to fullfil a set of Quality of Service constraints that mainly involve punctuality of delivery. Here we present some models, algorithms and computational results that have been developed throughout an on-going collaboration with Moovenda, a leading Italian food company service. Our models are strongly related to (multi-machine) scheduling with release times, due dates and bounded slack, for which we present a few new theoretical results. Keywords: food delivery, scheduling with release times and due dates, routing problems
3 - Optimizing over lattices of unrooted binary trees: Part I - Foundations
Speaker: Martin Frohn, CORE - UCL, BE, talk 1030
Co-Authors: *Daniele Catanzaro*, *Raffaele Pesenti*,
We show that the space of all unrooted binary trees (or phylogenies) for a finite set of taxa defines a lattice, which orders phylogenies by their imbalance. By representing phylogenies as path-length sequence collections, we show that the imbalance ordering is closely related to a majorization ordering on real-valued sequences, that correspond to discrete probability density functions. Furthermore, this imbalance ordering is a partial ordering that is consistent with the ordering induced by the entropy determined by the tree structure. On the imbalance lattice, specific functions of the path-length of a phylogeny (including, among others, the usual objective functions for Huffman coding in information theory and for the balanced minimum evolution problem in phylogenetics) may either enjoy combinatorial properties (such as submodularity) that prove useful in optimization or reveal new insights about the NP-hardness of some families of optimization problems in phylogenetics.
4 - Optimizing over lattices of unrooted binary trees: Part II - On the BMEP
Speaker: Daniele Catanzaro, CORE - UCL, BE, talk 830
Co-Authors: *Martin Frohn*, *Raffaele Pesenti*,
A phylogeny of a set $\Gamma = \{1, 2, \ldots, n\}$ of $n \geq 3$ vertices is an unrooted binary tree having Γ as leafset. Given a symmetric distance matrix $\mathbf{D} = \{d_{ij}\}$ among taxa, the Balanced Minimum Evolution Problem (BMEP) consists of finding a phylogeny T of Γ minimizing $\sum_{i\in\Gamma}\sum_{j\in\Gamma\setminus\{i\}} d_{ij}/2^{\tau_{ij}}$, where τ_{ij} is the length of the unique path in T connecting taxa i and j. In the light of the results presented in "Optimizing over lattices of unrooted binary trees: Part I - Foundations", here we investigate the polyhedral combinatorics of the BMEP and provide perspectives about the development of possible exact solution approaches.

Pricing

Specific Models, Algorithms, and Software
Learning - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

Contributed Session 478
Chair: Anastasiya Ivanova, MIPT, RU

1 - Distributed price adjustment for the resource allocation problem
Speaker: Anastasiya Ivanova, MIPT, RU, talk 780
Co-Authors: *Alexander Gasnikov*,
Using dual splitting technique [1] we propose interpretive centralized distributed algorithms for the resource allocation problem. In the case when the number of the resource constraints is large we developed a primal-dual technique from [2]. We also propose a new conception of master-slave communication based on the notion of controller for each of the resource constraints [3]. In the case when the number of the resource constraints is small we solve dual problem with center of gravity type method that generate some additional difficulties (we have to bound dual multiplyers we have to obtain the solution of the primal problem from the dual one with the desired precision e.t.c.). We concentrate on this difficulties. Literature 1. Nedic A., Ozdaglar A. Cooperative distributed multi-agent optimization. In Convex Optimization in Signal Processing and Communications. – Camb. Univ. Press, 2009. P. 340–386. 2. Nesterov Yu., Shikhman V. Distributed price adjustment based on convex analysis // Journal Optimization Theory and Applications. – 2017. – V. 172(2). – P. 594–622. 3. Bayandina A., Dvurechensky P., Gasnikov A., Stonyakin F., Titov A. Mirror descent and convex optimization problems with non-smooth inequality constraints. – LCCC Focus Period on Large-Scale and Distributed Optimization. Sweden, Lund: Springer, 2018.

2 - Price forecasting with machine learning algorithms for recommerce activities
Speaker: Yesmine Rouis, Recommerce Lab, FR, talk 1586
Co-Authors: *Sara Calleja*, *Xavier Schepler*, *Jeanjean Antoine*,
Based on a real-life recommerce activity, our work deals with computing forecasts for second-hand products. Through this study, we aim at computing accurate future market prices for each product, and each reselling grades. Eight years of historical data are used to build our models. Feature selection, one of the key components of an efficient forecast model, aims at selecting the best input variables among a large set of candidate ones. They encompass product age (in weeks), product family (iPhone/iPhone Plus/Galaxy S/Galaxy Note,...), product capacity (16Gb, 32Gb, etc.), real past resale prices on different marketplaces, etc. To produce good quality forecasts, an exploratory data analysis approach is first performed, allowing a better understanding of the data, identifying outliers and proposing specific strategies to handle them. The objective of this process is to select the appropriate statistical smoothing methods providing, in some cases, a new collection of the data. In addition, a comparison between the market price and the real price is hence investigated. Furthermore, we will present several models, discuss their performances and introduce the associated process of rolling forecasts by using the current week forecasting error in order to improve the accuracy of next week's forecasts.

3 - Volume forecasting with machine learning algorithms for recommerce activities
Speaker: Sara Calleja, Recommerce Lab, FR, talk 1592
Co-Authors: *Jeanjean Antoine*, *Yesmine Rouis*, *Xavier Schepler*,
Our work deals with forecasting buyback volumes for a real-life recommerce activity that consists in buy-backing pre-owned products, repairing or refurbishing them, in order to sell them as second-hand products. Here, the products are smartphones and the buybacks occur mainly in the stores of mobile network operators. A forecast holds for a week, a product, a collect grade, a channel (in store or online) and a partner. We use eight years of historical data in order to build our models. An important difficulty is to select the best explanatory variables among a large set of candidates. They encompass, among others, product age (in weeks), product family (iPhone, iPhone Plus, Galaxy S, Galaxy Note, etc.), holiday periods, historical collect volume data of all products, buyback bonus periods (used to boost collect) and release date of new products. Accordingly, we will present several regression models, using different subsets of explanatory variables and different learning algorithms, and discuss their forecasting performances. Furthermore, we will introduce the associated process of rolling forecasts, in order to use the current week forecasting error to improve the accuracy of next week's forecasts.

4 - Optimal Pricing and Introduction Timing of New Virtual Machines
Speaker: Spyros Zoumpoulis, INSEAD, FR, talk 1525
Co-Authors: *Ian Kash*, *Peter Key*,
Cloud service providers can provide increasingly powerful upgrades of their virtual machines to their customers, but at a launching cost, and at the expense of the sales of existing products. We propose a model of product introduction and characterize the optimal pricing and timing of introductions of new virtual machines for a cloud service provider in the face of customers who are averse to upgrading to improved offerings. Overall, we show that a simple policy of Myerson (i.e., myopic) pricing and periodic introductions is near-optimal. We first show that under a Myerson pricing rule, there is no loss of optimality with a periodic schedule of introductions, and that under periodic introductions, the potential additional revenue of any pricing policy over Myerson pricing decays to zero after sufficiently many introductions. We then show that, given arbitrary fixed introduction times, Myerson pricing is approximately optimal. To do so, we characterize the prices that achieve optimal revenue in a single introduction period and provide a bound for the competitive ratio of Myerson pricing over the optimal single-period pricing. Following our analysis, we examine our analytical bounds for Myerson pricing with simulations and show that they can provide strong guarantees for all values of the switching cost, for several natural distributions for the customer type. Furthermore, when we numerically compute optimal prices, rather than using our bounds, we find that Myerson pricing is often several orders of magnitude closer to optimal than our analytical bounds suggest.

Cutting Planes for Integer Programs

Discrete Optimization & Integer Programming
IPtheory - Tu 8:30am-10:30am, Format: 4x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4
Contributed Session 512
Chair: Matthias Köppe, UC Davis, US

1 - Characterization and Approximation of General Dual-Feasible Functions
Speaker: Jiawei Wang, UC Davis, US, talk 894
Co-Authors: *Matthias Köppe*,

Dual-feasible functions (DFFs) are a fascinating family of functions, which have been used in several combinatorial minimization problems to generate lower bounds efficiently. DFFs are in the scope of superadditive duality theory, and superadditive and nondecreasing DFFs can provide valid inequalities for general integer linear programs. A function $\phi : \mathbb{R} \to \mathbb{R}$ is called a general DFF, if for any finite list of real numbers x_i, $i \in I$, it holds that, $\sum_{i\in I} x_i \leq 1 \Rightarrow \sum_{i\in I} \phi(x_i) \leq 1$. We strengthen the notion of maximality for general DFFs and give full characterization of (restricted/strongly) maximal general DFFs. The extremality of general DFFs is another focus of our results. Inspired by the famous Gomory–Johnson's 2-slope theorem, we prove a 2-slope theorem for general DFFs: any continuous piecewise linear maximal general DFF with only 2 slope values, one of which is 0, is extreme. An important application of the 2-slope theorem is our approximation theorem, which indicates that continuous extreme (2-slope) general DFFs are dense in the (convex) set of continuous restricted maximal general DFFs. We study the relation between general DFFs and certain cut-generating functions, including Gomory–Johnson functions and more generalized Yildiz–Cornuejols model with various sets S. We introduce a conversion between general DFFs and a family of cut-generating functions which generate valid inequalities for the model where $S = \{0\}$.

2 - All finite group complexity injects

Speaker: Yuan Zhou, University of Kentucky, US, talk 1203

We give a variant of Basu-Hildebrand-Molinaro's approximation theorem [Minimal cut-generating functions are nearly extreme, IPCO 2016] for minimal valid functions by piecewise linear two-slope extreme functions. Our construction is for piecewise linear minimal valid functions that have only rational breakpoints in a group 1/qZ and take rational values at the breakpoints. In contrast to Basu et al.'s construction, our construction preserves all function values on the group 1/qZ. A corollary is that every extreme function for a finite group problem on 1/qZ is the restriction of a continuous piecewise linear two-slope extreme function for the infinite group problem with breakpoints on a refinement 1/(mq)Z. Earlier results such as the refutation of the 4-slope conjecture indicated that the space of extreme functions is very complicated. However, our result for the first time shows that the extreme functions for all finite group problems inject into the space of extreme functions of the infinite group problem, and thus all arithmetic (number-theoretic) complexity of the finite group problem is represented. We note that restrictions of continuous piecewise linear extreme functions with breakpoints on 1/(mq)Z to the finite group problem on 1/(mq)Z are necessarily extreme, but in general the coarser restrictions to the finite group problems on 1/qZ are NOT extreme. We give a counterexample for this.

3 - Projective cutting-planes by projecting interior points onto polytope facets

Speaker: Daniel Porumbel, Cons. National Art et Metiers, FR, talk 1136

Consider the problem of optimizing an LP over a polytope P with prohibitively-many constraints. The classical Cutting-Planes proceeds by iteratively solving a separation subproblem on the current optimal solution s. We propose to replace the separation sub-problem with a (more) general intersection sub-problem that asks to project an interior point $x \in P$ along some direction until reaching the boundary of P. Instead of applying the separation sub-problem on s, the projective Cutting-Planes solves an intersection sub-problem at each iteration: given the current interior point x, determine $t^* = max\{t \geq 0 : x + t(s - x) \in P\}$. Solving this subproblem also gives the response to the separation subproblem, e.g., if $t < 1$, then s can be separated. Furthermore, the intersection subproblem provides a hit-point $x + t^*(s - x)$ and a first-hit facet. The hit-point of the current iteration can become the new interior point x at the next iteration. Other versions replace x with $0.999x$ as the next interior point. In a loose sense, this is reminiscent of interior point algorithms that avoid touching the facets at all iterations. The proposed method generates a sequence of interior points and a sequence of outer points s that both converge to the optimum over P. The outer points s are the optimal solutions of the intermediary LPs generated by the first-hit facets (these LPs are solved using Simplex). Results will be presented for Column Generation models (where P is the dual polytope) and for a Benders decomposition model (where P is the primal polytope).

4 - cutgeneratingfunctionology: Python software for CGFs and superadditive duality

Speaker: Matthias Köppe, UC Davis, US, talk 1205

Co-Authors: *Yuan Zhou*, *Jiawei Wang*,

After giving an overview of the Python-based mathematical system SageMath and its facilities for discrete optimization and polyhedral geometry, I will present the latest developments in our package cutgeneratingfunctionology (with Y. Zhou, C. Y. Hong, and J. Wang). The package supports experimental mathematics and computer-assisted theorem proving for cut-generating functions in the single-row and multi-row Gomory-Johnson model (infinite group relaxation), Gomory's finite group relaxation, and other models related to the superadditive duality of integer programming. The software is available at: https://github.com/mkoeppe/cutgeneratingfunctionology

Electric Vehicles and Decarbonization

Specific Models, Algorithms, and Software

Energy - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle 23 Building: G, 3rd floor, Zone: 6

Contributed Session 519

Chair: Martim Joyce-Moniz, Polytechnique Montreal - GERAD, CA

1 - A techno-economic analysis of the impact of decarbonization

Speaker: Paolo Pisciella, NTNU, NO, talk 1322

In July 2009 the leaders of the European Union and the G8 announced the common objective of reducing greenhouse emissions by al least 80**2 - Equilibrium Analysis of a Carbon Tax With Pass-through Restrictions**

Speaker: Francisco Munoz, Universidad Adolfo Ibáñez, CL, talk 701

Co-Authors: *Gabriel Diaz*, *Rodrigo Moreno*,

Chile was the first country in Latin America to impose a tax on carbon emissions, however, the law does not allow firms to include emission charges as relevant costs for the dispatch and pricing of electricity in real time, which avoids price increases in the short term as a consequence of the emissions policy. Additionally, there is a provision that establishes that generators that cannot cover their emission costs with the spot price must receive a side payment that is financed by all inframarginal units. We develop an open-loop equilibrium model with endogenous investments in generation capacity and find a fixed point using a Gauss-Seidel iterative algorithm that allows us to take into account an administrative rule to determine annual carbon charges per technolgy. As expected, we find that this policy is much more inefficient than a standard tax on carbon emissions or a cap-and-trade program without pass-through restrictions and side-payment rules. Total system costs, long-term electricity prices, and carbon emissions are all lower under a standard carbon tax than under the current policy used in Chile. In fact, in one scenario pass-through restrictions and side-payment rules result in increasing carbon emissions as we rise the tax level. Tax revenues are also higher under the current policy than under a standard carbon tax, which gives the regulator weak incentives to modify the law.

3 - Management of EV Charging Stations under Advance Reservations Schemes

Speaker: Daniel Olivares, PUC-Chile, CL, talk 342

Co-Authors: *Matias Negrete-Pincetic*, *Alvaro Lorca*, *Rodrigo Bernal*,

As electric vehicles (EV) have surpassed the 2 million-vehicle threshold in 2016, charging stations (CS) have growth popularity allowing EV to charge while parked away from home. However, as a full charge can take significant amount of time and cars outnumber public charging stations by more than six to one, drivers may face queues and uncertainty over availability of charging facilities. Advance reservation (AR) systems are used in many services such as restaurants, flight tickets and communication networks, where they play a significant role in improving the provisioning quality of a resource manager and predictable behavior of the resources. AR benefits both users and service providers by reducing the risk of not being served, and the uncertainty associated with the number of customers to be served at any particular time, respectively. This work focuses on the design of an AR system for a CS; an optimization model is developed for a setting where a CS participates in a whole-sale energy market and in an ancillary services market. Game theory –more precisely poisson games– and utility theory are used to characterize the interaction between EV owners and the CS, in order to determine reservation decisions and the optimal participation of the CS in the electricity markets.

4 - Increasing electric vehicle adoption via strategic siting of charging stations

Speaker: Martim Joyce-Moniz, Polytechnique Montreal - GERAD, CA, talk 179

Co-Authors: *Miguel Anjos*, *Bernard Gendron*,

Governments everywhere have started setting ambitious goals for electric vehicle (EV) adoption for the next few decades. Today's charging infrastructure is, however, insufficient to service all these new EVs. Moreover, private investment in charging stations is unlikely while the number of EVs is small, and potential customers will not purchase EVs while these infrastructures are not widespread. Governments must therefore drive this investment during a first stage, thus promoting a higher EV adoption. Recent works on optimization problems for siting and sizing of charging stations for EVs have started addressing this issue by considering strategic multi-period siting optimization problems. One limitation of these works, however, is that they consider the demand (i.e. number of EVs and their geographical distribution) over time to be static and given as an input. We present a more holistic optimization framework, which considers how new infrastructure impacts future EV demand, and how the infrastructure can be installed such that it properly responds to future demand.

Risk Models for Electricity Markets

Specific Models, Algorithms, and Software

Energy - Tu 8:30am-10:30am, Format: 4x30 min

Room: Salle 24 Building: G, 3rd floor, Zone: 6

Contributed Session 521

Chair: Michael Ferris, University of Wisconsin, US

1 - Risky Capacity Equilibrium Models for risk averse investment equilibria

Speaker: Daniel Ralph, University of Cambridge, GB, talk 1681

Co-Authors: *Gauthier de Maere*, *Andreas Ehrenmann*, *Yves Smeers*,

We present the class of "Risky Capacity Equilibrium Problems" that incorporate (i) risk averse investment in power plants, (ii) financial trading to hedge those investments, and (iii) strategic production in a stochastic spot market. Each is structured in a unified stochastic Nash game framework as the concatenation of a short-term electricity market (perfect competition or Cournot) with long-term investment behaviour (risk neutral or risk averse behaviour in different risk trading settings). In the case of complete risk trading, these models directly extend their risk neutral capacity equilibrium counterparts with respect to economic formulation, reformulation as optimization problems or games, and existence theory. We report numerical results to illustrate the relevance of market imperfections on investments and welfare. Our focus is two stage models but the extension to multistage is essentially notational, via multistage risk functions, and is viable for industrial scale multistage models.

2 - Payment mechanisms, efficiency savings and risk-aversion in electricity markets

Speaker: Ryan Cory-Wright, MIT, US, talk 565

Co-Authors: *Golbon Zakeri*, *Andy Philpott*,

We examine an electricity market clearing mechanism which comprises dispatching intermittent, flexible and inflexible generation agents according to the optimal solution of a stochastic program. The first stage corresponds to a pre-commitment decision, and the second stage corresponds to real-time generation that adapts to different realisations of a random variable. By taking the Lagrangian and decoupling in different ways we obtain two payment mechanisms with different properties. We also consider generation agents who are risk-averse and model their risk-aversion using law-invariant coherent risk measures. We uncover a closed-form characterization of the optimal pre-commitment policy for a given real-time dispatch policy, with arbitrary risk-aversion. When participants cannot trade risk, a risked equilibrium exists which provides less pre-commitment than when participants are risk-neutral. Alternatively, when participants trade a rich set of financial instruments, a second risked equilibrium exists which provides more pre-commitment than when generators are risk-neutral. We illustrate our findings by implementing the SP mechanism in the New Zealand Electricity Market.

3 - Risk and Information Sharing in Peer-to-Peer Electricity Markets
Speaker: Fabio Moret, DTU, DK, talk 1052
Co-Authors: *Pierre Pinson*, *Athanasios Papakonstantinou*,
Organization in electricity markets is evolving from centralized pool-based to decentralized peer-to-peer structures. Within this decentralized framework, agents are expected to negotiate their energy procurement individually. Clearing markets with such characteristics requires consensus based distributed optimization and application of decomposition techniques to accommodate for the complexity due to privacy issues. Since power generation is mostly based on non-dispatchable distributed energy resources, any proposed decentralized negotiation mechanism needs to account for uncertainties. This translates to rethinking current centralized approaches to risk management. Consequently, we investigate risk hedging mechanisms under heterogeneous risk attitudes of agents. In particular, we analyze how capacity can be reserved endogenously in a distributed way. Keeping the optimization problem decomposable, we assess the impact of risk on market dynamics. Uncertainties are described by means of time correlated trajectories, used as scenarios for each stochastic optimization subproblem. We show that by sharing information on stochastic processes, i.e. generating space-time trajectories, risk sharing is further optimized among market participants.
4 - Dynamic Risked Equilibrium for Energy Planning
Speaker: Michael Ferris, University of Wisconsin, US, talk 1455
Co-Authors: *Andy Philpott*,
Electricity markets have evolved over the past three decades to facilitate the optimal allocation and scheduling of resources in the power grid. The recent explosion of use of renewable supply such as wind, solar and hydro has led to increased volatility in this system. We investigate models of competition and risk within the context of power system markets in a dynamic setting. A dynamic equilibrium aims to determine prices and dispatches that can be transmitted over the electricity grid to satisfy evolving consumer requirements for energy at different locations and times.We demonstrate how risk can impose significant costs on the system that are not modeled in the context of socially optimal power system markets and highlight the use of contracts to reduce or recover these costs. We also outline how battery storage can be used as an effective hedging instrument.We demonstrate when social optima exist, what properties on risk measures and contracts are needed, and how to solve these problems in large scale practical settings. We look at specific settings that give rise to problem insights, how computation allows large scale practical implementations of socially optimal models to be solved as part of the market operation, and how regulations can be imposed that aim to ensure competitive behavior of market participants.

Asymptotic Lagrangian duality for nonsmooth optimization

INVITED TALKS
KEYNOTE - Tu 11:00am-12:00am, Format: 1x60 min
Room: DENIGES Building: C, Ground Floor, Zone: 5
INVITED SESSION 541
Organizer: Xiaojun Chen, Hong Kong Polytechnic Univ., HK

1 - Asymptotic Lagrangian duality for nonsmooth optimization
Speaker: Regina Burachik, UniSA, AU, talk 1635
For nonconvex optimization problems, zero duality gap and saddle-point properties can be established by using a generalized Lagrangian function that verifies suitable properties. The latter fact was originally proved by Rockafellar and Wets in 2007 in finite dimensions and extended in various ways in the last decade. The main advantage of this approach is that the resulting dual problem is convex and hence tractable via standard techniques. In this way, the optimal value, and sometimes even a solution, of the original problem, can be obtained by solving the dual problem using nonsmooth convex techniques. In the first part of the talk, we will recall some recent advances and applications of this fact in nonconvex duality. We will show how techniques from nonsmooth convex analysis can be incorporated into this duality scheme and provide a solution of the original (nonconvex/nonsmooth problem). In the second part of the talk, we will report on some new results involving a sequence of dual problems that converge (in a suitable sense) to a given dual problem (called asymptotic dual problem). This model can be useful within an iterative scheme in which (i) we use a sequence of smooth approximations of a nonsmooth Lagrangian, or (ii) we want to incorporate current information to update the Lagrangian at each iteration. For the asymptotic duality, we establish hypotheses under which zero duality gap holds. We illustrate the new results in the context of equality constrained problems and nonlinear semi-definite problems.

Lower bounds on the size of linear programs

INVITED TALKS
KEYNOTE - Tu 11:00am-12:00am, Format: 1x60 min
Room: BROCA Building: W, 3rd floor, Zone: 0
INVITED SESSION 545
Organizer: Volker Kaibel, OVGU Magdeburg, DE

1 - Lower Bounds on the Size of Linear Programs
Speaker: Thomas Rothvoss, University of Washington, US, talk 1578
For half a century, proving that certain computational problems cannot be solved efficiently by a computer has turned out to be one of the hardest mathematical questions, with very little to no progress at all. However, in many scenarios it is very natural to consider restricted computational models, and here the situation is more promising. For example, a very standard approach in Operations Research is to model a computational problem as a linear program; this has the natural geometric interpretation of writing the solution space as projection of a higher dimensional polytope with few facets. There has been remarkable progress in the last few years in understanding this model, leading to almost tight lower bounds that we will describe in this talk.

Adaptive Robust Optimization with Scenario-wise Ambiguity Sets

Invited Talks
SEMI - Tu 11:00am-12:00am, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 551
Organizer: Daniel Kuhn, EPFL, CH

1 - Adaptive Robust Optimization with Scenario-wise Ambiguity Sets
Speaker: Melvyn Sim, NUS, SG, talk 1686
Co-Authors: *Chen Zhi*, *Peng Xiong*,
We present a tractable format for optimization under uncertainty based on the framework of adaptive robust optimization via a new class of scenario-wise ambiguity sets. The new format naturally unifies classical stochastic programming and robust optimization, and also incorporates the more recent distributionally robust optimization with ambiguity sets based on generalized moments, mixture distribution, Wasserstein (or Kantorovich-Rubinstein) metric, ϕ-divergence, and new ones such as k-means clustering, among others. We introduce a compatible scenario-wise affine recourse approximation, which is developed on the classical affine recourse approximation (a.k.a. linear decision rule or affine policy), to provide tractable solutions to adaptive robust optimization problems.

The Resurgence of Proximal Methods in Optimization

Invited Talks
PLENARY - Tu 1:30pm-2:30pm, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 555
Organizer: Claudia Sagastizabal, Unicamp, BR

1 - The resurgence of proximal methods in optimization
Speaker: Marc Teboulle, Tel Aviv University, IL, talk 1583
Proximal based methods are nowadays starring in modern optimization algorithms based on first order information, e.g., function values and gradient/subgradients. This renewed interest is motivated by the current high demand in solving large scale problems arising in a wide spectrum of disparate modern applications. This talk will describe the fundamentals of a fairly general proximal framework, and its impact on some iconic first order optimization algorithms, including recent extensions. Convergence properties and applications in both the convex and nonconvex settings will be described.

Sum-of-squares and moment problems: methods and applications

Continuous Optimization
NLP - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

Invited Session 2
Organizer: Etienne De Klerk, Tilburg University, NL

1 - LP, SOCP, and Optimization-Free Approaches to Polynomial Optimization
Speaker: Amir Ali Ahmadi, Princeton University, US, talk 350
Co-Authors: *Anirudha Majumdar*, *Georgina Hall*,
We propose alternatives to sum of squares optimization that do not rely on semidefinite programming, but instead use linear programming, or second-order cone programming, or are altogether free of optimization. In particular, we present the first Positivstellensatz that certifies infeasibility of a set of polynomial inequalities simply by multiplying certain fixed polynomials together and checking nonnegativity of the coefficients of the resulting product. We also demonstrate the impact of our LP/SOCP-based algorithms on large-scale verification problems in control and robotics.
2 - Distributionally robust optimization with SOS polynomial density functions and m
Speaker: Krzysztof Postek, Erasmus University Rotterdam, NL, talk 14
Co-Authors: *Etienne De Klerk*, *Daniel Kuhn*,
Numerous decision problems are solved using the tools of distributionally robust rptimization. In this framework, the distribution of the problem's random parameter is assumed to be known only partially in the form of, for example, the values of its first moments. The aim is to minimize the expected value of a function of the decision variables, assuming the worst-possible realization of the unknown probability measure. In the general moment problem approach, the worst-case distributions are atomic. We propose to model smooth uncertain density functions using sum-of-squares polynomials with known moments over a given domain. We show that in this setup, one can evaluate the worst-case expected values of the functions of the decision variables in a computationally tractable way.
3 - Nonnegative polynomials, and applications to learning
Speaker: Georgina Hall, Princeton University, US, talk 250
Co-Authors: *Amir Ali Ahmadi*, *Mihaela Curmei*,
The problem of recognizing nonnegativity of a multivariate polynomial has a celebrated history, tracing back to Hilbert's 17th problem. In recent years, there has been much renewed interest in the topic because of a multitude of applications in applied and computational mathematics and the observation that one can optimize over an interesting subset of nonnegative polynomials using "sum of squares (SOS) optimization". In this talk, we give a brief overview of the developments in this field and show how they can be applied to two problems at the interface of machine learning and polynomial optimization. In part (i), we study the problem of learning a monotone polynomial from data. This is motivated by regression problems where the underlying function to be learned is monotone (consider, e.g., the price of a car as a function of its fuel efficiency). In part (ii), we study the problem of optimally decomposing a multivariate polynomials as the difference of two convex polynomials. This is motivated by certain majorization-minimization algorithms used in nonconvex optimization that require such a decomposition.

Algorithms in the Sharing Economy

DISCRETE OPTIMIZATION & INTEGER PROGRAMMING
APPROX - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

INVITED SESSION 22
Organizer: David Shmoys, Cornell University, US

1 - Minimizing Latency in Online Ride and Delivery Services
Speaker: Anthony Kim, Stanford University, US, talk 252
Co-Authors: *Abhimanyu Das*, *Sreenivas Gollapudi*, *Debmalya Panigrahi*, *Chaitanya Swamy*,
Motivated by the popularity of online ride and delivery services, we study natural variants of classical multi-vehicle minimum latency problems where the objective is to route a set of vehicles located at depots to serve requests located on a metric space so as to minimize the total latency. In this paper, we consider point-to-point requests that come with source-destination pairs and release-time constraints that restrict when each request can be served. The point-to-point requests and release-time constraints model taxi rides and deliveries. For all the variants considered, we show constant-factor approximation algorithms based on a linear programming framework. To the best of our knowledge, these are the first set of results for the aforementioned variants of the minimum latency problems. Furthermore, we provide an empirical study of heuristics based on our theoretical algorithms on a real data set of taxi rides.

2 - Broken Bike Docks and the Prize-Collecting Traveling Salesman Problem
Speaker: Alice Paul, Brown University, US, talk 246
Co-Authors: *Daniel Freund*, *David Shmoys*, *David Williamson*, *Aaron Ferber*,
We consider constrained versions of the prize-collecting traveling salesman and the minimum spanning tree problems. The goal is to maximize the number of vertices in the returned tour/tree subject to a bound on the tour/tree cost. We present a 2-approximation algorithm for these problems based on a primal-dual approach. Our analysis extends to the setting with weighted vertices; we apply our algorithm to such instances using Citi Bike data in New York City, in which the weights correspond to the estimated number of broken docks at each station.

3 - Allocating capacity in bike-sharing systems
Speaker: David Shmoys, Cornell University, US, talk 242
Co-Authors: *Daniel Freund*, *Shane Henderson*,
The growing popularity of bike-sharing systems around the world has motivated recent attention to models and algorithms for the effective operation of these systems. In this work, we consider the more strategic question of how to (re-)allocate dock-capacity in such systems. We develop mathematical formulations for variations of this problem (service performance over the course of one day, long-run-average performance) and exhibit discrete convex properties in associated optimization problems. This allows us to design both theoretically and practically fast polynomial-time allocation algorithms. We apply our algorithm to data sets from Boston, New York City, and Chicago to investigate how different dock allocations can yield better service in these systems. Recommendations based on our analysis have been adopted by system operators in Boston and New York City.

Advances in DFO II

CONTINUOUS OPTIMIZATION
DERFREE - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 21 Building: G, Intermediate, Zone: 6

CONTRIBUTED SESSION 37
Chair: Warren Hare, University of British Columbia, CA

1 - Variable-fidelity derivative-free algorithms for road design
Speaker: Yves Lucet, University of British Columbia, CA, talk 648
Co-Authors: *Warren Hare*, *Mahdi Aziz*, *Majid Jaberipour*,
The horizontal alignment problem in road design (designing the road path from a satellite's viewpoint) is modeled as a bilevel optimization problem. The lower level optimization problem is called the vertical alignment problem (where to cut and fill the ground to design the road) and includes the earthwork problem (what material to move to minimize costs). It is modeled as a mixed-integer linear program for which a multi-fidelity surrogate is built using quantile regression over a set of 50 roads. To solve the upper-level problem (horizontal alignment problem), we compare two variable-fidelity algorithms from the literature (a generalized pattern search with adaptive precision function evaluations vs. a trust-region with controlled error) and report significant speedups.

2 - Derivative-Free Robust Optimization by Outer Approximations
Speaker: Matt Menickelly, Argonne National Laboratory, US, talk 586
Co-Authors: *Stefan Wild*,
We develop an algorithm for minimax problems that arise in robust optimization in the absence of objective function derivatives. The algorithm utilizes an extension of methods for inexact outer approximation in sampling a potentially infinite-cardinality uncertainty set. Inner subproblems are handled by a variant of the manifold sampling algorithm for derivative-free composite nonsmooth optimization. Clarke stationarity of the algorithm output is established alongside desirable features of the model-based trust-region subproblems encountered.

3 - The Mesh Adaptive Direct Search algorithm for granular and discrete variables
Speaker: Sébastien Le Digabel, Polytechnique Montreal, CA, talk 130
Co-Authors: *Charles Audet*, *Christop Tribes*,
The Mesh Adaptive Direct Search (MADS) algorithm is designed for black- box optimization problems where the functions defining the objective and the constraints are typically the outputs of a simulation seen as a blackbox. It is a derivative-free optimization method designed for continuous variables and is supported by a convergence analysis based on the Clarke calculus. This work introduces a modification to the MADS algorithm so that it handles granular variables, i.e. variables with a controlled number of decimals. This modification involves a new way of updating the underlying mesh so that the precision is progressively increased. A corollary of this new approach is the ability to treat discrete variables. Computational results are presented using the NOMAD software, the free C++ distribution of the MADS algorithm.

Bridging NLP and Theoretical Computer Science

Continuous Optimization
NLP - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle KC7 Building: K, Intermediate 2, Zone: 10

Invited Session 51
Organizer: Aleksander Madry, MIT, US

1 - Improved Max Flow and Bipartite Matching Algorithms via Interior Point Method
Speaker: Aleksander Madry, MIT, US, talk 1192
We describe a new way of employing electrical flow computations to solve classic graph problems. This approach draws on ideas underlying path-following interior-point methods (IPMs) and, in particular, it puts forth a new type of IPM in which the barrier function changes in an adaptive manner. The resulting algorithms provide improvements over some long-standing running time bounds for the maximum flow and minimum s-t cut problems, as well as, the closely related bipartite matching problem. Additionally, it proposes a new approach to analyzing the convergence behavior of IPMs. This approach enables us to improve in our setting over the celebrated convergence bound due to Renegar.

2 - First-order methods: from dynamical systems to discrete optimization
Speaker: Lorenzo Orecchia, Boston University, US, talk 1289
Co-Authors: *Jelena Diakonikolas*,
First-order methods for convex optimization are a fundamental tool in the design of efficient algorithms for large-scale computational problems. While the ideas underlying these methods are simple, e.g., steepest descent, there are a large number of algorithms with similar, yet distinct analyses. I will discuss how to unify many of these methods by viewing them as natural discretizations of dynamical systems that conserve a quantity related to the duality gap of the current solution. 1 I will then describe how the insight given by this continuous view helps in designing algorithms for convex relaxations of discrete problems that do not squarely match standard assumptions, such as positive linear programs and submodular maximization.

3 - A homotopy method for lp regression provably beyond self-concordance
Speaker: Yin Tat Lee, University of Washington, US, talk 334
Co-Authors: *Sébastien Bubeck*, *Michael Cohen*, *Yuanzhi Li*,
We consider the problem of linear regression where the l2 norm loss (i.e., the usual least squares loss) is replaced by the lp norm. We show how to solve such problems up to machine precision. This improves the state of the art . Furthermore we also propose a randomized algorithm solving such problems in input sparsity time. Such a result was only known for p=2. Finally we prove that these results lie outside the scope of the Nesterov-Nemirovski's theory of interior point methods by showing that any symmetric self-concordant barrier on the lp unit ball has self-concordance parameter.

Interior Point Methods in Engineering Applications II

Continuous Optimization
NLP - Tu 3:15pm-4:15pm, Format: 2x30 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 61
Organizer: Jacek Gondzio, University of Edinburgh, GB

1 - A multigrid interior point method for large scale topology optimization
Speaker: Michal Kocvara, University of Birmingham, GB, talk 431
Co-Authors: *Alexander Brune*,
Our aim is to design an interior point method for the structural topology optimization. This is a nonlinear optimization problem of potentially very high dimension.The linear systems arising in the method are solved by a Krylov subspace method preconditioned by geometric multigrid. We will explain the (expected as well as unexpected) difficulties connected with switching from two-dimensional topology optimization to three dimensions, where the dimension of a practical problem reaches tens or even hundreds of millions variables.

2 - Solving large-scale truss layout optimization problems by a primal-dual IPM
Speaker: Jacek Gondzio, University of Edinburgh, GB, talk 654
Co-Authors: *Alemseged Weldeyesus*,
We are concerned with solving challenging engineering problems arising in truss layout design. Such problems arise in the design of bridges, exoskeleton of tall buildings and large span roof structures. The problem is formulated as finding a structure which sustains a given set of applied loads and minimizes the overall weight of the structure. An excessive formulation of the problem involves huge number of possible interconnecting bars and defies any existing optimization software. We propose to solve the problem by a specialized primal-dual interior point method. We use member generation technique to identify only a small subset of possible bars, those which are essential to guarantee desired structural properties. We exploit the algebraic structure of the problem and reduce the normal equations originating from the interior point algorithm to much smaller linear equation systems and apply the preconditioned conjugate gradient method to solve these systems. A special purpose preconditioner based on the mathematical properties of the problem is designed. In the next step stability analysis of such obtained structures is performed. It involves positive semidefinite constraints and lifts the problem to another level of difficulty. Again a specially designed preconditioner combined with Krylov subspace method is applied to tackle the linear algebra subproblem. All proposed methods have been implemented and applied to solve case studies originating from genuine engineering design problems. Computational results demonstrate the efficiency and robustness of the method.

Recent Advances in Conic Programming I

Continuous Optimization
SDP - Tu 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 20 Building: G, 1st floor, Zone: 6

INVITED SESSION 82
Organizer: Makoto Yamashita, Tokyo Institute of Technology, JP

1 - Strong and Cheap SDP and SOCP Hierarchies for Polynomial Optimization
Speaker: Bissan Ghaddar, Ivey Business School, CA, talk 180
In this talk, we propose alternative SDP and SOCP approximation hierarchies to obtain global bounds for general polynomial optimization problems (POP), by using SOS, and SDSOS polynomials to strengthen existing hierarchies for POPs. Specifically, we show that the resulting approximations are substantially more effective in finding solutions of certain POPs for which the more common hierarchies of SDP relaxations are known to perform poorly. Numerical results based on the proposed hierarchies are presented on non-convex instances form the literature as well as on instances from the GLOBAL Library.

2 - BP: a Matlab package based on the Bisection and Projection method for POPs
Speaker: Sunyoung Kim, Ewha W. University, KR, talk 444
Co-Authors: *Naoki Ito*, *Masakazu Kojima*, *Akiko Takeda*, *Kim-Chuan Toh*,
We discuss a Matlab package BP proposed for solving a class of polynomial optimization problems (POPs) with binary, box and complementarity constraints. BP is based on the bisection and projection method (BP) proposed originally for large-scale combinatorial quadratic optimization problems by Kim, Kojima and Toh in 2016. It is designed to solve a simple conic optimizaiton problem derived from a hierarchy of sparse or dense doubly nonnegative relaxations of a large-scale POP in the class. The robustness, reliability and efficiency of matBP are demonstrated in comparison to the software package SDPNAL+ on randomly generated POPs of high degree up to 6 or 8 in several hundreds of variables.

3 - Sum-of-squares optimization with and without semidefinite programming
Speaker: David Papp, NC State University, US, talk 471
Co-Authors: *Sercan Yildiz*,
It is a well-known result of Nesterov's that the cone of sum-of-squares (SOS) polynomials is semidefinite representable. While theoretically satisfactory, the translation of optimization problems involving sum-of-squares polynomials to SDPs is not always practical for two reasons. First, in the common SDP formulation, the dual variables are semidefinite matrices whose condition numbers grow exponentially with the degree of the polynomials involved, which is detrimental for a floating-point implementation. Second, the SDP representation of sum-of-squares polynomials roughly squares the number of optimization variables, which increases the time and memory complexity of the solution algorithms by several orders of magnitude. In the first part of the talk, we show that the conditioning of the SDP representation can be improved substantially using polynomial interpolation techniques. In the second part of the talk, we show that we can avoid the introduction of auxiliary semidefinite matrix variables, and optimize directly over the SOS cone, by applying a customized homogeneous primal-dual interior-point method to SOS polynomials represented as interpolants. We also show that an optimal solution to the conventional SDP can be recovered with little additional effort, hence, our approach can also yield sum-of-squares certificates. Computational results confirm that the algorithm is stable even for problems involving very high-degree polynomials, and that it is several orders of magnitude faster than the conventional SDP approach. The talk is based on joint work with Sercan Yildiz.

Applications in Mixed-Integer Quadratic Programming

DISCRETE OPTIMIZATION & INTEGER PROGRAMMING
MINLP - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1

INVITED SESSION 107
Organizer: Boshi Yang, Clemson University, US

1 - Improved Representations of the Quadratic Linear Ordering Problem
Speaker: Boshi Yang, Clemson University, US, talk 669
Co-Authors: *Audrey DeVries*, *Warren Adams*,
The linear ordering problem (LOP) seeks a least-cost permutation of n objects where, for each pair of objects, a cost is incurred based on the relative ordering. The quadratic linear ordering problem (QLOP) is a generalization that also incurs costs based on products of pairwise orderings. We obtain three results for the QLOP, all in a suitably-defined, linearized-variable space. First, we provide a "lifting theorem" that shows that every facet-defining inequality (facet) for the convex hull of feasible solutions for n objects remains a facet for any $p \geq n$ objects. Such a theorem is known for the LOP, but the complex structure of the QLOP necessitates a more involved argument. Second, we obtain the convex hull representation for $n = 3$ objects. This representation allows for a mixed 0-1 linear form of the general QLOP that uses only half the number of restrictions in the same variable space as recent work, while maintaining the same linear programming relaxation strength. Third, we provide the convex hull representation for $n = 4$ objects, expressed in terms of five families of facets. As a comparison, we give computational experience to show the advantage of our reduced number of constraints in a solution strategy.

2 - Robust QCQPs Under Mixed Integer Uncertainty
Speaker: Areesh Mittal, University of Texas at Austin, US, talk 671
Co-Authors: *Grani Hanasusanto*, *Can Gokalp*,
We study robust convex quadratically constrained quadratic programs where the uncertain problem parameters can contain both continuous and integer components. Several important problems like portfolio management, least squares and support vector machines can be modeled using this framework. Under the natural boundedness assumption on the uncertainty set, we show that these problems are amenable to exact copositive programming reformulations of polynomial size. The emerging convex optimization problems are NP-hard but admit a conservative semidefinite programming (SDP) approximation that can be solved efficiently. We prove that this approximation is stronger than the popular approximate S-Lemma method for problem instances with only continuous uncertainty. We also show that all results can be extended to the two-stage robust optimization setting if

the problem has complete recourse. We assess the effectiveness of our proposed SDP reformulations and demonstrate their superiority over the state-of-the-art solution schemes on stylized instances of least squares, project management, and multi-item newsvendor problems.

3 - Machine Learning and Optimization for Neuroscience
Speaker: Chiara Liti, University of Rome Tor Vergata, IT, talk 873
Co-Authors: *Luigi Bianchi*, *Veronica Piccialli*, *Matteo Cosmi*, *Giampaolo Liuzzi*,
In neuroscience, a fundamental theme is the detection of brain state changes after stimulations. Evoked potentials, for example, which are the electrical responses recorded from the brain after specific stimulations, are widely used by researchers and clinicians to support scientific hypotheses, to make diagnoses or to build communication protocols. Detecting evoked potential translates into a hard binary classification problem. On the one hand, solving this problem requires an efficient machine learning algorithm for online training when the evoked potential is used to build a communication interface. On the other, there is also an interest into feature selection techniques in order not only to improve the classifier performances but also to better understand (offline) the underlying cerebral processes that generated the data in order to support scientific hypotheses or diagnoses. In this work, we give contributions in both these aspects using quadratic optimization and the knowledge of the protocol.

Relative Entropy Optimization II

Continuous Optimization
SDP - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle LC5 Building: L, Intermediate 1, Zone: 10
Invited Session 112
Organizer: Venkat Chandrasekaran, Caltech, US

1 - Newton Polytopes and Relative Entropy Optimization
Speaker: Venkat Chandrasekaran, Caltech, US, talk 97
We discuss the connection between Newton polytopes and relative entropy optimization problems. In particular, we highlight the role played by the Newton polytope structure underlying nonconvex signomial and polynomial optimization problems on the exactness of convex relaxations for these problems based on relative entropy programs.

2 - Optimization over the Hypercube via Sums of Nonnegative Circuit Polynomials
Speaker: Timo de Wolff, TU Berlin, DE, talk 156
Co-Authors: *Mareike Dressler*, *Adam Kurpisz*,
Various key problems from theoretical computer science can be expressed as polynomial optimization problems over the boolean hypercube $\mathcal{H}$. One particularly successful way to prove complexity bounds for these types of problems are based on sums of squares (SOS) as nonnegativity certificates. We initiate optimization over $\mathcal{H}$ via a recent, alternative certificate called sums of nonnegative circuit polynomials (SONC), which can be detected via relative entropy programming. We show that key results for SOS based certificates remain valid: First, for polynomials, which are nonnegative over the n-variate boolean hypercube $\mathcal{H}$ with constraints of degree at most d there exists a SONC certificate of degree at most $n+d$. Second, if there exists a degree d SONC certificate for nonnegativity of a polynomial over the boolean hypercube, then there also exists a short degree d SONC certificate, that includes at most $n^{O(d)}$ nonnegative circuit polynomials.

3 - The REPOP Toolbox: Polynomial Optimization Using Relative Entropy Relaxations
Speaker: Orcun Karaca, ETH Zurich, CH, talk 153
Co-Authors: *Angelos Georghiou*, *John Lygeros*, *Paul Beuchat*, *Georgios Darivianakis*,
Polynomial optimization can be used in a broad range of applications including the synthesis of control policies for non-linear systems, and robust formulations that appear, for example, in approximate dynamic programming. Finding the optimal solution of a polynomial optimization problem is in general computationally intractable. Several studies in the literature resort to hierarchical schemes by employing appropriate convex relaxations of the original problem. In this direction, sum-of-squares methods have shown to be effective in addressing problems of low degree and dimension, with numerous MATLAB toolboxes allowing for efficient implementation. An alternative solution method is to cast the problem as a signomial optimization and solve it using relative entropy relaxations. In contrast to sum-of-squares, this method can tackle problems involving high degree and dimension polynomials. In this talk, we present the REPOP toolbox to address polynomial optimization problems using relative entropy relaxations. The toolbox is equipped with appropriate pre-processing routines that considerably reduce the size of the resulting optimization problem. In addition, we propose a convergent hierarchy which combines aspects from sum-of-squares and relative entropy relaxations. The proposed method offers computational advantages over both methods.

Symmetry Handling in Integer Programs

Discrete Optimization & Integer Programming
IPpractice - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1
Invited Session 129
Organizer: Christopher Hojny, TU Darmstadt, DE

1 - Breaking full-orbitopal symmetries and sub-symmetries
Speaker: Cecile Rottner, EDF, FR, talk 552
Co-Authors: *Pascale Bendotti*, *Pierre Fouilhoux*,
We focus on integer linear programs whose solutions are binary matrices, and the corresponding symmetry group is the set of all column permutations. Orbitopal fixing, introduced by Kaibel et al., is a symmetry-breaking technique in the special case of partitioning (resp. packing) formulations involving matrices with exactly (resp. at most) one 1-entry per row. Our main result is to extend orbitopal fixing to formulations with no restrictions on the number of 1 per row. We determine all variables whose values are fixed in the intersection of an hypercube face with the full orbitope, defined as the convex hull of binary matrices with lexicographically nonincreasing columns. Sub-symmetries arising in a given subset of matrices are also considered, leading to define the full sub-orbitope in the case of the sub-symmetric group. We

propose a linear time orbitopal fixing algorithm handling both symmetries and sub-symmetries. Experimental results for the Unit Commitment Problem are presented to show the effectiveness of the algorithm.

2 - Symmetry Breaking Inequalities from the Schreier-Sims table

Speaker: Domenico Salvagnin, University of Padova, IT, talk 151

We propose a way to derive symmetry breaking inequalities for a mixed-integer programming (MIP) model from the Schreier-Sims table of its formulation group. We then show how to consider only the action of the formulation group onto a subset of the variables. Computational results show that this can lead to considerable speedups on some classes of models.

3 - Symmetry Breaking Polytopes: A Framework for Symmetry Handling in Binary Program

Speaker: Christopher Hojny, TU Darmstadt, DE, talk 143

Co-Authors: *Marc Pfetsch*,

A standard way to handle symmetries in binary programs is to add inequalities that cut off solutions that are lexicographically not maximal in their orbits w.r.t. the corresponding symmetry group. To allow for a general analysis of such inequalities, we consider symretopes, which are the convex hull of all binary vectors that are lexicographically maximal in their orbits. Thus, adding inequalities of an IP formulation for symretopes to a binary program removes all the symmetry of the program. Related knapsack polytopes are so-called symresacks that are based on one permutation. In this talk, we investigate these two kinds of polytopes. If the problem contains certain set packing and partitioning constraints, we show that strong symmetry handling inequalities for symresacks can be derived. In particular, a complete description can be obtained for special permutations. For so-called orbitopes, i.e., special symretopes in which symmetries act by permuting the columns of a 0/1-matrix, further polyhedral results can be proven. We then show how these results behave in practice. The corresponding numerical results investigate the effectiveness of the combination of these approaches.

Nonlinear Optimization and Variational Inequalities III

Continuous Optimization

Variat - Tu 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 143

Organizer: Xin Liu, Chinese Academy of Sciences, CN

1 - A primal-dual IPM with rapid detection on infeasibility for nonlinear programs

Speaker: Xinwei Liu, Hebei University of Technology, CN, talk 89

Co-Authors: *Yu-Hong Dai*, *Jie Sun*,

With the help of a logarithmic barrier augmented Lagrangian function, a two-parameter primal-dual nonlinear system is proposed, which corresponds to the Karush-Kuhn-Tucker conditions and the infeasible stationary condition of nonlinear programs, respectively, as one of two parameters vanishes. Based on this distinctive system, we present a new primal-dual interior-point method for nonlinear programs and prove that it has the capability to rapidly detect the infeasibility of the problem when a problem is infeasible. Our method converges to a Karush-Kuhn-Tucker point of the original problem as the barrier parameter tends to zero. Otherwise, the scaling parameter tends to zero, and the method converges to either an infeasible stationary point or a singular stationary point of the original problem. Moreover, Under suitable conditions, not only the method can be superlinearly or quadratically convergent to the Karush-Kuhn-Tucker point as the original problem is feasible, but also it can be superlinearly or quadratically convergent to the infeasible stationary point. Preliminary numerical results show that the method is efficient in solving some simple but hard problems and some standard test problems from the CUTE collection.

2 - Some discussion on nonsmooth convex regression with cardinality penalty

Speaker: Wei Bian, Harbin Institute of Technology, CN, talk 815

Co-Authors: *Xiaojun Chen*,

This paper studies a class of constrained sparsity regression problem. We focus on the case where the loss function is convex but nonsmooth, and the penalty (regularization) term is defined by the cardinality function. The contributions of this paper are fundamental and important for this problem on both the theoretical and algorithmic aspects. First, we prove that the lifted stationary points of the suggested continuous relaxation model with capped-l1 penalty not only preserve all the global minimizers, but also correspond to the local minimizers of the original regression problem with cardinality penalty. Second, we propose an algorithm, called the SPG algorithm, for solving the lifted stationary points of the continuous relaxation model, which is an effective method for finding a better local minimizer of the studied regression model with cardinality penalty. Our algorithm is a novel combination of the classical proximal gradient algorithm and the smoothing method.The proposed SPG algorithm due to the special structure of the optimization model, the decomposition and approximation methods for the objective function in each iteration, and the skilled design for the smoothing parameter achieves the only known global convergence and the best known convergence rate for this kind of problem. Finally, we provide numerical evidence with three examples to illustrate the validity and good performance of the results in this paper.

3 - Proximal Algorithms with Extrapolation for Nonconvex Nonsmooth Problems

Speaker: Bo Wen, Hebei University of Technology, CN, talk 243

In this talk, we mainly consider proximal algorithms with extrapolation for solving two classes of structured nonconvex nonsmooth optimization problems. We first consider the proximal gradient algorithm with extrapolation for minimizing the sum of a Lipschitz differentiable function and a proper closed convex function. Under one error bound condition, we establish the linear convergence rate of both the objective sequence and the iterate sequence generated by the algorithm, Then, we propose a proximal difference-of-convex(DC) algorithm with extrapolation for solving a class of DC problems. We show that any accumulation point of the sequence generated by our algorithm is a stationary point of the DC optimization problem for a general choice of extrapolation parameters. Moreover, using the Kurdyka-Lojasiewicz inequality, we establish global convergence of the sequence generated by our algorithm and analyze its convergence rate. From the results in our numerical experiments on two difference-of-convex regularized least squares models, proximal difference-of-convex algorithm with extrapolation usually outperforms the proximal DC algorithm and the general iterative shrinkage and thresholding algorithm.

Pricing Methods

Specific Models, Algorithms, and Software
Logistics - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 182
Organizer: Rafael Martinelli, PUC-Rio, BR

1 - A branch-and-price algorithm for the Minimum Latency Problem
Speaker: Teobaldo Bulhões Júnior, UFPB, BR, talk 1273
Co-Authors: *Ruslan Sadykov*, *Eduardo Uchoa*,
This work deals with the Minimum Latency Problem (MLP), a variant of the well-known Traveling Salesman Problem in which the objective is to minimize the sum of waiting times of customers. This problem arises in many applications where customer satisfaction is more important than the total time spent by the server. This paper presents a novel branch-and-price algorithm for MLP that strongly relies on new features for the ng-path relaxation, namely: a new labeling algorithm with an enhanced dominance rule named multiple partial label dominance; a generalized definition of ng-sets in terms of arcs, instead of nodes; and a strategy for decreasing ng-set sizes when those sets are being dynamically chosen. Also, other elements of efficient exact algorithms for vehicle routing problems are incorporated into our method, such as reduced cost fixing, dual stabilization, route enumeration and strong branching. Computational experiments over TSPLIB instances are reported, showing that several instances not solved by the current state-of-the-art method can now be solved.
2 - Pricing, cycles, and pivots
Speaker: Jacques Desrosiers, HEC Montreal, CA, talk 1066
Co-Authors: *Jean Bertran Gauthier*,
Within the realm of linear programming, iterative algorithms that maintain feasibility throughout the solution process all identify a direction and then move along the latter with some nonnegative step-size. We call the oracle used to identify a direction the pricing problem. Since this oracle maintains its form across the various algorithms, it is a common denominator whose canonical form is first observed in the minimum mean cycle-canceling algorithm, the average cost of a cycle being taken over the number of arcs. In this respect, the network flow nomenclature is heavily borrowed thus contributing to the intuitive understanding of the pricing problem. It is well known that all directed cycles necessary to reach an optimal minimum cost flow solution can be observed on the residual network. Furthermore, each of these can individually accommodate some strictly positive flow. In optimization terms, each of these directed cycles, or combination of, forms a direction. A degenerate pivot is therefore induced when the selected cycle does not actually exist on the residual network. The concepts of paths and cycles along with some network flow properties can be transferred to linear programs and alternative necessary and sufficient optimality conditions expressed on the so-called residual problem are obtained in the process. We propose a family of algorithms with non-degenerate pivots and also show that the local search heuristics for vehicle routing problems, such as 2-opt, 3-opt, relocate, ... are indeed directed cycles on the residual network.
3 - Branch-Cut-and-Price Solver for Vehicle Routing Problems
Speaker: Ruslan Sadykov, Inria Bordeaux - Sud-Ouest, FR, talk 1619
Co-Authors: *Issam Tahiri*, *Francois Vanderbeck*, *Rémi Duclos*, *Artur Pessoa*, *Eduardo Uchoa*,
Large progress have been made recently in solving exactly classical vehicle routing problems using Branch-Cut-and-Price approaches. The implementation of such advanced techniques remains very demanding. Hence a contribution to the community would be to make such code available for benchmarking. Our group is working towards this goal. Our first step is to provide a solver with a web interface to submit an instance and collect its solutions in return. Our modern Branch-Cut-and-Price algorithm is running on backhand server. The user receives the best primal and dual bound values found within the time limit and the best found primal solution (if any). The solver supports several variants including the Capacitated Vehicle Routing Problem, Vehicle Routing Problem with Time Windows, and the Distance-Constrained Vehicle Routing Problem. Multi-Depot, Heterogeneous-Fleet and Site-Dependent variants are also supported. We adopt VRP-REP format to define the instances.

Nonconvex Optimization: Theory and Methods - Part 2

Continuous Optimization
NonSmooth - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 186
Organizer: Russell Luke, University of Göttingen, DE

1 - Splitting methods for nonconvex feasibility problems
Speaker: Guoyin Li, University of New South Wales, AU, talk 1495
Co-Authors: *Ting Kei Pong*,
Splitting methods is a class of important and widely used approach for solving feasibility problems. The behaviour of these methods has been reasonably understood in the convex setting. They have been further successfully applied to various nonconvex instances recently; while the theoretical justification in this latter setting is far from complete. In this talk, we will examine global convergence of several popular splitting methods (including Douglas-Rachford splitting method and Peaceman Rachford splitting method) for general nonconvex nonsmooth optimization problems. We will then demonstrate how to make use of these new results to obtain innovative splitting methods with global convergence guarantees for solving nonconvex feasibility problems. Finally, we will also present numerical experiments illustrating the efficiency of the proposed methods.
2 - Projective Splitting with Forward Steps

Speaker: Patrick Johnstone, Rutgers, US, talk 82
Co-Authors: *Jonathan Eckstein*,
This work is concerned with the classical problem of finding a zero of a sum of maximal monotone operators. For the projective splitting framework recently proposed by Combettes and Eckstein, we show how to replace a calculation using a backward step with one based on two forward steps. The resulting algorithms have the same kind of coordination procedure and can be implemented in the same distributed, asynchronous, and block-iterative manner, but may perform backward steps on some operators and forward steps on others. Prior algorithms in the projective splitting family have used only backward steps. Forward steps can be used for any Lipschitz-continuous operators provided the stepsize is bounded by the inverse of the Lipschitz constant. If the Lipschitz constant is unknown, a simple backtracking linesearch procedure can be used. If a Lipschitz continuous operator is also affine, this backtracking procedure comes with only minor additional computation. We also derive convergence rates. An ergodic $O(1/k)$ objective function convergence rate is established in the context of convex optimization while linear convergence is established for monotone inclusion problems featuring strong monotonicity and cocoercivity. We close by empirically studying the performance of several kinds of projective splitting algorithms on various data fitting problems.

3 - Convergence Analysis for Nonconvex Optimization Made Easy
Speaker: Russell Luke, University of Göttingen, DE, talk 133
Co-Authors: *Nguyen Thao*, *Matthew Tam*,
If you want linear convergence of a fixed point algorithm it suffices to have two properties. One of the two properties is actually necessary, and the second property, in proper balance with the first, is sufficient. The necessary property is metric subregularity of your algorithm at the set of fixed points. This property is difficult to verify in general, but necessity of the condition permits empirical observation from numerical experiments. The sufficient condition is a relaxation of the averaging property associated with monotone mappings (through the resolvent) on linear spaces that allows us to handle fundamental algorithms for nonconvex optimization, for instance. The relaxation, what we call almost averaged, naturally leads to a categorization of tractable nonconvexity, and this is usually easy to characterize and verify. We demonstrate these ideas on popular algorithms for nonconvex optimization.

MIP under Uncertainty 2

Discrete Optimization & Integer Programming
IPtheory - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 232
Organizer: Simge Kucukyavuz, University of Washington, US

1 - Two-stage stochastic p-order conic mixed integer programs
Speaker: Manish Bansal, Virginia Tech, US, talk 154
Co-Authors: *Yingqiu Zhang*,
We consider two-stage stochastic p-order conic mixed integer programs (TSS-CMIPs) in which the second-stage problems have p-order conic constraints along with integer variables. We present sufficient conditions under which the addition of parametric (non)-linear cutting planes provides convex programming equivalent for the second-stage CMIPs. In addition, we introduce TSS-CMIPs with structured p-order CMIPs in the second stage and derive classes of parametric (non)-linear cuts that satisfy the foregoing conditions. These cuts allow us to relax the integrality restrictions on the second-stage integer variables without effecting the integrality of the optimal solution of the TSS-CMIP. We also perform extensive computational experiments by solving randomly generated structured TSS-CMIPs with second-order conic constraints, and observe that there is a significant reduction in the total solution time taken to solve these problems after adding our parametric cuts.

2 - Inexact cutting plane techniques for two-stage stochastic mixed-integer programs
Speaker: Ward Romeijnders, University of Groningen, NL, talk 228
Co-Authors: *Niels van der Laan*, *Suvrajeet Sen*,
We approximate two-stage stochastic mixed-integer programs by applying inexact cutting plane techniques to the second-stage problem. This yields an approximating model that is convex in the first-stage decision variables, so that it can be solved using standard decomposition techniques for solving continuous stochastic programs. We derive an error bound for this approximation and show that the approximation error converges to zero if all total variations of the probability density functions of the random variables in the model converge to zero.

3 - Solving Stochastic and Bilevel Mixed-Integer Programs via a Generalized Value F.
Speaker: Andrew Schaefer, Rice University, US, talk 560
Co-Authors: *Onur Tavaslioglu*, *Oleg Prokopyev*,
We introduce the generalized value function of a mixed-integer program, which is simultaneously parameterized by its objective and right-hand side. We describe its fundamental properties, which we exploit through three algorithms to calculate it. We then show how this generalized value function can be used to reformulate two classes of very difficult mixed-integer optimization problems: two-stage stochastic mixed-integer programming and multi-follower bilevel mixed-integer programming. For both of these problem classes, the generalized value function approach allows the solution of instances that are significantly larger than those solved in the literature.

Optimal Control and PDE Constrained Optimization

Continuous Optimization
Control - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Invited Session 233
Organizer: Hasnaa Zidani, ENSTA ParisTech, FR

1 - Control of semi discretized (in space) systems of parabolic equations.
Speaker: Damien Allonsius, Aix-Marseille Université, FR, talk 1340

Co-Authors: *Franck Boyer*, *Morgan Morancey*,
In this talk we consider the problem of null controllability of a semi discretized in space system of parabolic equations. The elliptic operator is discretized by a finite differences scheme. The problem consists in finding a discrete control that drives the solution to zero. Moreover, for stability reasons, we impose that this control remains uniformly bounded with respect to the discretization parameter. First, we study this problem when the space is of dimension one by applying the moments method. This method requires some spectral properties of the discretized elliptic operator. Second, we consider the same problem on a multi dimensional geometry. We tackle this problem using the previous result. Some numerical simulations in two dimensions based on the Hilbert Uniqueness Method will illustrate the presentation.

2 - Strong local optimality for generalised L^1 optimal control problems
Speaker: Francesca Chittaro, Université de Toulon, FR, talk 855
Co-Authors: *Laura Poggiolini*,
We consider the class of control affine optimal control problems with a cost functional involving the absolute value of the control. The Pontryagin extremals associated with such systems are given by (possible) concatenations of bang arcs with singular arcs and with inactivated arcs, that is, arcs where the control is identically zero. Here we consider Pontryagin extremals given by a bang-inactive-bang concatenation. We establish sufficient optimality conditions for such extremals, in terms of some regularity conditions and of the coercivity of a suitable finite-dimensional second variation.

3 - Shortest Dubins Paths through Three Points
Speaker: Zheng Chen, Technion, IL, talk 823
Co-Authors: *Tal Shima*,
The Dubins vehicle, moving only forward at a constant speed with a minimum turning radius, provides a good kinematic prototype for nonholonomic robots. In this work, the 3-Point Dubins Problem (3PDP), which consists of steering such vehicles through three consecutive points with prescribed heading orientations at initial and final points, is studied. By applying the Pontryagin Maximum Principle, some necessary conditions are formulated and some geometric properties for the 3PDP are established. As a result, it is shown that the shortest path of a 3PDP must be among 18 candidates. A common formula is established for these candidates and analyzing the formula not only covers existing results but also presents new properties. Since the common formula can be converted into a polynomial, the 3PDP can be efficiently solved by finding zeros of some polynomials. As an application of the polynomial-based solution, a gradient-free descent method is finally designed for solving a typical heuristic variant of the Dubins Traveling Salesman Problem.

Distributionally Robust and Stochastic Optimization: A Sampling/Scenario Perspective

Optimization under Uncertainty
Stoch - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 32 Building: B, Ground Floor, Zone: 5

Invited Session 249

Organizer: Guzin Bayraksan, Ohio State University, US

1 - Optimizing the Design of a Latin Hypercube Sampling Estimator for SAA
Speaker: Alexander Zolan, University of Texas-Austin, US, talk 1361
Co-Authors: *John Hasenbein*, *David Morton*,
Latin hypercube sampling (LHS) reduces variance, relative to naive Monte Carlo sampling, by partitioning the support of a random vector into strata. When creating these estimators, we must determine: (i) the number of strata; and, (ii) the partition that defines the strata. In this paper, we address the second point by formulating a nonlinear optimization model that designs the strata to yield a minimum-variance LHS estimator for a univariate function. Under a discrete set of candidate boundary points, the optimization model can be solved via dynamic programming. We extend this method by using an approximation of estimator variance to obtain strata for the domain of a multivariate function. We solve this problem exactly via a dynamic program for each random component. We present sufficient conditions for this technique to guarantee variance reduction compared to using LHS with equal-probability strata. Finally, we show empirical evidence of variance and bias reduction when using sample average approximation to solve stochastic programming problems in the literature via our sampling method, compared to commonly used variance reduction techniques.

2 - Out-of-sample analysis of distributionally robust optimization
Speaker: Jun-ya Gotoh, Chuo university, JP, talk 926
Co-Authors: *Michael Kim*, *Andrew Lim*,
In this paper, we study the out-of-sample properties of robust empirical optimization and develop a theory for data-driven calibration of the robustness parameter for worst-case maximization problems with concave reward functions. Building on the intuition that robust optimization reduces the sensitivity of the expected reward to errors in the model by controlling the spread of the reward distribution, we show that the first-order benefit of "little bit of robustness" is a significant reduction in the variance of the out-of-sample reward while the corresponding impact on the mean is almost an order of magnitude smaller. One implication is that a substantial reduction in the variance of the out-of-sample reward (i.e. sensitivity of the expected reward to model misspecification) is possible at little cost if the robustness parameter is properly calibrated. To this end, we introduce the notion of a robust mean-variance frontier to select the robustness parameter and show that it can be approximated using resampling methods like the bootstrap. Our examples show that robust solutions resulting from "open loop" calibration methods (e.g. selecting a 90 percent confidence level regardless of the data and objective function) can be very conservative out-of-sample, while those corresponding to the ambiguity parameter that optimizes an estimate of the out-of-sample expected reward (e.g. via the bootstrap) with no regard for the variance are often insufficiently robust.

3 - Effective Scenarios in Multistage Distributionally Robust Stochastic Programs
Speaker: Guzin Bayraksan, Ohio State University, US, talk 1547
Co-Authors: *Hamed Rahimian*, *Tito Homem-de-Mello*,
Traditional multistage stochastic programs assume the underlying probability distribution is known. However, in practice,

the probability distribution is often not known or cannot be accurately approximated. One way to address such distributional ambiguity is to use distributionally robust stochastic programming (DRSP), which minimize the worst-case expected cost with respect to a set of probability distributions. In this talk, we study multistage convex DRSP with a finite set of scenarios. We illustrate that not all but only some scenarios might have an effect on the optimal value, and we formally define this notion for multistage DRSP. In particular, we investigate problems where the distributional ambiguity is modeled stagewise by the total variation distance on conditional probability distributions. We show the resulting problem is a multistage risk-averse optimization with nested coherent risk measures formed by a convex combination of the worst-case and conditional value-at-risk. We conduct perturbation analysis with respect to a collection of scenarios being excluded and propose easy-to-check sufficient conditions for effectiveness. We explore effectiveness of scenario paths as well as scenarios conditional on the history of the stochastic process. Computational experiments illustrate the results on finance and energy problems.

New developments in prophet inequalities and related settings

Discrete Optimization & Integer Programming
COMB - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 41 Building: C, 3rd floor, Zone: 1

Invited Session 258
Organizer: Ruben Hoeksma, Universität Bremen, DE

1 - Prophet Inequality and Prophet Secretary
Speaker: Ashish Chiplunkar, EPFL, CH, talk 171
Co-Authors: *Yossi Azar*, *Haim Kaplan*,
The problems of Prophet Inequality and Prophet Secretary concern choosing the one out of an online sequence of samples from a known adversarial or random sequence of probability distributions, with the objective of maximizing the value of the chosen sample. These problems model online posted price mechanisms for approximate welfare maximization. Over the last four decades, several interesting variants of the Prophet Inequality have been studied, and tight bounds on the performance of algorithms are known. In contrast, the Prophet Secretary problem has been introduced only recently and remains relatively poorly understood. In this talk I will present a survey of results related to the Prophet Inequality and Prophet Secretary problems. I will conclude with the recent results in collaboration with Yossi Azar and Haim Kaplan, about improved bounds on the performance of online algorithms for Prophet Secretary.

2 - Prophets, Secretaries, and Prices
Speaker: Brendan Lucier, Microsoft, US, talk 518
Prophet inequalities capture a natural class of online selection problems. A recent flurry of developments has extended prophet inequalities in multiple ways. This includes improved results under mild input restrictions, such as Prophet Secretary (random arrival order) or large-market assumptions. It also includes extensions to new reward and decision structures, as in matching and combinatorial markets. Each new extension has led to exciting developments in posted-price mechanisms for increasingly complex allocation problems. In this talk I will survey this line of work, highlighting connections between the economic perspective and the theory of online stochastic optimization.

3 - Posted Prices and Threshold Strategies for Random Arrivals
Speaker: Tim Oosterwijk, Universidad de Chile, CL, talk 68
Co-Authors: *José Correa*, *Ruben Hoeksma*, *Tjark Vredeveld*, *Patricio Foncea*,
The classic prophet inequality states that, when faced with a finite sequence of non-negative independent random variables, a gambler who knows their distribution and is allowed to stop the sequence at any time, can obtain, in expectation, at least half as much reward as a prophet who knows the values of each random variable and can choose the largest one. The fraction 1/2 is also best possible. In this work we consider the situation in which the sequence comes in random order. We look at both a non-adaptive and an adaptive version of the problem. In the former case the gambler sets a threshold for every random variable a priori, while in the latter case the thresholds are set when a random variable arrives. For the non-adaptive case, we obtain an algorithm computing thresholds achieving an expected reward within at least a 1 - 1/e fraction of the expected maximum and prove this constant is optimal. For the adaptive case with i.i.d. random variables, we obtain a tight 0.745-approximation, solving a problem posed by Hill and Kertz in 1982 and proving a follow-up conjecture of Kertz from 1986. We also apply these prophet inequalities to posted price mechanisms, and prove the same tight bounds for both a non-adaptive and an adaptive posted price mechanism when buyers arrive in random order.

Convex relaxations in MINLP

Discrete Optimization & Integer Programming
MINLP - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 278
Organizer: Adam Letchford, Lancaster University, GB

1 - A convex reformulation and an outer approximation for a class of BQP
Speaker: Borzou Rostami, Polytechnique Montreal, CA, talk 1185
Co-Authors: *Andrea Lodi*, *Fausto Errico*,
In this paper, we propose a general modeling framework for a large class of binary quadratic programs subject to variable partitioning constraints. This problem has a wide range of applications as many of the binary quadratic programs with linear constraints can be represented in this form. By exploiting the problems' structure, we propose mixed-integer nonlinear program (MINLP) and mixed-integer linear program (MILP) reformulations and show the relationship between the two models in terms of the relaxation strength. Our methodology relies on a convex reformulation of the proposed MINLP and a branch-and-cut algorithm based on outer approximation cuts where the cuts are generated on the fly by efficiently solving separation subproblems. Our experimental results on various quadratic combinatorial optimization problems show that our approach outperforms the state-of-the-art solver applied to different MILP reformulations of the corresponding

problems.

2 - Separating over the convex hull of MINL constraints
Speaker: Felipe Serrano, Zuse Institute Berlin, DE, talk 1219
Exact separation is a technique to solve the separation problem exactly. It has had many applications, a recent one being the computation of facets arbitrary polyhedral mixed-integer sets. We apply this methodology to optimize over the relaxation obtained by intersecting the convex hull of every 1-row MINL relaxations of a MINLP and report on the gap closed by this relaxation over the MINLPLib

3 - Bi-Perspective Cuts for Mixed-Integer Fractional Programs
Speaker: Adam Letchford, Lancaster University, GB, talk 94
Co-Authors: *Qiang Ni*, *Zhaoyu Zhong*,
Perspective functions have long been used to convert fractional programs into convex programs. More recently, they have been used to form tight relaxations of mixed-integer nonlinear programs with indicator variables. Motivated by a practical application, we consider problems that have a fractional objective and indicator variables simultaneously. To obtain a tight relaxation of such problems, one must consider what we call a bi-perspective (BP) function. An analysis of BP functions leads to the derivation of a new family of cutting planes, which we call BP-cuts. Computational results indicate that BP-cuts typically close a substantial proportion of the integrality gap.

Applications of MINLP

Discrete Optimization & Integer Programming
MINLP - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4

Invited Session 281
Organizer: Dolores Romero Morales, Copenhagen Business School, DK

1 - Packing problem as mixed integer non-linear model using formulation space search
Speaker: Claudia López, National University of Mexico, MX, talk 1472
Co-Authors: *John Beasley*,
In this work we present the packing problem as a mixed integer non-linear programming problem which is solved using a heuristic called formulation space search. The packing problems that we solved consider a circular container, as for the objects to be pack we have two different shapes: circles and squares/rectangles. Each case is considered in an independent manner. The mathematical model that describes the packing problem may take two different objectives, maximize the objects to be packed or maximize the total area covered by the objects to be packed. In both cases, the size of the objects is fixed. Here we introduce an element of choice; the object may or may not be packed. Hence, it is possible that not all the objects considered to be pack will be in the final arrangement. We show how we managed to eliminate a maximization term that arise in one of the constraints of our formulation when working with the rectangle/square case. Computational results are presented for the test instances considered.

2 - Piecewise Linear Function Fitting via Mixed-Integer Linear Programming
Speaker: Steffen Rebennack, KIT, DE, talk 313
Co-Authors: *Vitaliy Krasko*,
Piecewise linear (PWL) functions are used in a variety of applications. Computing such continuous PWL functions, however, is a challenging task. Software packages and the literature on PWL function fitting are dominated by heuristic methods. This is true for both fitting discrete data points and continuous univariate functions. The only exact methods rely on non-convex model formulations. Exact methods compute continuous PWL function for a fixed number of breakpoints minimizing some distance function between the original function and the PWL function. An optimal PWL function can only be computed if the breakpoints are allowed to be placed freely and are not fixed to a set of candidate breakpoints. In this paper, we propose the fi rst convex model for optimal continuous univariate PWL function fi tting. Dependent on the metrics chosen, the resulting formulations are either mixed-integer linear programming or mixed-integer quadratic programming problems. These models yield optimal continuous PWL functions for a set of discrete data. Based on these convex formulations, we further develop an exact algorithm to fit continuous univariate functions. Computational results for benchmark instances from the literature demonstrate the superiority of the proposed convex models compared to state-of-the-art non-convex models.

3 - Feature Selection for Benchmarking
Speaker: Dolores Romero Morales, Copenhagen Business School, DK, talk 1469
Co-Authors: *Sandra Benítez-Peña*, *Peter Bogetoft*,
In this talk we present novel Mixed Integer Nonlinear Programming formulations for Benchmarking. Within Benchmarking, Data Envelopment Analysis is one of the most widely used tools. It aims at benchmarking the performance of decision marking units (DMUs), which use the same inputs and produce the same outputs, against each other. Data Envelopment Analysis calculates an efficiency score for each of the DMUs, so that DMUs with a score equal to one are in the so-called efficient frontier. Feature (outputs and inputs) selection has a significant impact on the shape of the efficient frontier, as well as the insights given to the inefficient DMUs. It is common to use apriori selection rules based on Statistical Analysis or Information Theory. Alternatively, an ex-post analysis of the sensitivity of the efficient frontier to additional features can be run to detect whether relevant features have been left out. In this talk, we present Mixed Integer Nonlinear Programming formulations that enrich the classical Data Envelopment Analysis mathematical optimization formulation with (i) zero-one decision variables modelling the selection of features, and (ii) a regularization term to control the number of used features. Numerical results will be presented using data from Electricity Distribution System Operators.

Equilibrium Modelling in Energy

Specific Models, Algorithms, and Software
Energy - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 290
Organizer: Thomas Kallabis, University of Duisburg-Essen, DE

1 - Optimal Price Zones and Investment Incentives in Electricity Markets
Speaker: Mirjam Ambrosius, FAU, DE, talk 1482
Co-Authors: *Veronika Grimm*, *Thomas Kleinert*, *Frauke Liers*, *Martin Schmidt*, *Gregor Zöttl*,
With a growing share of renewables, regional price signals become more important as a possible remedy for dealing with network congestion. Additional bidding zones within countries could enable better signaling of scarcities induced by the transmission network and are therefore under discussion. This paper addresses the problem of determining the welfare-optimal bidding zone configuration for the German electricity market, and its impact on investment incentives. We use a multilevel optimization model to determine the optimal configuration of price zones via graph partitioning. It incorporates the optimal determination of interzonal transmission capacities, generation capacity investment, spot market trading, and redispatch. The resulting optimization problem is solved to global optimality using a specifically tailored Benders decomposition approach. Our results show that market splitting with the right zonal configuration and optimal interzonal transmission capacities can lead to high welfare gains and to a more efficient allocation of generation capacity as compared to the case of a single price zone.

2 - Strategic generation investment using a stochastic rollinghorizon MPEC approach
Speaker: Thomas Kallabis, University of Duisburg-Essen, DE, talk 879
Co-Authors: *Steven Gabriel*,
Investments in power generation assets are multi-year projects with high costs and multi-decade lifetimes. Since market circumstances can significantly change over time, investments into such assets are risky and require structured decision-support systems. Investment decisions and dispatch in electricity spot markets are connected, thus requiring anticipation of expected market outcomes. This strategic situation can be described as a bilevel optimization model. At the upper level, an investor decides on investments while anticipating the market results. At the lower level, a market operator maximizes welfare given consumer demand and installed generation assets as well as producer price bids. In this paper, we formulate this problem as a mathematical program with equilibrium constraints (MPEC). We consider this model to include a dynamic rolling-horizon optimization. This structure splits the investment process into multiple stages, allowing the modification of wait-and-see decisions. This is a realistic representation of actors making their decision under imperfect information. We test the rolling-horizon configuration against multiple alternatives to evaluate its impact on results and runtimes as well as the value of recourse action.

3 - Coordination Problems in the Coupling of Gas and Electricity Markets
Speaker: Christoph Weber, U Duisburg-Essen, DE, talk 1539
In future energy systems with a high proportion of renewables, a "‘dark cold calm"’ leads to high electricity demand with little renewable supply and simultaneously high gas demand for heating purposes. In the current European market framework, a multi-stage framework is used to coordinate supply and demand across sectors. This includes notably an Entry-Exit booking and nomination approach for the gas market and a copperplate network assumption for the electricity market. We base our model on the gas market model proposed by Grimm et al. (2017) and extend the model to include the electricity market. Hence the problem is formulated as a multilevel optimization problem under uncertainty. Thereby two interrelated types of uncertainty are considered: uncertain demand from gas-fired electricity plants and uncertain gas demand for heating purposes. We furthermore extend the model proposed by Grimm et al. by including the possibility for booking of non-secure capacities. The analysis of a stylized example shows that the staged coordination process leads to efficiency losses compared to a coordinated planning with full use of available information. Reference: Grimm, V., Schewe, L., Schmidt, M., Zöttl, G. (2017): A Multilevel Model of the European Entry-Exit Gas Market. Working Paper SSRN-ID 2978135

Recent Advances in Stochastic and Non-convex Optimization II

Continuous Optimization
RandomM - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10
Invited Session 304
Organizer: Mingyi Hong, University of Minnesota, US

1 - First-order Stochastic Algorithms for Escaping From Saddle Points
Speaker: Tianbao Yang, University of Iowa, US, talk 549
Co-Authors: *Yi Xu*, *Rong Jin*,
In this talk, I will focus on first-order methods for solving stochastic non-convex optimization problems. To escape from saddle points, we propose first-order procedures to extract negative curvature from the Hessian matrix through a principled sequence starting from noise, which are referred to NEgative-curvature-Originated-from-Noise or NEON. The proposed procedures enable one to design purely first-order stochastic algorithms for escaping from non-degenerate saddle points with a much better time complexity (almost linear time in the problem's dimensionality). In particular, I will present a general framework of first-order stochastic algorithms with a second-order convergence guarantee based on our new technique and existing algorithms that may only converge to a first-order stationary point. For finding a nearly second-order stationary point x such that $\|\nabla F(x)\| \leq \epsilon$ and $\nabla^2 F(x) \geq -\sqrt{\epsilon} I$ (in high probability), the best time complexity of the presented algorithms is $\widetilde{O}(d/\epsilon^{3.5})$, where $F(\cdot)$ denotes the objective function and d is the dimensionality of the problem. To the best of our knowledge, this is the first theoretical result of first-order stochastic algorithms with an almost linear time in terms of problem's dimensionality for finding second-order stationary points, which is even competitive with existing stochastic algorithms hinging on the second-order information.

2 - Markov chain Monte Carlo methods for Dynamic Stochastic Optimization
Speaker: John Birge, University of Chicago, US, talk 1447
This talk will discuss methods for MCMC method for stochastic optimization. The goal of these methods is to reduce the effect of dimensionality which usually arises in dynamic stochastic optimization that suffers from the curse of dimensionality as state spaces grow exponentially in dimension and in the number of periods. The approach maintains a constant number of particles and optimizes over transitions

from sets of particles at one stage to another. With this approach, the distribution of particles converges to a posterior distribution over the states and values that are optimal for a discrete choice. Using importance sampling can then reduce the bias in this approach to achieve overall convergence. This talk will discuss how this approach can be applied in a variety of contexts including portfolio optimization and production planning.

3 - Composite Difference-Max Programs for Modern Statistical Estimation Problems

Speaker: Jong-Shi Pang, Univ. Southern California, US, talk 1682

Co-Authors: *Cui Ying*, *Bodhisattva Sen*,

Many modern statistical estimation problems are defined by three major components: a statistical model that postulates the dependenceof an output variable on the input features; a loss function measuring the error between the observed output and the model predicted output; and a regularizer that controls the overfitting and/or variable selection in the model. We study the sampling version of this generic statistical estimation problem where the model parameters are estimated by empirical risk minimization, which involves the minimization of the empirical average of the loss function at the data points weighted by the model regularizer. In our setup we allow all three component functions discussed above to be of the difference-of-convex (dc) type and illustrate them with a host of commonly used examples, including those in continuous piecewise affine regression and in deep learning (where the activation functions are piecewise affine). We describe a nonmonotone majorization-minimization (MM) algorithm for solving the unified nonconvex, nondifferentiable optimization problem which is formulated as a specially structured composite dc program of the pointwise max type, and present convergence results to a directional stationary solution. An efficient semismooth Newton method is proposed to solve the dual of the MM subproblems. Numerical results are presented to demonstrate the effectiveness of the proposed algorithm and the superiority of continuous piecewise affine regression over the standard linear model.

Distributed and Asynchronous Learning

Specific Models, Algorithms, and Software

Learning - Tu 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 16 Building: I, 2nd floor, Zone: 7

Invited Session 323

Organizer: Ion Necoara, Univ. Politehnica Bucharest, RO

1 - Avoiding communication in first-order methods for convex optimization

Speaker: Aditya Devarakonda, UC Berkeley, US, talk 1211

Co-Authors: *Kimon Fountoulakis*, *James Demmel*, *Michael Mahoney*,

Parallel computing has played an important role in speeding up convex optimization methods for big data analytics and large-scale machine learning (ML). However, the scalability of these optimization methods is inhibited by the cost of communicating and synchronizing processors in a parallel setting. Iterative ML methods are particularly sensitive to communication cost since they often require communication every iteration. In this work, we extend well known techniques from Communication-Avoiding Krylov subspace methods to first-order, primal and dual coordinate descent methods for regression and classification problems. Our Communication-Avoiding (CA) variants reduce the latency cost by a tunable factor of s at the expense of a factor of s increase in flops and bandwidth costs. We show that the CA-variants are numerically stable and can attain large speedups of up to 5.1 on a Cray XC30 supercomputer.

2 - On the Expected Convergence of SGD with Large Stepsizes

Speaker: Marten van Dijk, University of Connecticut, US, talk 513

Co-Authors: *Phuong Nguyen*, *Lam Nguyen*,

We study the convergence of Stochastic Gradient Descent (SGD) with diminishing stepsize (non-adaptive) in the strong convex case. As a rule of thumb, in order for SGD to converge, the sequence of stepsizes $\{\eta_t\}$ should satisfy the following two conditions: The stepsizes should be chosen (1) large enough such that

$$\sum_{t=1}^{\infty} \eta_t = \infty,$$

but should be chosen (2) small enough such that

$$\sum_{t=1}^{\infty} \eta_t^2 < \infty.$$

We show that the second condition is not needed for expected convergence of SGD. Within our framework $\eta_t = O(1/t)$ does enjoy the fastest $O(1/t)$ expected convergence rate. In other words, even though larger stepsizes do lead to convergence, the smaller stepsizes $\eta_t = O(1/t)$ are preferred. We discuss how these observations generalize towards SGD where each iteration computes the gradient of the average of a subset of randomly chosen component functions rather than the gradient of a single randomly chosen component function. This in turn sheds some light on convergence in the asynchronous parallel setting (which includes Hogwild!) where we assume a delay τ such that during the t-th iteration a gradient of a previously read vector (from shared memory) is computed which includes the aggregate of all the updates made during the first $t - \tau$ iterations. Delay τ shows into what extend past updates have committed in shared memory. Our analysis provides an intuitive explanation for why τ can be large without affecting the asymptotic convergence.

3 - Asynchronous primal-dual proximal algorithms for large-scale optimization

Speaker: Puya Latafat, KU Leuven, BE, talk 1008

Co-Authors: *Panos Patrinos*,

Primal-dual proximal algorithms are a class of first-order methods that yield the primal and dual solutions simultaneously. They are able to exploit the structure of the problem efficiently resulting in fully split algorithms applicable to a wide range of problems in machine learning and signal processing. Another important feature of this class of algorithms pertinent to large-scale optimization is the parallelizability. In particular, our focus in this work is on solving global structured optimization problems over a network of agents through local communications between neighbors. An important challenge in such a network is the need for synchronization and the assumption that the agents have access to the latest information. In this work we explore two forms of asynchrony for primal-dual algorithms. First, we consider an asynchronous scheme where the agents wake up at random independently of one another to perform their local updates. Linear convergence rate is established under a weak regularity assumption that is satisfied in many applications. The second form of asynchrony is the case where local updates are carried out using outdated information. In this setting, convergence analysis involves the assumption that the delay experienced by the agents with respect to their neighbors is bounded, but otherwise arbitrary. It is shown that under a strong convexity assumption (linear) convergence is established provided that the stepsizes are small enough.

Advances in large-scale machine learning

Specific Models, Algorithms, and Software
Learning - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 327
Organizer: Mark Schmidt, UBC, CA

1 - Exponential convergence of testing error for stochastic gradient methods.
Speaker: Francis Bach, INRIA - ENS, FR, talk 964
Co-Authors: *Loucas Pillaud-Vivien*, *Alessandro Rudi*,
We consider binary classification problems with positive definite kernels and square loss, and study the convergence rates of stochastic gradient methods. We show that while the excess testing loss (squared loss) converges slowly to zero as the number of observations (and thus iterations) goes to infinity, the testing error (classification error) converges exponentially fast if low-noise conditions are assumed. To achieve these rates of convergence we show sharper high-probability bounds with respect to the number of observations for stochastic gradient descent.

2 - Mirrored Langevin Dynamics
Speaker: Volkan Cevher, EPFL, CH, talk 332
Co-Authors: *Ya-Ping Hsieh*,
We generalize the Langevin Dynamics through the mirror descent framework for first-order sampling. The naive approach of incorporating Brownian motion into the mirror descent dynamics, which we refer to as Symmetric Mirrored Langevin Dynamics (S-MLD), is shown to connected to the theory of Weighted Hessian Manifolds. The S-MLD, unfortunately, contains the hard instance of Cox–Ingersoll–Ross processes, whose discrete-time approximation exhibits slow convergence both theoretically and empirically. We then propose a new dynamics, which we refer to as the Asymmetric Mirrored Langevin Dynamics (A-MLD), that avoids the hurdles of S-MLD. In particular, we prove that discretized A-MLD implies the existence of a first-order sampling algorithm that sharpens the state-of-the-art $\tilde{O}(\epsilon^{-6}d^5)$ rate to $\tilde{O}(\epsilon^{-2}d)$, when the target distribution is strongly log-concave with compact support. For sampling on a simplex, A-MLD can transform certain non-log-concave sampling problems into log-concave ones. As a concrete example, we derive the first non-asymptotic $\tilde{O}(\epsilon^{-4}d^5)$ rate for first-order sampling of Dirichlet posteriors.

3 - Catalyst Acceleration for Gradient-based Optimization of Structured Models
Speaker: Zaid Harchaoui, UW, US, talk 1162
Co-Authors: *Krishna Pillutla*, *Sham Kakade*,
We introduce a generic scheme to solve structured non-convex optimization problems using gradient-based algorithms originally designed for minimizing simpler convex optimization problems. We establish its worst-case information-based complexity guarantee, which either matches or outperforms existing algorithms. We obtain compelling experimental results in practice on two tasks on real-world tasks, namely named entity recognition and visual object localization.

Local Search and Facility Location

Discrete Optimization & Integer Programming
APPROX - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4

Invited Session 342
Organizer: Felix Willamowski, RWTH Aachen University, DE

1 - Local Search based Approximation Algorithms for Capacitated k median problems.
Speaker: Neelima Gupta, University of Delhi, IN, talk 848
Co-Authors: *Aditya Pancholi*,
Facility location (FLP) and k-median problems (kM) are well studied in literature. These problems are well known to be NP-hard. In this talk, we will present some of their generalizations with a focus on capacities. k-FLP is a common generalization of FLP and kM. Natural LP is known to have unbounded integrality gaps for the capacitated variants of these problems. For capacitated kM (CkM), natural LP has unbounded integrality gap even when one of the constraints (capacities/cardinality) is allowed to be violated by a factor less than 2 without violating the other. Obtaining constant factor approximation for CkM is open. Local search heuristic has been successful in dealing with capacities in case of FLP. We will present the following results for CkM and capacitated k-FLP (CkFLP) using local search heuristics: 1. $(3+\epsilon)$ factor approximation for CkM violating the cardinality constraint by a factor of 8/3. 2. Extend result 1 to CkFLP. 3. Extend result 1 to CkM with penalties and outliers. 4. Extend result 2 to CkFLP with penalties and outliers. Though better results are known for the first two variants of the problems using LP rounding, local search techniques are simple to apply and have been shown to perform well in practice via empirical studies. All the existing results, except the one by Koruplou et al. are based on LP-relaxation. Koruplou et al. gave $(1+\alpha)$ approximation factor for CkM with $(5 + 5/\alpha)$ factor loss in cardinality (k). Though the approximation factor can be made arbitrarily small, cardinality loss is at least 5.

2 - Proportional Approval Voting, Harmonic k-median, and Negative Association
Speaker: Krzysztof Sornat, University of Wroclaw, PL, talk 851
Co-Authors: *Jaroslaw Byrka*, *Piotr Skowron*,
We study a generic framework that provides a unified view on two important classes of problems: (i) extensions of the k-median problem where clients are interested in having mul-

tiple facilities in their vicinity (e.g., due to the fact that the closest facility might be malfunctioning), and (ii) finding winners according to some appealing multiwinner election rules, i.e., election system aimed for choosing representatives bodies, such as parliaments, based on preferences of a population of voters over individual candidates. Each problem in our framework is associated with a vector of weights: we show that the approximability of the problem depends on structural properties of these vectors. We specifically focus on the harmonic sequence of weights for which the objective function interpreted in a multiwinner election setup reflects to the well-known Proportional Approval Voting (PAV) rule. Our main result is a constant factor approximation for harmonic weights. This is surprising since the problem can be interpreted as a variant of the k-median problem where we do not assume that the connection costs satisfy the triangle inequality. The algorithm we propose is based on dependent rounding [Srinivasan, FOCS'01] applied to the solution of a natural LP-relaxation of the problem. In our analysis, however, we need to use the fact that the carefully implemented rounding process satisfies a stronger property, called Negative Association (NA), which allows us to apply standard concentration bounds for conditional random variables. Available at http://arxiv.org/abs/1704.02183.

3 - Hard Instances for Local Search via Mixed Integer Programming

Speaker: Felix Willamowski, RWTH Aachen University, DE, talk 168

Co-Authors: *Marco Lübbecke*,

We introduce a mixed integer programming formulation modeling worst local optima for the metric uncapacitated facility location (UFL) problem. The investigated local search uses three operations: add, drop, and swap. It is well known, that this local search gives a 3-approximation for the metric UFL problem. To gain a better understanding of this local search, we try to bound the gap between worst local and global optimal value dependent only on the number of facilities, clients, and the number of opened facilities.

Game Theory and Energy Markets

Optimization under Uncertainty

Game - Tu 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 375

Chair: Didier Aussel, University of Perpignan, FR

1 - Constraint quali cations for parametrized optimization problems and applications

Speaker: Anton Svensson, Universidad de Chile, CL, talk 1111

Co-Authors: *Didier Aussel*,

Parametric optimization problems are very important in applications, for instance, to de fine noncoopertive games such as Nash games or Bilevel programs, which are particular cases of the class of multi-leader-follower games. To ensure that a parametrized convex optimization problem (convex for each parameter) is equivalent to its parametrized KKT conditions, one could verify that a constraint quali cation is satis ed for each parameter. We show a simple way for doing so by assuming joint convexity of the parametrized optimization problem, that is, the functions that defi ne the constraints are convex on the joint vector composed by a solution and a parameter. We show how this is applied for comparing solutions of a Generalized Nash Equilibrium Problem (GNEP) with the concatenation of KKT conditions of all players, and the solutions of a multi-leader-follower game and its MPCC reformulation, obtained by replacing the lower level GNEP by its concatenated KKT conditions.

2 - TrEMa: A Trilevel Energy Market Model

Speaker: Léonard vonNiederhäusern, Inria, FR, talk 1100

Co-Authors: *Didier Aussel*, *Luce Brotcorne*, *Sébastien Lepaul*,

The energy domain faces multiple challenges. Ensuring the supply-demand balance is essential to avoid blackouts. The integration of renewable energies and the increasingly chaotic demand made the management of the grid more difficult. To cope with these issues, one approach consists in fitting the demand to the production: this is called demand-side management (DSM). DSM relies on several techniques, including time-of-use pricing. Electricity furnishers offer different prices to consumers to induce load shifting. TrEMa models this situation. TrEMa consider four types of actors: furnishers sell electricity, local agents trade and consume energy, aggregators trade energy and provide energy to end-users, who consume it. This gives rise to three levels of optimization. The interaction between aggregators and their end-users is modelled with a bilevel program, and so is the interaction between furnishers, and local agents and aggregators. Since solving bilevel programs is difficult in itself, solving trilevel programs requires particular care. We propose three possible approaches, two of them relying on a characterization of the intermediary optimization level.

3 - Electricity market model with elastic demand

Speaker: Didier Aussel, University of Perpignan, FR, talk 239

Co-Authors: *Elisabetta Allevi*, *Rossana Riccardi*,

We consider a model of pay-as-clear electricity market based on a Equilibrium Problem with Complementarity Constraints approach where the producers are playing a noncooperative game parameterized by the decisions of regulator of the market (ISO). The demand is endogenously determined, that is elastic and the ISO problem aims to maximize the total welfare of the market. This total welfare take into account at the same time the willingness to pay of the aggregated consumer, as well as the cost of transactions. An explicit formula for the optimal solution of the ISO problem is obtained and the optimal price is proved to be unique. We also state some conditions for the existence of equilibria for this electricity market with elastic demand. Some numerical experiments on a simplified market model are also provided.

Market places and dynamic programming

Optimization under Uncertainty

Markov - Tu 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 31 Building: B, Ground Floor, Zone: 5

Contributed Session 380

Chair: Dan Iancu, Stanford University, US

1 - Revenue Management with Repeated Customer Interactions
Speaker: Gonzalo Romero, University of Toronto, CA, talk 1396
Co-Authors: *Andre Calmon*, *Florin Ciocan*,
We model and analyze a revenue management problem where a platform interacts with a set of customers over a number of periods. Unlike traditional network revenue management, we consider customers who can dynamically change state between periods. A customer's state depends on the quality of their past service and determines the amount of budget that they allocate to the platform. These dynamics create a trade-off between the platform myopically maximizing short-term revenues, versus maximizing the long-term goodwill of its customers. We (i) show that, in general, finite look-ahead policies can perform arbitrarily poorly in this repeated setting and (ii) identify a set of reasonable conditions under which myopic policies that ignore the budget dynamics are either optimal or near-optimal.
2 - Dynamic Inventory Control with Stockout Substitution and Demand Learning
Speaker: Boxiao Chen, University of Illinois Chicago, US, talk 1180
Co-Authors: *Xiuli Chao*,
We consider an inventory control problem with multiple products and stockout substitution. The firm knows neither the primary demand distribution for each product nor the customers' substitution probabilities between products a priori, and needs to learn such information from sales data (censored demand) on the fly. A main challenge in this problem is that the firm cannot distinguish between primary demand and substitution (overflow) demand from the sales data of any product, and due to data censoring, lost customers from either demand sources cannot be observed. To circumvent these difficulties, we construct learning stages with each stage including a cyclic testing scheme and a benchmark exploration interval. The benchmark interval allows us to isolate the primary demand information from the sales data, that is used against the sales data from a cyclic exploration interval to estimate substitution probabilities. Since raising inventory level helps obtain primary demand information but hinders substitution demand information, inventory decisions have to be carefully balanced to learn both of them. We design learning algorithms for both stationary and dynamically changing environments, and show that their regret rates (almost) match the theoretical lower bounds. Numerical experiments reveal that the proposed algorithms perform very well.
3 - Revenue Losses From Income Guarantees in Centralized Allocation Systems
Speaker: Dan Iancu, Stanford University, US, talk 379
Co-Authors: *Yonatan Gur*, *Xavier Warnes*,
In many centralized allocation systems where consumers are assigned to service providers, a planner aims to maximize instantaneous revenue while accounting for various considerations that may impact long-run sustainability. We analyze the relative loss of instantaneous revenue that may be incurred by such a centralized platform under a revenue share model between the platform and the providers and when allocations of consumers to providers are subject to constraints that belong to a broad set of restrictions that include guaranteed income and fairness among providers. We prove upper bounds for the worst-case relative loss by modeling this loss as a fractional linear program. We characterize the instances that achieve the worst-case loss for any fixed number of providers and thus show that our upper bounds are tight. Finally, we conduct an empirical study aimed at understanding the extent of the instantaneous revenue loss that may arise in real-world instances.

Optimization in Medicine
Specific Models, Algorithms, and Software Sciences - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle LA4 Building: L, Basement, Zone: 8
Invited Session 394
Organizer: Sebastian Sager, University Magdeburg, DE

1 - Optimizing the individual treatment of patients with polycythemia vera
Speaker: Manuel Tetschke, OvGU Magdeburg, DE, talk 1307
Co-Authors: *Patrick Lilienthal*, *Sebastian Sager*,
Polycythemia vera is a slow growing type of blood cancer, i.e. the production of blood cells is increased. Most prominently the red blood cells (RBCs) are affected which causes the main problems for the patients: If the ratio of erythrocytes to the whole blood volume exceeds a certain threshold, the blood cells may clot and thus can cause thromboembolic events. This can lead e.g. to a stroke, heart attack or pulmonary embolism. The initial treatment of the patients is bloodletting (phlebotomy) at regular intervals, which is complemented with chemotherapy if necessary. Thereby, the treatment schedule is based on personal experiences of the physicians. Until now it is not known how to find the optimal frequency of the phlebotomies. In the talk an approach to model the disease with the help of erythropoiesis models is presented. The model parameters can be identified individually for each patient using clinical data and parameter estimation. On this basis an Optimal Control problem can be used to find the best treatment protocol for each patient.
2 - Combinatorial Problems and Models to Help Prevention and Combat Arboviruses
Speaker: Nelson Maculan, UFRJ, BR, talk 1276
Co-Authors: *Marcos Negreiros*, *Bruno Chaves*,
Along fifteen years we follow the development and outbreak of dengue disease in Fortaleza and Rio de Janeiro cities. A group of Brazilian researchers from different areas: medicine (epidemiology), mathematic, statistic, operations research and computer science did important efforts in develop, design and implement a web based Mathematical Programming Decision Support System (MP-DSS) - computational framework, to help track and manage the resources and people around the process of prevention and combat dengue. The cyclic evolution of the disease from 2003 to 2017 and most recently the incorporation of new more dangerous diseases Zyka and Chikungunya, confirm the name "Arboviruses" for diseases provoked by the Aedes Aegypty mosquito. This is increasingly turns WHO-TDR and Brazilian health authorities' attention to a more accurate process effort in prevention and combat. This work shows combinatorial-mathematical and space-temporal models to prevent and combat the arboviruses with the coordinated effort driven by a framework of DSS to track simultaneously the mosquito and human cases, and assign human and vehicles forces to prevent/combat the affected territories. The MP-models consider well known problems

and new solutions for Constrained Clustering, Arc Routing, Scheduling and Dynamic Clustering with space-temporal predictive component. The evolution of the actual used tools indicates that the success for this coordination, with and without the presence of our DSS, passes through the adoption of Mathematical Programming based DSS technology.

3 - Towards optimized consolidation (chemo)therapy for acute myeloid leukemia

Speaker: Sebastian Sager, University Magdeburg, DE, talk 735

Co-Authors: *Felix Jost*, *Thomas Fischer*, *Enrico Schalk*,

We consider consolidation therapy for acute myeloid leukemia, a malignant clonal disorder of myeloid stem and progenitor cells. In untreated AML, immature neoplastic myeloid blasts rapidly proliferate and suppress the generation and maturation of blood cells in the bone marrow. While being a curable disease using chemotherapy including cytarabine (Ara-C), this approach leads to prolonged myelosuppression with extremely low white blood cell (WBC) counts (leukopenia) associated with a high risk of infection and treatment-related mortality. If predictions from personalised mathematical models were reliable and accurate, they could be used for providing better care to AML patients receiving Ara-C consolidation treatment. Precisely identifying the period of Ara-C-induced profound leukopenia and modification of treatment schedules based on such predictions might enable prevention of severe infectious complications, sepsis, and thus delay to undergo subsequent treatment cycles. We discuss the mathematical modeling of WBC dynamics in such a setting and cross-validation of predictions with clinical data. Extending the power of mere forward simulations, we discuss the usage of the derived (personalized) mathematical models for an optimization of different inputs, such as chemotherapy and immune booster dosage and timing.

Optimization software and applications

Specific Models, Algorithms, and Software

Algo - Tu 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 399

Chair: Bartolomeo Stellato, MIT, US

1 - OSQP: An Operator Splitting Solver for Quadratic Programs

Speaker: Bartolomeo Stellato, MIT, US, talk 1151

Co-Authors: *Goran Banjac*, *Paul Goulart*, *Alberto Bemporad*, *Stephen Boyd*,

We present a general purpose solver for quadratic programs based on the alternating direction method of multipliers (ADMM), employing a novel operator splitting technique that requires the solution of a quasi-definite linear system with the same coefficient matrix in each iteration. Our algorithm is very robust, placing no requirements on the problem data such as positive definiteness of the objective function or linear independence of the constraint functions. It is division-free once an initial matrix factorization is carried out, making it suitable for real-time applications in embedded systems. In addition, our technique is the first operator splitting method for quadratic programs able to reliably detect primal and dual infeasible problems from the algorithm iterates. The method also supports factorization caching and warm starting, making it particularly efficient when solving parametrized problems arising in finance, control, and machine learning. Our open-source C implementation OSQP has a small footprint, is library-free, and has been extensively tested on many problem instances from a wide variety of application areas. It is typically ten times faster than competing interior point methods, and sometimes much more when factorization caching or warm start is used.

2 - High-level abstractions for checkpointing in PDE-constrained optimisation

Speaker: Navjot Kukreja, Imperial College London, GB, talk 880

Co-Authors: *Jan Hueckelheim*, *Simon Funke*, *Mathias Louboutin*, *Michael Lange*, *Andrea Walther*, *Gerard Gorman*,

Gradient-based methods for PDE-constrained optimization problems often rely on solving a pair of forward and adjoint equations to calculate the gradient. This requires storing large amounts of intermediate data, limiting the largest problem that might be solved with a given amount of memory. Checkpointing is an approach that can reduce the amount of memory required by redoing parts of the computation instead of storing intermediate results. The Revolve checkpointing algorithm offers an optimal schedule that trades computational cost for smaller memory footprints. Integrating Revolve into a modern python HPC code is not straightforward. We present pyrevolve, an API to the Revolve library that makes checkpointing accessible from a code generation environment. The separation of concerns effected by pyrevolve allows arbitrary operators to utilise checkpointing with no coupling. This means that more complex schedules like multi-level checkpointing can be implemented with no change in the PDE solver. We also present some initial results in the context of a seismic imaging problem.

3 - A quadratic penalty algorithm for linear programming

Speaker: Ivet Galabova, University of Edinburgh, GB, talk 1351

A crashing technique for linear programming problems is presented. The underlying algorithm is based on a classic quadratic penalty method for constrained optimization and has additional similarities with Augmented Lagrangian type algorithms. The subproblem in each iteration is solved with naive approximate minimization. This talk considers the effect of exact minimisation and presents performance results for a collection of test problems. Particular results are discussed for a class of quadratic assignment problem linearisations. Additional uses of the crash as a way of generating bounds for quadratic assignment problems are presented.

Submodular optimization and beyond

Discrete Optimization & Integer Programming

COMB - Tu 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 39 Building: E, 3rd floor, Zone: 1

Contributed Session 418

Chair: Satoru Iwata, University of Tokyo, JP

1 - Submodular Minimization Under Congruency Constraints
Speaker: Martin Nägele, ETH Zürich, CH, talk 1588
Co-Authors: *Benny Sudakov*, *Rico Zenklusen*,
Submodular function minimization (SFM) is a fundamental and efficiently solvable problem class in combinatorial optimization with a multitude of applications in various fields. Surprisingly, there is only very little known about constraint types under which SFM remains efficiently solvable. The arguably most relevant non-trivial constraint class for which polynomial SFM algorithms are known are parity constraints. Parity constraints capture classical combinatorial optimization problems like the odd-cut problem, and they are a key tool in a recent technique to efficiently solve integer programs with a constraint matrix whose subdeterminants are bounded by two in absolute value. We show that efficient SFM is possible even for a significantly larger class than parity constraints, by introducing a new approach that combines techniques from Combinatorial Optimization, Combinatorics, and Number Theory. In particular, we can show that efficient SFM is possible over all sets of cardinality r mod m, as long as m is a constant prime power. This covers generalizations of the odd-cut problem with open complexity status, and with relevance in the context of integer programming with higher subdeterminants. Moreover, our results settle two open questions raised by Geelen and Kapadia [Combinatorica, 2017] in the context of computing the girth and cogirth of certain types of binary matroids.

2 - The *b*-bibranching Problem: TDI System, Packing, and Discrete Convexity
Speaker: Kenjiro Takazawa, Hosei University, JP, talk 55
We introduce the *b*-bibranching problem in digraphs, which is a common generalization of the bibranching and *b*-branching problems. The bibranching problem, introduced by Schrijver (1982), is a common generalization of the branching and bipartite edge cover problems. Previous results on bibranchings include polynomial algorithms, a linear programming formulation with total dual integrality, a packing theorem, and an M-convex submodular flow formulation. The *b*-branching problem, recently introduced by Kakimura, Kamiyama, and Takazawa (2018), is a generalization of the branching problem admitting higher indegree, i.e., each vertex v can have indegree at most $b(v)$. For *b*-branchings, a combinatorial algorithm, a linear programming formulation with total dual integrality, and a packing theorem for branchings are extended. Our main contribution is to extend those previous results on bibranchings and *b*-branchings to *b*-bibranchings. That is, we present a linear programming formulation with total dual integrality, a packing theorem, and an M-convex submodular flow formulation for *b*-bibranchings. In particular, the linear program and M-convex submodular flow formulations respectively imply polynomial algorithms for finding a shortest *b*-bibranching.

3 - Index Reduction via Unimodular Transformations
Speaker: Satoru Iwata, University of Tokyo, JP, talk 1177
Co-Authors: *Mizuyo Takamatsu*,
This talk presents an algorithm for transforming a matrix pencil $A(s)$ into another matrix pencil $U(s)A(s)$ with a unimodular matrix $U(s)$ so that the resulting Kronecker index is at most one. The algorithm is based on the framework of combinatorial relaxation, which combines graph-algorithmic techniques and matrix computation. Our algorithm works for index reduction of linear constant coefficient differential-algebraic equations, including those for which the existing index reduction methods based on Pantelides' algorithm or the signature method are known to fail.

Linear Optimization III

Continuous Optimization
NLP - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 9 Building: N, 4th floor, Zone: 12
Contributed Session 439
Chair: Rodrigo Mendoza Smith, University of Oxford, GB

1 - Neural constraint selection in Linear Programming
Speaker: Rodrigo Mendoza Smith, University of Oxford, GB, talk 1546
Co-Authors: *Pawan Kumar*,
Some problems of practical interest like neural network verification require the solution of a set of overdetermined linear programs, which can yield the application computationally impractical when the number of constraints is considerably large. We consider the problem of reducing the number of constraints in a linear program by training a message-passing neural network classifier that learns to predict whether a constraint is active or not. Our approach is designed to capture the structure of underlying LP data generated by a particular application, so the resulting networks can be used as a preprocessing step to reduce the number of constraints before passing the data to an LP solver.

2 - New station cone algorithm variant for linear programming and computing experiment
Speaker: Chu Nguyen, Viet Power Ltd Company, VN, talk 1665
Co-Authors: *Hue Thanh*,
"A New Variant of Station Cone Algorithm for Linear Programming and Its Computational Experiments" Abstract: In this paper we introduce a new variant of station cone algorithm to solve linear programmimg problems. It uses a series of interior points Ok to determine the entering variables. The number of these interior points is finite and they move toward the optimal point. The proposed algorithm will be a polynomial time algorithm if the number of points Ok is limited by a polynomial function. The second objective of this paper is to carry out experimental calculations and compare with simplex methods and dual simplex method. The results show that the number of pivots of the station cone algorithm is less than 30 to 50 times that of the dual algorithm. And with the number of variables n and the number of constraints m increasing, the number of pivots of the dual algorithm is growing much faster than the number of pivots of the station cone algorithm.This conclusion is drawn from the coputational experiments with n <= 500 and m <= 2000. In particular we also test for cases where n = 2, m = 100 000 and n = 3, m = 200 000. For case where n = 2 and m = 100 000, station cone algorithm is given no more than 16 pivots. In case of n = 3, m = 200 000, station cone algorithm has a pivot number less than 24. Keywords Linear programming, simplex method, dual problem, station cone

3 - A predictor-corrector algorithm for lp problems using the mixed penalty approach
Speaker: Khalid El Yassini, Moulay Ismail University, MA,

talk 1458
Co-Authors: *Kenza Oufaska*, *Ahmed El Ghali*,
Interior-exterior penalty algorithms for linear programming (LP) were presented in last recent decades by many authors. By using similar steps and adapting the process used by El Yassini et al., we give a new predictor-corrector algorithm based on a mixed penalty approach with two distinct parameters. The proposed algorithm is inspired from the path following method. At each iteration, there is an updating of penalty parameters. An approximate solution, of Karush-Kuhn-Tucker system of equations which characterizes a solution of the mixed penalty function, is computed by using Newton directions for both prediction and correction steps. The generated approximate solution gives a feasible dual point and a pseudo-feasible primal point. Since the primal solution is infeasible, a new pseudo-duality gap definition is introduced to characterize primal and dual solutions and to measure proximity to both optimality and feasibility. Some numerical results will be presented. The polynomial complexity of the new algorithm can be proved under very general assumptions. Finally and based on results in this paper, an extension could be easily conceivable for convex quadratic programming (QP).

Recent Advances in Robust Optimization I

Optimization under Uncertainty
Robust - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 33 Building: B, Ground Floor, Zone: 5

Invited Session 442
Organizer: Phebe Vayanos, USC, US

1 - Optimization in the Small-Data, Large-Scale Regime
Speaker: Vishal Gupta, USC Marshall, US, talk 1516
Co-Authors: *Paat Rusmevichientong*,
Optimization applications often depend upon a huge number of uncertain parameters. In many contexts, however, the amount of relevant data per parameter is small, and hence, we may have only imprecise estimates. We term this setting – where the number of uncertainties is large, but all estimates have fixed and low precision – the “small-data, large-scale regime." We formalize a model for this regime, focusing on linear programs with uncertain objective coefficients, and prove that the small-data, large-scale regime is distinct from the traditional large-sample regime. Consequently, methods like sample average approximation, data-driven robust optimization, regularization, and “estimate-then-optimize" policies can perform poorly. We propose a novel framework that, given a policy class, identifies an asymptotically best-in-class policy, where the asymptotics hold as the number of uncertain parameters grows large, but the amount of data per uncertainty (and hence the estimate’s precision) remains small. In typical cases, the sub-optimality gap between our proposed method and the best-in-class policy decays exponentially fast in the number of uncertain parameters, even for a fixed amount of data. We also show that in the usual large-sample regime our policies are comparable to the sample average approximation. Thus, our policies retain the strong large-sample performance of SAA, with improved performance in the small-data, large-scale regime.

2 - Interpretable Optimal Stopping
Speaker: Velibor Misic, UCLA, US, talk 1358
Co-Authors: *Florin Ciocan*,
Optimal stopping is the problem of deciding when to stop a stochastic system to obtain the greatest reward, arising in numerous areas such as finance and healthcare. State of the art methods for this problem rely on obtaining an approximate value function for use within a greedy policy. However, such policies are generally not <i>interpretable</i>, in that it is often difficult to see how the policy maps each system state to a decision. We propose a new data-driven approach for optimal stopping that directly learns interpretable policies. We specifically consider policies in the form of binary trees. While the problem is theoretically intractable, we propose two greedy algorithms for constructing and then locally optimizing a tree policy. We apply our approach to a canonical option pricing and the problem of dynamically predicting septic shock in ICU patients. In the former, our approach quickly obtains interpretable policies that outperform existing non-interpretable policies based on simulation-regression. In the latter, we show using real critical care data that, relative to a widely used clinical scoring rule, our policies significantly reduce the false positive rate while maintaining the true positive rate.

3 - Fair, Efficient, and Interpretable Policies for Allocating Scarce Resources
Speaker: Phebe Vayanos, USC, US, talk 899
Co-Authors: *Mohammad Azizi*, *Bryan Wilder*, *Eric Rice*, *Milind Tambe*,
We consider the problem of designing fair, efficient, and interpretable policies for prioritizing heterogeneous homeless youth on a waiting list for scarce housing resources of different types. We focus on point-based policies that use features of the housing resources (e.g., permanent supportive housing, rapid rehousing) and the youth (e.g., age, history of substance use) to maximize the probability that the youth will have a safe and stable exit from the housing program. The policies can be used to prioritize waitlisted youth each time a housing resource is procured. Our framework provides the policy-maker the flexibility to select both their desired structure for the policy and their desired fairness requirements. Our approach can thus explicitly trade-off interpretability and efficiency while ensuring that fairness constraints are met. We propose a flexible data-driven mixed-integer optimization formulation for designing the policy, along with an approximate formulation which can be solved efficiently for broad classes of interpretable policies using Bender’s decomposition. We evaluate our framework using real-world data from the United States homeless youth housing system. We show that our framework results in policies that are more fair than the current policy in place and than classical interpretable machine learning approaches while achieving a similar (or higher) level of overall efficiency.

Recent Advances in Robust Optimization II

Optimization under Uncertainty
Robust - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 445
Organizer: Wolfram Wiesemann, Imperial College London, GB

1 - A Robust Optimization Perspective on Bilinear Programming
Speaker: Jianzhe Zhen, EPFL, CH, talk 827
Co-Authors: *Ahmadreza Marandi*, *Dick den Hertog*, *Lieven Vandenberghe*,
We show that a bilinear problem with separable feasible regions can be cast as a two-stage fixed-recourse robust linear optimization problem, and techniques such as Fourier-Motzkin elimination and linear decision rules for adjustable robust optimization can be used to solve the resulting problem. We show a close relation between McCormick relaxation and linear decision rules, and extend McCormick relaxation to bilinear problems with a general convex feasible region. Numerical experiments on Bimatrix games and norm maximization problems show that the proposed method is superior to the state-of-the-art solvers SCIP and CPLEX.
2 - Calibrating Optimization under Uncertainty
Speaker: Huajie Qian, Columbia University, US, talk 1600
Co-Authors: *Henry Lam*,
Optimization formulations to handle decision-making under uncertainty, such as (distributionally) robust optimization, often contain tuning parameters that control the level of conservativeness. We investigate strategies to select parameter values based on data splitting and the validation of their performances in terms of feasibility and optimality. The validation step attempts to select the best parameters so that the resulting solution satisfies the constraint up to a simultaneous margin calibrated by the supremum of a suitable Gaussian vector. We demonstrate asymptotic and finite-sample performance guarantees for our strategies, which also reveal how the sample size needed for our schemes scales favorably with the problem dimension.
3 - The Distributionally Robust Chance Constrained Vehicle Routing Problem
Speaker: Wolfram Wiesemann, Imperial College London, GB, talk 817
Co-Authors: *Shubhechyya Ghosal*,
We study a variant of the capacitated vehicle routing problem (CVRP), which asks for the cost-optimal delivery of a single product to geographically dispersed customers through a fleet of capacity-constrained vehicles. Contrary to the classical CVRP, which assumes that the customer demands are deterministic, we model the demands as a random vector whose distribution is only known to belong to an ambiguity set. Moreover, we require the delivery schedule to be feasible with a probability of at least $1 - \epsilon$, where ϵ characterizes the risk tolerance of the decision maker. We argue that the emerging distributionally robust CVRP can be solved efficiently with modern branch-and-cut algorithms if and only if the ambiguity set satisfies a subadditivity condition. We then show that this subadditivity condition holds for a large class of moment ambiguity sets. We derive efficient cut generation schemes for ambiguity sets that specify the support as well as (bounds on) the first and second moments of the customer demands. Our numerical results indicate that the distributionally robust CVRP has favorable scaling properties and can often be solved in runtimes comparable to those of the deterministic CVRP.

Learning for mixed integer optimization

Specific Models, Algorithms, and Software
Learning - Tu 3:15pm-4:15pm, Format: 2x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

Contributed Session 482
Chair: Hari Bandi, MIT, US

1 - Learning a Mixture of Gaussians via Mixed Integer Optimization
Speaker: Hari Bandi, MIT, US, talk 1501
Co-Authors: *Dimitris Bertsimas*, *Rahul Mazumder*,
We consider the problem of estimating the parameters of a multivariate Gaussian mixture model (GMM) given access to n samples $x_1, x_2, ..., x_n \in R^d$ that are believed to have come from a mixture of multiple subpopulations. State-of-the-art algorithms to recover these parameters use heuristics to either maximize the log-likelihood of the sample or try to fit first few moments of the GMM to the sample moments. In contrast, we present here a novel Mixed Integer Optimization (MIO) formulation that optimally recovers the parameters of the GMM by minimizing a discrepancy measure (either the Kolmogorov-Smirnov or the Total variation distance) between the empirical distribution function and the distribution function of the GMM whenever the mixture component weights are known. We also present an algorithm for multidimensional data that optimally recovers corresponding means and covariance matrices. We show that the MIO approaches are practically solvable for datasets with n in the tens of thousands in minutes and achieve an average improvement of 60-70 percent and 50-60 percent on mean absolute percentage error (MAPE) in estimating the means and the covariance matrices, respectively over the EM (Expectation-Maximization) algorithm independent of the sample size n. As the separation of the Gaussians decrease and correspondingly the problem becomes more difficult, the edge in performance in favor of the MIO methods widens. Finally, we also show that the MIO methods outperform the EM algorithm with an average improvement of 4-5 percent on the out-of-sample accuracy for real-world datasets.
2 - Learning for Tuning Parameters of NUOPT MILP Solver
Speaker: Takanori Maehara, RIKEN AIP, JP, talk 1257
Co-Authors: *Kensuke Otsuki*, *Yasumi Ishibashi*, *Koichi Fujii*, *Tomohiro Takahashi*,
In a modern MILP solver with the branch and bound, various features such as cutting plane method, presolving, heuristics are implemented. These features have various parameters that have a big influence on performance. In recent years, a machine learning based approach for tuning parameters of a MILP solver have been extensively studied. These methods train machine learning models to predict the running time or the number of expanded nodes from several static features and dynamic features, and use the models to find an efficient parameters of MILP solvers. In this presentation we will present the experimental results of applying the machine learning methods for tuning NUOPT MILP solver.

Optimization Models for Renewable Energy Integration 2

Specific Models, Algorithms, and Software
Energy - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6

Contributed Session 523
Chair: Michel Denault, HEC Montréal, CA

1 - A MIP formulation of a Hybrid AC-DC offshore wind power plant topology
Speaker: Cristina Corchero, IREC, ES, talk 1244
Co-Authors: *Josep Homs-Moreno*, *F.-Javier Heredia*, *Lucia Igualada*, *Mikel de Prada*,
The current study analyses a hybrid offshore wind farm design in which individual wind turbine power converters are removed from wind turbines and are installed on intermediate offshore collector platforms. In this study a compact and small-sized mixed-integer linear optimisation model makes four decisions with the goal of minimising installation and operation costs: the location and the number of offshore platforms and power converters to be installed, the optimal wind farm cable layout and the cluster optimal operating frequency of each wind turbine. The solutions found either for small and large offshore wind farms improve notoriously real-world designs, reducing up to 8 percent installation and maintenance costs. On the optimization technical results, a variant of Local Branching has been developed, reducing in some cases more than half of computing time with respect to default Local Branching. The model developed serves as a mathematical tool to provide rigorous evidences of the suitability of the hybrid design versus traditional offshore wind farm designs.
2 - Optimal Design of a Decentralized Energy Network including Renewable Energies
Speaker: Kristina Janzen, TU Darmstadt, DE, talk 877
Co-Authors: *Stefan Ulbrich*, *Sven Leyffer*,
The ongoing replacement of traditional centralized energy systems by decentralized structures of energy supply including local renewable energy generation is an emerging topic in today's discussions, which brings new challenges for the design and operation of energy supply systems. Therefore, we present an optimization model that minimizes the investment and operational cost while satisfying the customer heat and power demand. Due to the potential of decentralized energy networks to supply heat and power at a lower cost and emissions rate compared to classical systems, we consider a coupled energy network. The developed algebraic model includes multiple energy carriers as well as renewable energy sources to determine the optimal design for an urban settlement. According to acquisition choices of different technologies and discrete sizes for transmissions lines, discrete integer decision variables occur. Along with nonlinear equations for modeling the energy generation and the energy transmission, this results in a mixed-integer nonlinear optimization problem (MINLP). Numerical results of representative problem instances are shown by using the algebraic modeling language AMPL. We demonstrate different scenarios in terms of price, weather and availability. Furthermore we discuss an extension of our energy model including ordinary and partial differential equations.
3 - Approximate dynamic programming for hydropower optimization
Speaker: Michel Denault, HEC Montréal, CA, talk 1473
Co-Authors: *Pascal CôTé*, *Jean-Guy Simonato*, *Nicolas Léveillé*, *Jean-Phil. Olivier-Meunier*, *Maël Veron*,
We develop and compare techniques based on approximate dynamic programming to derive optimal policies for hydropower plants. In particular, we use a simulation-and-regression approach that relies on Q-functions, compared to a sampling stochastic dynamic program, and investigate alternatives based on reinforcement learning. We provide results for the two large power systems of RioTinto in Canada, and will also discuss the choice of state variables, which is of paramount importance.

Supply Chain and Lot Sizing

Specific Models, Algorithms, and Software
Scheduling - Tu 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 23 Building: G, 3rd floor, Zone: 6

Contributed Session 534
Chair: Simon Thevenin, HEC Montréal, CA

1 - Decision Rule-based Method for Flexible Multi-Facility Capacity Planning Problem
Speaker: Sixiang Zhao, ISEM, NUS, SG, talk 1272
Co-Authors: *William Haskell*, *Michel Cardin*,
Strategic capacity planning for flexible multiple-facility systems is an important field of the capacity expansion problem with random demands. The difficulties of this problem lie in the multidimensional nature of its random variables and action space. This study designs a novel decision rule-based method in solving a multi-facility capacity expansion problem (MCEP) with compound options, discrete capacity, and a concave capacity expansion cost. An if-then decision rule is designed and the original multi-stage problem is thus transformed into a master problem and a multi-period sub-problem. As the sub-problem contains nonbinding constraints, we combine a stochastic approximation algorithm with a branch-and-cut technique so that the sub-problem can be further decomposed across scenarios and be solved efficiently. The proposed decision rule-based method is also extended to solving the MCEP with fixed costs. Numerical studies illustrate that the proposed method affords not only improved performance relative to an inflexible design taken as benchmark but also time-saving relative to approximate dynamic programming analysis.
2 - Two-Period Relaxations for Big-Bucket Lot-Sizing: Polyhedra and Algorithms
Speaker: Kerem Akartunali, University of Strathclyde, GB, talk 1149
Co-Authors: *Mahdi Doostmohammadi*, *Ioannis Fragkos*,
In this paper, we study two-period relaxations for lot-sizing problems with big-bucket capacities. In particular, we extend our recent polyhedral results from the special case of zero setups (Doostmohammadi and Akartunali (2018)) to the general case of nonzero setups. In this polyhedral study, we investigate the structure of a number of mixed integer sets inherent in these relaxations, and also study the original two-period relaxation. This study enables us to identify a number of families of valid inequalities that are facet defining for the two-period relaxations. We next discuss exact separation algorithms for these families of inequalities, which

prove to be computationally challenging and often limited to handle smaller test instances only. In order to address these challenges, we discuss various strategies for improvement, including some separation heuristics, and discuss computational results and analysis to identify the most effective strategies. Finally, we present a branch-and-cut algorithm framework and report preliminary computational results. We conclude with future research directions.

3 - Scenario based stochastic optimization for the multi-echelon lot-sizing problem

Speaker: Simon Thevenin, HEC Montréal, CA, talk 348
Co-Authors: *Yossiri Adulyasak*, *J.-F. Cordeau*,

We investigate stochastic optimization approaches for Material Requirements Planning (MRP) systems. A two-stage (resp. multi-stage) stochastic program models the static-static (resp. static-dynamic) execution of the MRP. In the static-static execution, the production quantities are decided in period 0, and they are fixed for the entire horizon. On the contrary, in the static-dynamic execution, the quantities to produce in period t+1 are decided in period t, after having observed the demands of period t. In both environments, the setup decisions are made in period 0 for the entire planning horizon. To address scalability issues, a fix-and-optimize heuristic, and advanced sampling methods are proposed. In addition, to ease the execution, a S-policy is derived from the solution of the multi-stage model. Extensive simulations (including a rolling horizon simulation) show that stochastic optimization methods lead to signficantly lower costs than classical approaches. In addition, the multi-stage model slightly outperforms the two-stage model, whereas the latter one can be solved much more efficiently.

A.W. Tucker Prize Session

Invited Talks
INTERFACE - Tu 3:15pm-4:45pm, Format:
Room: SIGALAS Building: C, 2nd floor, Zone: 2

Contributed Session 559
Chair: Simge Kucukyavuz, University of Washington, US

Approximation Algorithms for the Traveling Salesman Problem

Discrete Optimization & Integer Programming
APPROX - We 8:30am-10:30am, Format: 4x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 23
Organizer: Anke van Zuylen, College of William Mary, US

1 - Vehicle Routing with Subtours

Speaker: Stephan Held, University of Bonn, DE, talk 212
Co-Authors: *Jochen Koenemann*, *Jens Vygen*,

When delivering items to a set of destinations, one can save time and cost by passing a subset to a sub-contractor at any point en route. We consider a model where a set of items are initially loaded in one vehicle and should be distributed before a given deadline Δ. In addition to travel time and time for deliveries, we assume that there is a fixed delay for handing over an item from one vehicle to another. We will show that it is easy to decide whether an instance is feasible, i.e., whether it is possible to deliver all items before the deadline Δ. We then consider computing a feasible tour of minimum cost, where we incur a cost per unit distance traveled by the vehicles, and a setup cost for every used vehicle. Our problem arises in practical applications and generalizes classical problems such as shallow-light trees and the bounded-latency problem. Our main result is a polynomial-time algorithm that, for any given $\epsilon > 0$ and any feasible instance, computes a solution that delivers all items before time $(1+\epsilon)\Delta$ and has cost $O(1+\frac{1}{\epsilon})OPT$, where OPT is the minimum cost of any feasible solution. We show that our result is best possible in the sense that any improvement would lead to progress on 25-year-old questions on shallow-light trees.

2 - Fast Approximations for Metric TSP

Speaker: Kent Quanrud, UIUC, US, talk 487
Co-Authors: *Chandra Chekuri*,

Let G be an undirected edge-weighted graph with m edges and $\epsilon > 0$, and consider the Metric-TSP instance induced by the shortest path metric on G. First, we give an algorithm that computes, in $\tilde{O}(m/\epsilon^2)$ randomized time and with high probability, a $(1+\epsilon)$-approximation for an LP relaxation of Metric-TSP which is equivalent to the Held-Karp bound [Held and Karp, 1970]. Second, we describe an algorithm that computes, in $\tilde{O}(m/\epsilon^2 + n^{1.5}/\epsilon^3)$ randomized time and with high probability, a tour of G with cost at most $(3+\epsilon)/2$ times the minimum cost tour of G. The second algorithm uses the LP solution from the first algorithm as a starting point. (The $\tilde{O}$ notation hides logarithmic factors.)

3 - The s-t-path TSP: past, present, and future

Speaker: Jens Vygen, University of Bonn, DE, talk 210
Co-Authors: *Vera Traub*,

In a variant of the traveling salesman problem, we ask for a shortest tour that visits all cities and starts and ends at given cities s and t. The case s and t are unequal seems to be harder than the classical case $s = t$. For example, Christofides' algorithm yields only a 5/3-approximation here. An, Kleinberg and Shmoys showed that one can do better, and recently a variety of new techniques led to a sequence of improvements, the latest being Zenklusen's 3/2-approximation algorithm. The integrality ratio of the natural LP relaxation is conjectured to be 3/2, but there is no proof yet. We will survey the state of the art and open problems, and also present some new results.

4 - The Salesman's Paths: Layered Christofides' Trees, Deletion and Matroids

Speaker: Anke van Zuylen, College of William Mary, US, talk 177
Co-Authors: *Andras Sebo*, *Frans Schalekamp*, *Vera Traub*,

We present a new strongly polynomial time algorithm and improved analysis for the metric s-t path TSP. A key new idea is the deletion of some edges of Christofides' trees, which is accompanied by novel arguments in the analysis: edge-deletion disconnects the trees, which are then partly reconnected by "parity correction". We show that the remaining "reconnection" problem can be solved for a minor extra cost. New tools are introduced, such as a flow problem used for analyzing the reconnection cost, and the use of a set of more and more restrictive minimum cost spanning trees, which are bases of a sequence of increasingly restrictive matroids. Since these trees can be found by the greedy algorithm, this leads to a simple Christofides-like algorithm, avoiding the computation of a convex combination of spanning trees. The new methods lead to an improvement of the integrality ratio and approximation guarantee below 1.53. We also show simple proofs of the 1.5 target-ratio in some relevant new cases.

Stochastic and Nonlinear Optimization III

Continuous Optimization
NLP - We 8:30am-10:30am, Format: 4x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

Invited Session 31
Organizer: Jorge Nocedal, Northwestern University, US

1 - Efficient Newton-type methods for non-convex machine learning problems
Speaker: Fred Roosta, University of Queensland, AU, talk 486
Co-Authors: *Michael Mahoney*, *Peng Xu*,
Contrary to the scientific computing community which has, wholeheartedly, embraced the second-order optimization algorithms, the machine learning community has long nurtured a distaste for such methods, in favour of first-order alternatives. In this talk, we argue that such reluctance to employ curvature information can indeed hinder the training procedure in a variety of ways. Specifically, in the context of non-convex machine learning problems, we demonstrate the theoretical properties as well as empirical performance of a variety of efficient Newton-type algorithms. In the process, we highlight the serious disadvantages of first-order methods and, in their light, showcase the practical advantages offered by such second-order methods.
2 - Optimization Methods for Training Neural Networks
Speaker: Jorge Nocedal, Northwestern University, US, talk 563
It has been observed that neural networks have a benign geometry that permits standard optimization methods to find acceptable solutions during the training phase. However, solution times can be very high, and not all minimizers of the neural network loss functions are equally desirable, as some lead to prediction systems with better generalization properties than others. In this talk we give an overview of optimization methods designed to address these challenges.
3 - A Newton-CG Method with Complexity Guarantees
Speaker: Stephen Wright, U Wisconsin-Madison, US, talk 422
Co-Authors: *Clément Royer*, *Michael ONeill*,
We consider minimization of a smooth nonconvex objective function using an iterative algorithm based on Newton's method and linear conjugate gradient, with explicit detection and use of negative curvature directions for the Hessian of the objective function. The algorithm closely tracks Newton-conjugate gradient procedures developed in the 1980s, but includes enhancements that allow worst-case complexity results to be proved for convergence to points that satisfy approximate first-order and second-order optimality conditions. The complexity results match the best known results in the literature for second-order methods.
4 - Smoothed Variable Sample-size Acc. Prox. Methods for Stoch. Convex Optimization
Speaker: Uday Shanbhag, Pennsylvania State University, US, talk 427
Co-Authors: *Afrooz Jalilzadeh*, *Jose Blanchet*, *Peter Glynn*,
We develop a variable sample-size accelerated proximal method (VS-APM) for the minimization of $f(x)+g(x)$, where $g(x)$ has an efficient prox evaluation and $f(x) = E[f(x,\xi(\omega))]$. (I) Strongly convex f. We show that the no. of prox evals to obtain an ϵ-solution is shown to be $O(\sqrt{\kappa}\log(1/\epsilon))$ while the oracle complexity is $O(\sqrt{\kappa}/\epsilon)$, both of which are optimal and κ denotes the condn. number; (II) Convex and nonsmooth f. We develop an iterative smoothing scheme (sVS-APM) where the sample-average of gradients of a smoothed function is employed at every step. By suitably choosing the smoothing, steplength, and batch-size sequences, we show that we prove that the expected sub-optimality diminishes to zero at the rate of $O(1/k)$ and admits the optimal oracle complexity of $O(1/\epsilon^2)$. Our results can be specialized to two important cases: (a) **Smooth f.** Since smoothing is no longer required, we observe that (**VS-APM**) admits the optimal rate and oracle complexity matching recent results; (b) **Deterministic nonsmooth f.** In the nonsmooth deterministic regime, (**sVS-APM**) reduces to a smoothed accelerated proximal method (**s-APM**) that is both asymptotically convergent and admits a non-asymptotic rate $O(1/k)$, identical to that produced by Nesterov for producing approximate solutions. (III) **Convex f.** Finally, we show that (**sVS-APM**) and (**VS-APM**) produce sequences that converge a.s. to a solution of the original problem.

New derivative-free algorithms

Continuous Optimization
DerFree - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 34
Chair: Margherita Porcelli, University of Florence, IT

1 - Gray-box optimization of structured problems and other new developments in BFO
Speaker: Margherita Porcelli, University of Florence, IT, talk 609
Co-Authors: *Philippe Toint*,
The talk will introduces techniques that allow the solution of large structured optimization problems in the context of random pattern search in nonlinear optimization. They result from a re-interpretation of techniques proposed by Price and Toint, but introduce some significant new ideas which prove to be very efficient. Also, polynomial interpolation models will be adapted to the partial separable case and employed through the exploitation of the search step feature. Examples will be shown where partially separable problems in more than 10000 variables are solved by the BFO package with a very small number of (complete) function evaluations. Also, a short review of other new features of the derivative-free optimizer BFO package will be presented, covering the support of categorical variables, new optimizer's training strategies and options-file features.
2 - Model-based derivative-free methods for nonsmooth black-box functions

Speaker: Francesco Rinaldi, University of Padova, IT, talk 825
Co-Authors: *Giampaolo Liuzzi*, *Stefano Lucidi*, *Luis Nunes Vicente*,
In this talk, we first describe a model-based algorithmic framework for the unconstrained minimization of a nonsmooth black-box function. Then, we carry out a theoretical analysis of the approach. Finally, we report some preliminary numerical results showing the effectiveness of the method.

3 - A flexible, robust and efficient derivative-free solver for least squares
Speaker: Lindon Roberts, University of Oxford, GB, talk 864
Co-Authors: *Coralia Cartis*, *Benjamin Marteau*, *Jan Fiala*,
We present DFO-LS, a software package for derivative-free optimization (DFO) for nonlinear least-squares problems, that has simplified models, flexible initialization and improved robustness to noise. Inspired by the Gauss-Newton method, DFO-LS constructs simplified linear regression models for the residuals. DFO-LS also has improved flexibility for expensive problems, whereby it can begin making progress from as few as two objective evaluations. Numerical results show DFO-LS can gain reasonable progress on some medium-scale problems with fewer objective evaluations than is needed for one gradient evaluation. For noisy problems, DFO-LS allows a wide variety of sample averaging methodologies, the construction of highly overdetermined regression models, and restart strategies. Our extensive numerical experimentation shows that restarting the solver when stagnation is detected is a cheap and effective mechanism for achieving robustness, with superior performance. We also discuss our package Py-BOBYQA, a Python implementation of BOBYQA (Powell, 2009) which implements some of these features for general objective problems.

4 - MultiGLODS: Clever Multistart in Multiobjective Directional Direct Search
Speaker: Ana Custodio, Universidade Nova de Lisboa, PT, talk 1480
Co-Authors: *Jose Madeira*,
The optimization of multimodal functions is a challenging task, in particular when derivatives are not available for use. Recently, in a directional direct search framework, a clever multistart strategy was proposed for global derivative-free optimization of single objective functions. The goal of the current work is to generalize this approach to the computation of global Pareto fronts for multiobjective multimodal derivative-free optimization problems. The proposed algorithm alternates between initializing new searches, using a multistart strategy, and exploring promising subregions, resorting to directional direct search. Components of the objective function are not aggregated and new points are accepted using the concept of Pareto dominance. The initialized searches are not all conducted until the end, merging when start to be close to each other. We will describe the algorithmic structure considered, present the main associated theoretical results, and report related numerical experience that evidences the quality of the final solutions generated by the new algorithm and its capability in identifying approximations to global and local Pareto fronts of a given problem.

Optimality conditions in NLP and conic problems

CONTINUOUS OPTIMIZATION
NLP - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

INVITED SESSION 43
Organizer: Roberto Andreani, UNICAMP, BR

1 - A SEQUENTIAL OPTIMALITY CONDITION RELATED TO THE QUASINORMALITY CQ
Speaker: Roberto Andreani, UNICAMP, BR, talk 522
Co-Authors: *Nadia Fazio*, *Maria Schuverdt*, *Leonardo Secchin*,
In the present paper, we prove that the augmented Lagrangian method converges to KKT points under the quasinormality constraint qualification, which is associated with the external penalty theory. For this purpose, a new sequential optimality condition for smooth constrained optimization, called PAKKT, is defined. The new condition takes into account the sign of the dual sequence, constituting an adequate sequential counterpart to the (enhanced) Fritz-John necessary optimality conditions proposed by Hestenes, and later extensively treated by Bertsekas. We also provided the appropriate strict constraint qualification associated with the PAKKT sequential opti- mality condition and we prove that it is strictly weaker than both quasinormality and cone continuity property. This generalizes all previous theoretical convergence results for the augmented Lagrangian method in the literature.

2 - An extension of Yuan's Lemma and its applications in optimization
Speaker: Gabriel Haeser, University of Sao Paulo, BR, talk 205
We prove an extension of Yuan's lemma to more than two matrices, as long as the set of matrices has rank at most 2. This is used to generalize the main result of Baccari and Trad (SIAM J Optim 15(2):394-408, 2005), where the classical necessary second-order optimality condition is proved, under the assumption that the set of Lagrange multipliers is a bounded line segment. We prove the result under the more general assumption that the Hessian of the Lagrangian, evaluated at the vertices of the Lagrange multiplier set, is a matrix set with at most rank 2. We apply the results to prove the classical second-order optimality condition to problems with quadratic constraints and without constant rank of the Jacobian matrix, which settles a new particular case of the conjecture of Andreani, Martínez and Schuverdt (Optim 56:529-542, 2007). Some further recent results about this conjecture will also be discussed.

3 - Optimality Conditions for Generalized Nash Equilibrium Problems
Speaker: Luis Felipe Bueno, UNIFESP, BR, talk 194
Co-Authors: *Gabriel Haeser*, *Frank Rojas*,
Generalized Nash Equilibrium Problems (GNEPs) are a generalization of the classic Nash Equilibrium Problems (NEPs), where each player's strategy set depends on the choices of the other players. In this work we study constraint qualifications and optimality conditions tailored for GNEPs and we discuss their relations and implications for global convergence of algorithms. Surprisingly, diferently from the case of nonlinear programming, we show that, in general, the KKT residual can not be made arbitrarily small near a solution of a GNEP. We then discuss some important practical consequences of this

fact. We also prove that this phenomenon is not present in an important class of GNEPs, including NEPs. Finally, under a weak constraint qualifcation introduced, we prove global convergence to a KKT point of an Augmented Lagrangian algorithm for GNEPs and under the quasinormality constraint qualifcation for GNEPs, we prove boundedness of the dual sequence.

4 - On Optimality Conditions for Linear Copositive Programming

Speaker: Tatiana Tchemisova, University of AVeiro, PT, talk 526

Co-Authors: *Olga Kostyukova*,

A linear problem of Copositive Programming consists in minimization of a linear function subject to linear constraints defined in a conic (infinite) index set. Using the equivalent formulation of the linear copositive problem in the form of a convex Semi-infinite Programming problem and "using" the previously developed approach based on the immobile indices of constraints, we obtain new optimality conditions that do not need any additional conditions for the constraints (Constraints Qualifications).

Energy markets

Specific Models, Algorithms, and Software

Sciences - We 9:00am-10:30am, Format: 3x30 min

Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 50

Organizer: Martine Labbé, Université Libre de Bruxelles, BE

1 - Unit Commitment under Market Equilibrium Constraints

Speaker: Bernard Fortz, ULB, BE, talk 575

Co-Authors: *Luce Brotcorne*, *Fabio D Andreagiovanni*, *Jérôme De Boeck*,

The classical Unit Commitment problem (UC) can be essentially described as the problem of establishing the energy output of a set of generation units over a time horizon, in order to satisfy a demand for energy, while minimizing the cost of generation and respecting technological restrictions of the units (e.g., minimum on/off times, ramp up/down constraints). Traditional (deterministic) models for the UC assume that the net demand for each period is known in advance. However, in practice, the demand is dictated by the amounts that can be sold by the producer at given prices on the day-ahead market. Our aim is to model and solve the UC problem with a second level of decisions ensuring that the produced quantities are cleared at market equilibrium. In their simplest form, market equilibrium constraints are equivalent to the first-order optimality conditions of a linear program. We are faced to a bilevel optimization problem where the first level is a MIP and the second level linear. In this talk, as a first approach to the problem, we assume that demand curves and offers of competitors in the market are known to the operator. We present the transformation of the problem into a single-level program by rewriting and linearizing the first-order optimality conditions of the second level, and some preliminary results on the performance of MIP solvers on this model.

2 - The Impact of Physics on Market Equilibria in Energy Networks

Speaker: Martin Schmidt, FAU Erlangen-Nürnberg, DE, talk 470

Co-Authors: *Vanessa Krebs*, *Lars Schewe*, *Veronika Grimm*, *Gregor Zöttl*, *Julia Grübel*,

We consider perfectly competitive energy market models, where the traded goods are transported through a network. For this setup, we study questions on uniqueness and multiplicity of market equilibria for different network flow models. Starting with classical linear network flow transport models we show that uniqueness holds under rather mild conditions. This changes if the same market equilibrium model is studied but with the classical linear lossless DC approximation for the network flow. Here, uniqueness of equilibria holds on trees but fails to hold on simple graphs containing cycles. Finally, we also consider nonlinear network flow models as they occur in gas networks. For this setting, we sketch that classical complementarity system modeling is not suitable anymore and derive a hierarchical bilevel model.

3 - Dynamic programming approach for bidding problems on day-ahead markets

Speaker: Martine Labbé, Université Libre de Bruxelles, BE, talk 305

Co-Authors: *Jérôme De Boeck*, *Etienne Marcotte*, *Patrice Marcotte*, *Gilles Savard*,

In several markets, such as the electricity market, spot prices are determined via a bidding system involving an oligopoly of producers and a system operator. Once time-dependent price-quantity bids are placed by each producer for its production units, the system operator determines a production schedule that meets demand at minimal cost. The spot price is then set to the marginal production cost. Fampa et al. (2098, 2015) have considered the problem faced by a profit maximizing producer, whose bids depend on the behaviour of the system operator, as well as the stochastic nature of final demand, and that can be cast within the framework of stochastic bilevel programming. In this presentation, we consider an enhanced model that embeds two key features, namely the uncertainty related to competitors' bids, as well as the impact of spot prices on demand. Our aim is to develop efficient algorithms for addressing instances involving a large number of scenarios. Under the assumptions that production costs are linear and that demand is piecewise constant, the bilevel model can be reformulated as a large mixed integer program. Although this problem becomes numerically intractable as the number of scenarios increases, it becomes much simpler when producers are allowed to place several price quantity bids for a given generator. This relaxation can be solved in polynomial time using dynamic programming. This algorithm can then be adapted to heuristically solve the original problem, yielding very quickly feasible solutions characterized by small optimality gaps.

MINLP (I)

Discrete Optimization & Integer Programming

MINLP - We 9:00am-10:30am, Format: 3x30 min

Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 65

Organizer: Daniel Bienstock, Columbia University, US

1 - Time-Varying Semidefinite Programs

Speaker: Bachir El Khadir, Princeton University, US, talk 1194
Co-Authors: *Amir Ali Ahmadi*,
We study semidefinite programs whose data is not constant but varies polynomially with time. Motivated by practical applications where a smooth solution is desired, we show that, under some conditions, we can find solutions that are polynomial in time and arbitrarily close to being optimal. We also provide a duality theory to give an upper bound on the approximation error to the optimal value. Furthermore, using sum of squares techniques and certain Positivstellensatze from real algebra, we show that the problem of finding the optimal polynomial solution of a given degree to a time-varying SDP can be cast exactly as a semidefinite program of tractable size.

2 - Strengthened Relaxations for Quadratic Optimization with Switching Variables

Speaker: Kurt Anstreicher, University of Iowa, US, talk 147
We consider indefinite quadratic optimization problems that include continuous and discrete variables of the form $F = \{(x, y) \mid 0 \le x \le y,\ y \in \{0, 1\}^n\}$. The binary variables y are often referred to as "switching" or "indicator" variables and occur frequently in applications. Our goal is to represent, or approximate, the convex hull of $\{(x, xx^T, y) \mid (x, y) \in F\}$ using constraints that include semidefiniteness conditions. We obtain an exact convex hull representation for $n = 2$ that also provides valid constraints that can be used to tighten semidefinite relaxations for higher n.

3 - A Simple Nearly-Optimal Restart Scheme For Speeding-Up First Order Methods

Speaker: James Renegar, Cornell University, US, talk 117
Co-Authors: *Benjamin Grimmer*,
We present a simple scheme for restarting first-order methods for convex optimization problems. Restarts are made based only on achieving specified decreases in objective values, the specified amounts being the same for all optimization problems. Unlike existing restart schemes, the scheme makes no attempt to learn parameter values characterizing the structure of an optimization problem, nor does it require any special information that would not be available in practice (unless the first-order method chosen to be employed in the scheme itself requires special information). As immediate corollaries to the main theorems, we show that when some well-known first-order methods are employed in the scheme, the resulting complexity bounds are nearly optimal for particular – yet quite general – classes of problems.

Approximation Algorithms for Scheduling Problems

Discrete Optimization & Integer Programming
APPROX - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4

Invited Session 72
Organizer: Nicole Megow, University of Bremen, DE

1 - The general scheduling problem with uniform release dates is not APX-hard

Speaker: Ruben Hoeksma, Universität Bremen, DE, talk 144
Co-Authors: *Antonios Antoniadis*, *Julie Meißner*, *Jose Verschae*, *Andreas Wiese*,
The general scheduling problem (GSP) generalizes single machine scheduling problems with total cost objectives such as weighted flow time and weighted tardiness. Given a set of jobs with processing times, release dates, and job dependent cost functions, we seek to find a minimum cost, preemptive schedule on a single machine. The best known result for this setting is an O(log log P)-approximation in polynomial time, where P denotes the range of job processing times. Noteworthy is that classical objective functions like weighted flow time and weighted tardiness can be modeled in this setting. Even for these objective functions no better results are known. The best known lower bound for GSP is strong NP-hardness, which holds even for uniform release dates, thus leaving a large gap in our understanding of the complexity of the problem. In the case of uniform release dates this gap is smaller, yet our understanding is still incomplete. When release dates are uniform, there exist a (4 + eps)-approximation and an (e + eps)-approximation in polynomial and quasipolynomial time, respectively. Here, we nearly close the gap for the identical release dates setting by showing that GSP with identical release dates is not APX-hard, unless SAT is contained in DTIME(exp(polylog(n))). The proof consists of a quasi-polynomial time approximation scheme (QPTAS) for GSP with identical release dates. The existence of this QPTAS directly implies the theorem. This work appeared in the proceedings of ICALP 2017.

2 - Minimizing Maximum Flow Time on Related Machines via Dynamic Pricing

Speaker: Clifford Stein, Columbia University, US, talk 695
Co-Authors: *Sungjin Im*, *Benjamin Moseley*, *Kirk Pruhs*,
We consider a setting where selfish agents want to schedule jobs on related machines. The agent submitting a job picks a server that minimizes a linear combination of the server price and the resulting response time for that job on the selected server. The manager's task is to maintain server prices to (approximately) optimize the maximum response time, which is a measure of social good. We show that the existence of a pricing scheme with certain competitiveness is equivalent to the existence of a monotone immediate-dispatch algorithm. Our main result is a monotone immediate-dispatch algorithm that is $O(1)$-competitive with respect to the maximum response time.

3 - Generalizing the Kawaguchi-Kyan Bound to Stochastic Parallel Machine Scheduling

Speaker: Sven Jäger, TU Berlin, DE, talk 661
Co-Authors: *Martin Skutella*,
Minimizing the sum of weighted completion times on m identical parallel machines is one of the most important classical scheduling problems. For the stochastic variant where processing times of jobs are random variables, Möhring, Schulz, and Uetz (1999) presented the first and still best known approximation result, achieving, for arbitrarily many machines, performance guarantee $1+\frac{1}{2}(1+\Delta)$, where Δ is an upper bound on the squared coefficient of variation of the processing times. We prove performance guarantee $1 + \frac{1}{2}(\sqrt{2}-1)(1+\Delta)$ for the same underlying algorithm—the Weighted Shortest Expected Processing Time (WSEPT) rule. For the special case of deterministic scheduling (i.e., $\Delta = 0$), our bound matches the tight performance ratio $\frac{1}{2}(1+\sqrt{2})$ of this algorithm (WSPT rule) by Kawaguchi and Kyan (1986).

4 - Precedence-Constrained Min Sum Set Cover

Speaker: Julian Mestre, Facebook, US, talk 92
Co-Authors: *Anthony Wirth*, *Jessica McClintock*,
We introduce a version of the Min Sum Set Cover (MSSC) problem in which there are "AND" precedence constraints on m sets. In the Precedence-Constrained Min Sum Set Cover (PCMSSC) problem, when interpreted as directed edges, the constraints induce an acyclic directed graph. PCMSSC models the aim of scheduling software tests to prioritize the rate of fault detection subject to dependencies between tests. Our greedy scheme for PCMSSC is similar to the approaches of Feige, Lovasz, and, Tetali for MSSC, and Chekuri and Motwani for precedence-constrained scheduling to minimize weighted completion time. With a factor-4 increase in approximation ratio, we reduce PCMSSC to the problem of finding a maximum-density precedence-closed sub-family of sets, where density is the ratio of sub-family union size to cardinality. We provide a greedy factor-$\sqrt{m}$ algorithm for maximizing density; on forests of in-trees, we show this algorithm finds an optimal solution. Harnessing an alternative greedy argument of Chekuri and Kumar for Maximum Coverage with Group Budget Constraints, on forests of out-trees, we design an algorithm with approximation ratio equal to maximum tree height. Finally, with a reduction from the Planted Dense Subgraph detection problem, we show that its conjectured hardness implies there is no polynomial-time algorithm for PCMSSC with approximation factor in $O(m^{1/12-\epsilon})$.

Recent Advances in Conic Programming II

Continuous Optimization
SDP - We 8:30am-10:30am, Format: 4x30 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Invited Session 83
Organizer: Sena Safarina, Tokyo Institute of Technology, JP

1 - Convex Relaxations for Nonconvex Quadratically Constrained Quadratic Program
Speaker: Rujun Jiang, Fudan University, CN, talk 131
Co-Authors: *Duan Li*,
We present new convex relaxations for nonconvex quadratically constrained quadratic programming (QCQP) problems. While recent research has focused on strengthening convex relaxations using reformulationlinearization technique (RLT), the state-of-the-art methods lose their effectiveness when dealing with (multiple) nonconvex quadratic constraints in QCQP. In this research, we decompose and relax each nonconvex constraint to two second order cone (SOC) constraints and then linearize the products of the SOC constraints and linear constraints to construct some effective new valid constraints. Moreover, we extend the reach of the RLT-like techniques for almost all different types of constraint-pairs (including valid inequalities by linearizing the product of a pair of SOC constraints, and the Hadamard product or the Kronecker product of two respective valid linear matrix inequalities), examine dominance relationships among different valid inequalities, and explore almost all possibilities of gaining benefits from generating valid constraints. Especially, we successfully demonstrate that applying RLT-like techniques to additional redundant linear constraints could reduce the relaxation gap significantly. We demonstrate the efficiency of our results with numerical experiments.

2 - Cone Decomposition Method for Mixed-Integer SOCP arising from tree breeding
Speaker: Sena Safarina, Tokyo Institute of Technology, JP, talk 606
Co-Authors: *Makoto Yamashita*,
The utilization of mathematical optimization has been increasing for modeling and solving practical problems in the field of tree breeding. One of the mathematical optimization problems is an optimal contribution selection (OCS) in which the aims is to maximize the total benefit under a constraint to keep genetic diversity. This research is focused on an equal deployment (ED) in OCS arising from seed orchard problem. Since the genetic diversity constraint in OCS can be described with a second-order cone, our problem can be mathematically modeled as mixed-integer second-order cone programming (MI-SOCP). However, a main difficulty of the MI-SOCP formulation is that the non-linearity constraint which leads to a heavy computation cost. We propose two numerical approaches based on polyhedral programming relaxation to remove the non-linearity and to generate effective linear approximations for OCS. The first approach is an implementation of lifted polyhedral programming relaxation with an active constraint selection method. The other is a cone decomposition method (CDM) that also combines the mixed-integer linear programming an outer-approximation method. Through the numerical results, we observed that CDM successively solves OCS problems much faster than a generic solver for MI-SOCP. Moreover, the decomposition of CDM can be applied not only to the OCS problem in tree breeding but also to other MI-SOCP problems. The talk is based on joint work with Tim J. Mullin.

3 - Infeasibility detection in ADMM for convex optimization
Speaker: Goran Banjac, University of Oxford, GB, talk 746
Co-Authors: *Paul Goulart*, *Bartolomeo Stellato*, *Stephen Boyd*,
The alternating direction method of multipliers (ADMM) is a powerful operator splitting technique for solving structured optimization problems. For convex optimization problems, it is well-known that the iterates generated by ADMM converge to a solution provided that it exists. If a solution does not exist, then some of the ADMM iterates diverge. Nevertheless, we show that the ADMM iterates yield conclusive information regarding problem infeasibility for a wide class of convex optimization problems including both quadratic and conic programs. In particular, we show that in the limit the ADMM iterates either satisfy a set of first-order optimality conditions, or produce a certificate of either primal or dual infeasibility. Based on these results, we propose termination criteria for detecting primal and dual infeasibility in ADMM. Infeasibility detection based on these criteria is used in OSQP, an open-source operator splitting solver for quadratic programming.

4 - A Simplex-like algorithm for the infimum point w.r.t. the second order cone
Speaker: Marta Cavaleiro, Rutgers University, US, talk 406
Co-Authors: *Farid Alizadeh*,
We define the notion of infimum and supremum of a set of points with respect to the second order cone. These problems can be formulated as second order cone optimization and thus solvable by interior point methods in polynomial time. We

present an extension of the simplex method to solve these problems. We also show some applications of infimum and supremum problems. In particular, application to the minimum ball containing a set of balls, and the maximum ball contained in the intersection of a set of balls, will be examined.

Theory and algorithms in conic linear programming 2

Continuous Optimization
SDP - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 20 Building: G, 1st floor, Zone: 6

Invited Session 89
Organizer: Gabor Pataki, UNC Chapel Hill, US

1 - An extension of Chubanov's algorithm to symmetric cone programming
Speaker: Masakazu Muramatsu, UEC, JP, talk 530
Co-Authors: *Bruno Lourenco*, *Tomonari Kitahara*, *Takashi Tsuchiya*,
We extend Chubanov's algorithm for finding an interior feasible solution of homogeneous linear programming to symmetric cone programming. The main algorithm calls a basic procedure to find a feasible solution, a certificate that there's no feasible solution, or the fact that the scaled feasible region is confined to the intersection of a half-space and the symmetric cone. Then the main algorithm rescale the problem so that the intersection looks like the original form and call the basic procedure again. When the main algorithm cannot find a feasible solution nor a certificate that there's no feasible solution, it declares that the feasible set is *thin* in the sense that the volume of the scaled feasible region is small enough. We prove that the main algorithm stops in a polynomial number of calls of the basic procedure and that each call of the basic procedure stops in a polynomial number of iterations. A distinguishing feature of our approach is the usage of a spectral norm that takes into account the way that the symmetric cone is decomposed into simple ones. In several key cases, including semidefinite programming and second order cone programming, the choice of such norm make it possible to obtain better complexity bounds for the basic procedure when compared to a recent approach by Pena and Soheili.
2 - Extending MOSEK with exponential cones
Speaker: Joachim Dahl, MOSEK, DK, talk 327
We discuss the new implementation of exponential cones in MOSEK. The implementation is based on scalings proposed by Tuncel, and is similar to the implementation of symmetric cones. We also discuss a higher-order corrector that significantly reduces the average number of iterations required to solve a collection of benchmark problems.
3 - Primal Facial Reduction in Semidefinite Programming and Matrix Completions
Speaker: Stefan Sremac, University of Waterloo, CA, talk 747
Co-Authors: *Hugo Woerdeman*, *Henry Wolkowicz*,
In semidefinite programming (SDP) strong duality is not an inherent property, but instead requires a constraint qualification such as the Slater condition. While the Slater condition holds generically for randomly generated instances, there are many relevant problems where the condition fails and consequently strong duality is not guaranteed and the primal or dual problem may not attain its optimal value. One popular regularization technique is facial reduction, where the problem is reduced to the minimal face of the positive semidefinite cone containing the feasible set. Most facial reduction algorithms in the literature attain the minimal face through a 'dual' procedure, i.e., obtaining a series of exposing vectors from the conjugate face. In this talk we present an algorithm that does not rely on exposing vectors. Instead, it obtains a matrix in the relative interior of the feasible set. We view this as a 'primal' approach to facial reduction. We consider an application to positive semidefinite Toeplitz matrix completion problems.
4 - Amenable cones: bridging error bounds and facial reduction
Speaker: Bruno Lourenco, University of Tokyo, JP, talk 532
In 2000, Jos Sturm showed how error bounds for linear matrix inequalities can be obtained without assuming regularity conditions and showed that the quality of the bound depends on the singularity degree of the problem. The singularity degree is defined as the number of facial reduction steps needed to regularize the problem. Motivated by Sturm's work, we show that error bounds without constraint qualification holds for a new family of cones called "amenable cones". Similarly, the quality of the bound is controlled by the singularity degree of the underlying problem. Among the amenable cones we have strictly convex cones, polyhedral cones, symmetric cones and others. Furthermore, amenability is preserved by direct products and bijective linear images. In particular, we provide a new Hölderian error bound for the doubly nonnegative cone and for symmetric cones, which recovers Sturm's result as a special case. The preprint can be found at https://arxiv.org/abs/1712.06221

Determinantal structures of IPs

Discrete Optimization & Integer Programming
IPtheory - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 131
Organizer: Martin Henk, TU Berlin, DE

1 - Width in congruency-constrained TU-systems.
Speaker: Stephan Artmann, ETH Zurich, CH, talk 723
Co-Authors: *Christoph Glanzer*, *Robert Weismantel*,
Let P be an integral polyhedron given by $P = \{x \in \mathbf{R}^n \mid Ax \leq b\}$, where $A \in \mathbf{Z}^{m\times n}$ is totally unimodular, $b \in \mathbf{Z}^m$. We consider sets of the form $Q = \{x \in P \cap \mathbf{Z}^n,\ d^\top x \equiv k \pmod 3\}$, where $d \in \{\pm1, 0\}^n$ and $0 \leq k < 3$, $k \in \mathbf{Z}$. We investigate bounds on the width of P if $Q = \emptyset$ and discuss the implications for polyhedra $\{x \in \mathbf{R}^n \mid Bx \leq c\}$ whose constraint matrix B has $(n \times n)$-subdeterminants only in $\{0, \pm3\}$. This is joint work with C. Glanzer and R. Weismantel.
2 - Faster algorithms for Integer Programming using the Steinitz Lemma
Speaker: Friedrich Eisenbrand, EPFL, CH, talk 52
Co-Authors: *Robert Weismantel*,
We consider integer programming problems in standard form $\max\{c^T x : Ax = b,\ x \geq 0,\ x \in Z^n\}$ where $A \in Z^{m\times n}$, $b \in Z^m$ and $c \in Z^n$. We show that such an integer program can be solved in time $(m\Delta)^{O(m)} \cdot \|b\|_\infty^2$, where Δ is an upper bound

on each absolute value of an entry in A. This improves upon the longstanding best bound of Papadimitriou (1981) of $(m \cdot \Delta)^{O(m^2)}$, where in addition, the absolute values of the entries of b also need to be bounded by Δ. Our result relies on a lemma of Steinitz that states that a set of vectors in R^m that is contained in the unit ball of a norm and that sum up to zero can be ordered such that all partial sums are of norm bounded by m. We also use the Steinitz lemma to show that the ℓ_1-distance of an optimal integer and fractional solution, also under the presence of upper bounds on the variables, is bounded by $m \cdot (2\,m \cdot \Delta + 1)^m$. Here Δ is again an upper bound on the absolute values of the entries of A. The novel strength of our bound is that it is independent of n. We provide evidence for the significance of our bound by applying it to general knapsack problems where we obtain structural and algorithmic results that improve upon the recent literature.

3 - On the number of distinct rows of a matrix with bounded sub-determinants

Speaker: Christoph Glanzer, ETH Zürich, CH, talk 722

Co-Authors: *Robert Weismantel*, *Rico Zenklusen*,

Let A be an integral matrix with m rows and n columns whose maximal submatrices have a determinant of at most Δ in absolute value. Assume that A attains full column-rank and that all of its rows are distinct. What is the maximal number of rows such a matrix can have? We prove that for $\Delta \geq 2$, m is bounded by $\frac{1}{2} \cdot \Delta^{\log_2 \log_2 \Delta + 2} \cdot n^2$. This is a generalization of a well-known bound by Heller showing that totally unimodular matrices admit at most $O(n^2)$ distinct rows. We also present extensions of our result to cases where Δ is a function of n.

4 - Distances between LPs, IPs and MIPs

Speaker: Robert Weismantel, ETH Zurich, CH, talk 717

Co-Authors: *Stefan Weltge*, *Joseph Paat*,

A result of Cook, Gerards, Schrijver, Tardos 1986 bounds distances between optimal solutions of an LP, a MIP or an IP associated with a given polyhedron and a linear objective function. We present several improvements of their bounds. This is joint work with S. Weltge and J. Paat.

Decomposition Techniques to Solve Large-Scale Optimization Problems for Electricity and Natural Gas Systems

Specific Models, Algorithms, and Software

Energy - We 8:30am-10:30am, Format: 4x30 min

Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 136

Organizer: Ramteen Sioshansi, The Ohio State University, US

1 - Toward Scalable Stochastic Economic Dispatch on an Industrial-Scale Model

Speaker: Jean-Paul Watson, Sandia National Laboratories, US, talk 1556

Co-Authors: *Bernard Knueven*,

We consider the problem of scalable security-constrained economic dispatch, in which a PTDF network representation is utilized. Decomposition is performed via progressive hedging, executed in a modest-scale parallel computing environment. Our base optimization model is that of the PJM Independent System Operator and contains full-fidelity representations of all ancillary services. We consider performance of instances considering variable wind penetration levels, and analyze the relationship between penetration level and algorithm behavior/performance. We show that progressive hedging approaches can effective address this problem, at scale, for a real-world power system.

2 - Distributionally Robust Transmission Expansion Planning

Speaker: David Pozo, Skoltech, RU, talk 950

Co-Authors: *Alexandre Velloso*, *Alexandre Street*,

We present a Distributionally Robust Optimization (DRO) mathematical framework for addressing the electric transmission expansion planning problem that accounts for long- and short-term uncertainty for significant penetration of renewable energy sources (RES). We consider the case where the exact probability distribution of future is ambiguous, i.e., hard to accurately estimate. The resulting DRO model is robust against all possible probability distribution functions that lie on an ambiguity set with partial information of the exact probability distribution. We then present a solution framework for a general class of DRO models with only first-moment information of the true underlying random distribution. The proposed framework allows the use of both well-known column-and-constraint generation and Benders decomposition techniques. A Dantzig-Wolfe-type upper bound is developed allowing the aforementioned decomposition techniques to converge to an epsilon-near-global-optimal solution in finite time. Finally, we conduct numerical tests on IEEE 118 system to demonstrate the benefits proposed approach and methodology of resolution.

3 - Structures and algorithms for nomination validation in steady-state gas networks

Speaker: Gerrit Slevogt, Universität Duisburg-Essen, DE, talk 621

Co-Authors: *Sabrina Nitsche*, *Ruediger Schultz*,

Nomination validation, i.e., the decision on whether a transportation order in a gas network is technically feasible, has become a recurring task in today's operation of gas networks. It goes beyond the problem of analysing feasibility for an individual parameter choice and requires a parametric global investigation instead. A reasonably good approximation of steady-state gas flow in pipeline systems, and hence starting point of the present investigations, is given by Kirchhoff's Laws on conservation of mass and momentum which, in turn, are represented by polynomial equations involving absolute values. The talk addresses different mathematical aspects induced by the need of arguing in global fashion. This concerns topics as different as coercivity and monotonicity of operators, detection of acyclic cycles in directed graphs, or symbolic computation with extended Gröbner bases of polynomial ideals.

4 - A bilevel model for the waste-to-energy supply chain in a circular economy

Speaker: Giorgia Oggioni, University of Brescia, IT, talk 521

Co-Authors: *Elisabetta Allevi*, *Luigi Boffino*, *Maria Elena De Giuli*,

On December 2015, the European Commission adopted a package to support the EU's transition to circular economy. Looking beyond the current linear economy approach based on "take, make and dispose" industrial models, the circular economy fosters the principle of "reusing-reducing-recycling" raw materials to guarantee energy saving and to reduce carbon emissions. Waste plays an important role in circular economy since it can be adopted to produce energy. In this paper, we consider the point of view of a power producer, which manages a waste-to-energy supply chain and decides the amount of electricity to sell in the day-ahead energy market, taking into account its technology portfolio. In particular, we assume that the power producer disposes of technologies for the waste-to-energy treatment, renewables and conventional power plants. For this analysis, we propose a bilevel model, where the upper-level problem describes the producer's operation decisions, while the lower-level problem defines the equilibrium of the day-ahead energy market.

Stochastic Optimization and Variational Inequalities II

Continuous Optimization
Variat - We 9:30am-10:30am, Format: 2x30 min
Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 156
Organizer: Alejandro Jofre, Universidad de Chile, CL

1 - How does uncertainty of demand propagate to flows under network equilibrium
Speaker: Yueyue Fan, University of California Davis, US, talk 1115
Co-Authors: *Ning Liu*,
Network equilibrium problems are widely studied in many types of service networks including transportation, energy, communication, etc. Recently, with a growing interest in resilience and reliability issues, more efforts are made to better understand network equilibrium problems in a stochastic setting. In this talk, we will present a new analysis approach for understanding the statistical properties of the input-output relationship in a general network equilibrium problem. Mathematically, the general problem is stated as following. Let ξ be a random variable obeying probability distribution F_ξ. For each realization of ξ, x corresponds to a user equilibrium, which obeys probability distribution F_x depending on F_ξ. We study the statistical properties of the mapping $\mathcal{S}$ which maps (ξ, F_ξ) to (x, F_x). As an example, we demonstrate how this analysis approach could be used to understand the propagation of uncertainty from travel demand to network flows in a congested traffic network.

2 - Variance-based stochastic extragradient methods with linear search for Stoch. VI
Speaker: Alejandro Jofre, Universidad de Chile, CL, talk 1116
Co-Authors: *Philip Thompson*, *Alfredo Iusem*,
We propose dynamic sampled stochastic approximated (DS-SA) extragradient methods for stochastic variational inequalities (SVI) that are *robust* with respect to an unknown Lipschitz constant L. We propose, to the best of our knowledge, the first provably convergent *robust* SA *method with variance reduction*, either for SVIs or stochastic optimization, assuming just an unbiased stochastic oracle within a large sample regime. This widens the applicability and improves, up to constants, the desired efficient acceleration of previous variance reduction methods, all of which still assume knowledge of L (and, hence, are not robust against its estimate). Precisely, compared to the iteration and oracle complexities of $O(\epsilon^{-2})$ of previous robust methods with a small stepsize policy, our robust method uses a DS-SA line search scheme obtaining the faster iteration complexity of $O(\epsilon^{-1})$ with oracle complexity of $(\ln L)O(d\epsilon^{-2})$ (up to log factors on ϵ^{-1}) for a d-dimensional space. Differently from previous robust methods for ill-conditioned problems, we allow an unbounded feasible set and an oracle with *multiplicative noise* (MN) whose variance is not necessarily uniformly bounded. These properties are appreciated in our complexity estimates which depend only on L and *local* variances or forth moments at solutions.

Benders Decomposition for Combinatorial and Bilevel Optimization

Discrete Optimization & Integer Programming
IPpractice - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Invited Session 171
Organizer: Fabio Furini, LAMSADE–Paris-Dauphine, FR

1 - A Framework for Benders with Integer Sub-Problem
Speaker: Arthur Mahéo, ANU, AU, talk 1210
Co-Authors: *Yossiri Adulyasak*, *J.-F. Cordeau*,
Benders decomposition is a famous method for dealing with complex MIPs. It operates by creating an integer master problem and a linear sub-problem. The sub-problem needs to be continuous to get dual information, which restricts the method's applicability. Existing approaches that extend its scope rely on complex relaxations, or very specific sub-structures. We propose a new framework to handle integer sub-problems. First, it operates on integer nodes during the branch-and-bound of the master problem. The LP relaxation gives a lower bound and dual information to generate cuts, a heuristic provides an upper bound. Second, after the branch-and-bound finishes, solving those solutions whose LP relaxation is lower than the global upper bound gives the optimum. We showcase the framework on three stochastic problems: a TSP with the possibility to pay a third party to visit a customer; a server location problem with stochastic demands; and, a stochastic knapsack with different objects realizations.

2 - New ILP formulations for the k-Vertex Cut Problem
Speaker: Paolo Paronuzzi, University of Bologna, IT, talk 1527
Co-Authors: *Fabio Furini*, *Ivana Ljubic*, *Enrico Malaguti*,
A vertex cut is a set of vertices whose removal disconnects the graph into several connected components. If the number of connected (not-empty) components is at least k, this set is called a k-vertex cut. Given a graph and an integer value k, the objective of the k-Vertex Cut Problem consists in finding a k-vertex cut of minimum cardinality. Our main motivations for studying this problem comes from the matrix decomposition problem and from the field of group technology. We propose a compact formulation, with a polynomial number of constraints, and a natural formulation with a number of inequalities that is exponential in the size of the input data. The latter formulation is expressed as a Bilevel Optimization problem in which the leader has to find the minimum number of nodes to delete while the follower solves a maximization

problem on the residual graph.

3 - Decomposition Approaches to Covering Location Problems

Speaker: Ivana Ljubic, ESSEC Business School, FR, talk 1439

Co-Authors: *JeanFrancois Cordeau*, *Fabio Furini*,

Covering problems constitute an important family of facility location problems. These problems embed a notion of proximity (or coverage radius) that specifies whether a given demand point can be served or "covered" by a potential facility location. One of the best known members of this family is the set covering problem location problem (SCLP) in which one must choose a minimum cost set of facilities so that every demand point is covered at least once. The drawback of the SCLP is that it often leads to costly or unrealistic solutions because it gives the same importance to every demand point, regardless of its position and size. To overcome this weakness, two main variants have been proposed: i) the maximal covering location problem (MCLP), which requires choosing a subset of facilities that maximizes the demand covered while respecting a budget constraint on the cost of the facilities; ii) the partial set covering location problem (PSCLP), which minimizes the cost of the open facilities while forcing a certain amount of demand to be covered. We study an effective decomposition approach to the MCLP and PSCLP based on the Benders-cut reformulation. We also draw a connection between Benders and submodular cuts and provide a series of computational experiments demonstrating that, thanks to this decomposition techniques, optimal solutions can be found very quickly, even for benchmark instances involving up to one million of demand points.

4 - The Maximum Clique Interdiction Game

Speaker: Fabio Furini, LAMSADE–Paris-Dauphine, FR, talk 126

Co-Authors: *Ivana Ljubic*, *Pablo San Segundo*, *Sebastie Martin*,

We study the two player zero-sum Stackelberg game in which the leader interdicts (removes) a limited number of vertices from the graph, and the follower searches for the maximum clique in the interdicted graph. The goal of the leader is to derive an interdiction policy which will result in the worst possible outcome for the follower (see [1]). This problem has applications in many areas, such as crime detection, prevention of outbreaks of infectious diseases and surveillance of communication networks. We design an exact solution framework based on a Bilevel Integer Linear Programming model. Thanks to the study of the polytope of the corresponding single-level reformulation, we derive a branch-and-cut algorithm and enhance it by tight combinatorial lower and upper bounds, which also allow for a drastic reduction of the size of the input graph. Our model is based on an exponential family of Clique-Interdiction Cuts whose separation requires solving the maximum clique problem. We derive an effective separation procedure based on a newly developed combinatorial algorithm that is tailored for finding maximum cliques in interdicted graphs. We assess the applicability and the limits of our exact framework on publicly available instances, including large-scale social networks with up to one hundred thousand vertices and three million edges. Most of these instances are solved to provable optimality within short computing times.

Energy-aware planning and scheduling 1

Specific Models, Algorithms, and Software

Energy - We 8:30am-10:30am, Format: 4x30 min

Room: Salle 23 Building: G, 3rd floor, Zone: 6

Invited Session 177

Organizer: Sandra U. Ngueveu, Univ de Toulouse, INP, LAAS, FR

1 - Robust optimisation of storage in a power generation expansion planning problem

Speaker: Sophie Demassey, CMA Mines ParisTech, FR, talk 1270

Co-Authors: *Edi Assoumou*, *Welnigton de Oliveira*,

System's periodicity is often exploited in long-term planning to reduce the size of the model by decomposing the time horizon into a limited set of representative periods. System's dynamicity is then captured by a fine time discretization within each period. However, this representation does not capture the temporal interdependencies between the periods. We address the problem of modelling non-periodic storage in large power systems, by coupling a long-term generation expansion planning model, based on the MARKAL-TIMES linear programming framework, with a mid-term storage investment model to optimize the system operation on each milestone-year. Uncertainties on price, load and renewable production are also considered in the proposed robust storage model, which is solved by Bender's cut and column generation. The approach is numerically assessed on an aggregated model of the French power system.

2 - Microgrid Energy Flexibility Optimization – 3 use cases

Speaker: Peter Pflaum, Schneider Electric, FR, talk 1520

Co-Authors: *Claude Le Pape*,

Microgrids are considered as a response to the challenges arising from an increasing amount of renewable energy resources. The principle is to manage flexibilities such as small production and storage facilities in a decentralized fashion, to achieve a more resilient and cost-efficient operation of the energy system. Control methods for microgrids based on mathematical programming stand out due to their ability to optimally anticipate future events in the system. In practice however, numerous challenges must be addressed in the control design due to the large variety of microgrid system configurations. In this talk, three use cases will be exposed and the specific modeling challenges will be discussed. The three use cases are: (i) a microgrid composed of a photovoltaic system, a battery and a natural gas engine with a simple energy cost minimization objective, (ii) a virtual power plant for managing the global energy account of a multi-site company, (iii) a microgrid participating to the capacity market, managing both reserve allocation and energy supply cost minimization.

3 - ILP models for the job-shop scheduling problem with energy consideration

Speaker: Paolo Gianessi, Mines Saint-Étienne, FR, talk 1452

Co-Authors: *Oussama Masmoudi*, *Xavier Delorme*,

Nowadays, energy consideration in the evaluation of industrial systems performances is becoming more and more a key factor, as a natural consequence of both increasing electricity prices and a general environmental concern. These aspects have given rise in recent years to numerous works in the literature of Operations Research concerning production system optimization. As to scheduling problems, the objective often sums up to minimizing production energy cost, consumed energy, or makespan subject to a maximum power peak constraint. In this work, we propose a job-shop scheduling problem with maximum power peak limit and production energy cost minimization. The planning horizon is composed of a sequence of time slots each having a different price per unit for used energy. The objective is therefore to determine a minimum cost deployment of the operations composing each task while respecting production and power constraints. Two different integer linear programming models are developed and presented, which are tested on two benchmark instances taken from the literature, namely mt06 and la04 with respectively 6 machines and 6 tasks, and 5 machines and 10 tasks. Different scenarios are defined in which machines power limits vary. Different time horizon width are considered with values of up to 1.2 times the completion time of last task obtained when minimizing the makespan. An analysis of the obtained results is proposed.

4 - Decomposition method in a scheduling problem with energy storage and costs

Speaker: Sandra U. Ngueveu, Univ de Toulouse, INP, LAAS, FR, talk 1405

Co-Authors: *Nabil Absi*, *Christian Artigues*, *Safia Kedad-Sidhoum*, *Félix Goupil*,

We consider a scheduling and energy sources assignment problem abstracted from several applications including data, smart buildings, hybrid-vehicles and manufacturing. A set of pre-emptive jobs has to be scheduled on a set machines. The energy consumed by a machine has a fixed part (if switched on/off) and a variable part depending on the tasks in process. Each task requires a known energy amount when processed on a given machine. A given schedule therefore induces a time-dependent total energy demand. Two energy sources are available to supply the demand. One is a reversible source, able to produce and retrieve energy assuming a limited capacity. The other is a non-reversible source of infinite capacity, only able to produce energy, but its usage comes with a cost expressed as a time-dependent piecewise linear function of the energy supplied. The objective is to minimize the total energy cost. We present original lot sizing and scheduling decomposition approaches, analysis of sub-problems and computational results.

Recent advances in first-order algorithms for non-smooth optimization

Continuous Optimization

NonSmooth - We 8:30am-10:30am, Format: 4x30 min

Room: Salle LC4 Building: L, Intermediate 1, Zone: 9

Invited Session 198

Organizer: Thomas Pock, Graz University of Technology, AT

1 - Non-smooth Non-convex Bregman Minimization: Unification and new Algorithms

Speaker: Peter Ochs, Saarland University, DE, talk 134

Co-Authors: *Jalal Fadili*,

We propose a unifying algorithm for non-smooth non-convex optimization. The algorithm approximates the objective function by a convex model function and finds an approximate (Bregman) proximal point of the convex model. This approximate minimizer of the model function yields a descent direction, along which the next iterate is found. Complemented with an Armijo-like line search strategy, we obtain a flexible algorithm for which we prove (subsequential) convergence to a stationary point under weak assumptions on the growth of the model function error. Special instances of the algorithm with a Euclidean distance function are, for example, Gradient Descent, Forward-Backward Splitting, ProxDescent, without the common requirement of a "Lipschitz continuous gradient". In addition, we consider a broad class of Bregman distance functions (generated by Legendre functions) replacing the Euclidean distance. The algorithm has a wide range of applications including many linear and non-linear inverse problems in signal/image processing and machine learning.

2 - Primal-dual algorithm for linearly constrained optimization problem

Speaker: Yura Malitsky, Univeristy of Göttingen, DE, talk 155

In this talk we present several recent results about the primal-dual hybrid gradient algorithm for nonsmooth minimization over linear constraints. First, we show how this algorithm allows one to use a simple linesearch for the cases where the norm of the operator is not known or when one wants to use larger steps during iterations. Remarkably, that this linesearch does not need any expensive extra evaluations as matrix-vector multiplications or proximal mappings. Second, we establish the relation of the primal-dual algorithm to the Tseng proximal gradient method. This allows us to show that the primal-dual method converges even in cases when the duality does not hold or when the linear constraints are inconsistent. For a problem with a separable objective function we develop a randomized coordinate primal-dual algorithm that also has fore-mentioned properties. Finally, using obtained insight, we propose an extension of the Tseng method for bilevel optimization problem, where both lower and upper problems are instances of composite problems. We prove its convergence without assumptions of strong convexity that is typical for many existing methods.

3 - Stochastic PDHG with Arbitrary Sampling and Applications to Medical Imaging

Speaker: Matthias Ehrhardt, University of Cambridge, GB, talk 127

Co-Authors: *Carola Schoenlieb*, *Peter Richtarik*, *Antonin Chambolle*,

A very popular algorithm for image processing and image reconstruction with non-differentiable priors is the primal-dual hybrid gradient (PDHG) algorithm proposed by Chambolle and Pock. In some scenarios it is beneficial to employ a stochastic version of this algorithm where not all of the dual updates are executed simultaneously. It turns out that the stochastic version has convergence rates along the same lines as the deterministic PDHG. Numerical results on clinical positron emission tomography (PET) data show a dramatic speed up by the proposed method and thereby the impact this may have on clinical applications.

4 - Acceleration and global convergence of the NL-PDHGM

Speaker: Stanislav Mazurenko, University of Liverpool, GB, talk 1655

Co-Authors: *Tuomo Valkonen*, *C. Clason*,
First-order primal-dual algorithms are the backbone for mathematical image processing and more general inverse problems that can be formulated as convex optimization problems. Recent advances have extended their applicability to areas previously dominated by second-order algorithms, such as nonconvex problems arising in optimal control. Nonetheless, the application of first-order primal-dual algorithms to nonconvex large-scale optimization still requires further investigation. In this paper, we analyze an extension of the primal-dual hybrid gradient method (PDHGM, also known as the Chambolle-Pock method) designed to solve problems with a nonlinear operator in the saddle term. Based on the idea of testing, we derive new step length parameter conditions for the convergence in infinite-dimensional Hilbert spaces and provide acceleration rules for suitably locally monotone problems. Importantly, we demonstrate linear convergence rates and prove global convergence in certain cases. We demonstrate the efficacy of these new step length rules on PDE-constrained optimization problems.

Advances in Integer Programming

Discrete Optimization & Integer Programming
IPtheory - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4
Invited Session 230
Organizer: Santanu Dey, GaTech, US

1 - A generalization of Gomory-Chvatal cuts
Speaker: Sanjeeb Dash, IBM Research, US, talk 940
Co-Authors: *Oktay Gunluk*, *Dabeen Lee*,
Integer programming problems often have nonnegative or bounded variables. Gomory-Chvatal (GC) cuts form a practically useful class of cutting planes for integer programs, but usually do not incorporate all available variable bounds. In this talk, we consider a natural generalization of GC cuts that uses available bound information. We prove that the closure of a rational polyhedron, defined as the set of points satisfying all the generalized GC cuts, is also a rational polyhedron. Our technique is motivated by a result of Dunkel and Schulz, but is very different from prior techniques used to prove polyhedrality of Gomory-Chvatal closures or split closures. This is joint work with Oktay Gunluk and Dabeen Lee.

2 - Integer Programming Techniques for Optimal Transmission Switching Problems
Speaker: Burak Kocuk, Sabanci University, TR, talk 853
Co-Authors: *Santanu Dey*, *Andy Sun*,
As the modern transmission control and relay technologies evolve, transmission line switching has become an important option in power system operators' toolkits to reduce operational cost and improve system reliability. Most recent research has relied on the direct current (DC) approximation of the power flow model in the optimal transmission switching problem. However, it is known that DC approximation may lead to inaccurate flow solutions and also overlook stability issues. In this study, we focus on the optimal transmission switching problem with the full alternating current (AC) power flow model, abbreviated as AC OTS, which can be formulated as a mixed-integer quadratically constrained quadratic program (MIQCQP). We propose a new exact formulation for AC OTS and its mixed-integer second order cone programming (MISOCP) relaxation. We improve this relaxation via several types of strong valid inequalities inspired by the recent developments for the closely related AC Optimal Power Flow (AC OPF) and DC Optimal Transmission Switching (DC OTS) problems. We also propose a practical algorithm to obtain high quality feasible solutions for the AC OTS problem. Extensive computational experiments show that the proposed formulation and algorithms efficiently solve IEEE standard and congested instances, and lead to significant cost benefits with provably tight bounds.

3 - Time-indexed Relaxations for the Online Bipartite Matching Problem
Speaker: Alejandro Toriello, Georgia Tech, US, talk 1101
Co-Authors: *Alfredo Torrico*,
We study the i.i.d. online bipartite matching problem, where one side of the bipartition is fixed and known in advance, while nodes from the other side appear one at a time as i.i.d. realizations of an underlying distribution, and must immediately be matched or discarded. We consider time-indexed relaxations of the set of achievable matching probabilities, introduce complete subgraph inequalities, show how they theoretically dominate inequalities from a lower-dimensional relaxation presented in previous work, and discuss when they are facet-defining. We finally present a computational study to demonstrate the empirical quality of the new relaxations and the heuristic policies they imply.

4 - Constant Capacity Flow Cover Inequalities on a Path or a Variant of Lot-Sizing
Speaker: Laurence Wolsey, Univ. cath. de Louvain, BE, talk 1222
Co-Authors: *Hande Yaman*,
It is known (or assumed) that for constant capacity single node flow sets the corresponding flow cover inequalities suffice to describe the convex hull of solutions. Here we show that under certain conditions the result extends to paths, in the sense that only flow cover inequalities for the original or certain aggregated constraints need to be added. The resulting sets can be interpreted as variants of the classical Wagner-Whitin lot-sizing model in which the capacity constraints and the storage bounds (and not the demands) drive the model. Also other valid inequalities are presented for the case when the flow cover inequalities do not suffice.

Progress in MIP Solvers I

Specific Models, Algorithms, and Software
Algo - We 9:00am-10:30am, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8
Invited Session 235
Organizer: Michael Winkler, Gurobi, DE

1 - New features and improvements in the SAS/OR optimization package
Speaker: Imre Polik, SAS Institute, US, talk 898
SAS/OR offers a full array of solvers and also a powerful modelling language to drive it, all integrated with the rest of the SAS analytics platform. In this talk we discuss the latest developments and performance improvements focusing on the mixed-integer linear optimization solver. In the second part of the talk we will present a truly cloud-based optimiza-

tion computing environment in the new SAS Viya product.

2 - MIPLIB 2017+1

Speaker: Thorsten Koch, ZIB and TU Berlin, DE, talk 370
Co-Authors: *The MIPLIB-team*,
We will report on the state of the upcomming MIPLIB 2017. This will include details on the selection process and the rationale for the decisions taken.

3 - Benchmarks of commercial and noncommercial optimization software

Speaker: Hans Mittelmann, Arizona State University, US, talk 41
Based on our benchmarking service we will report about the current state of the art in several areas of optimization.

Discrete Convex Analysis

Discrete Optimization & Integer Programming
COMB - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 41 Building: C, 3rd floor, Zone: 1

Invited Session 243
Organizer: Akiyoshi Shioura, Tokyo Institute of Technology, JP

1 - M-convex Function Minimization under L1-distance Constraint

Speaker: Akiyoshi Shioura, Tokyo Institute of Technology, JP, talk 495
M-convex function is a class of discrete convex function defined on the integer lattice points, and plays a primary role in the theory of discrete convex analysis. In this talk, we consider the following problem: we are given an M-convex function f, a vector x_0, and a positive constant U, and minimize the M-convex function f under the constraint that the L1-distance between a solution vector x and the given vector x_0 is at most U. This problem is motivated from the re-allocation of resource, where a new allocation of resource should not be much different from the old allocation. We show that the L1-distance constraint can be represented by a submodular constraint. This fact immediately implies that our problem is a special case of M-convex intersection problem and can be solved efficiently by existing algorithms. We then prove that our problem can be solved by a variant of steepest descent algorithm for the unconstrained M-convex function minimization.

2 - On the Construction of Substitutes

Speaker: Eric Balkanski, Harvard, US, talk 647
Co-Authors: *Renato Paes Leme*,
Gross substitutability is a central concept in Economics and is connected to important notions in Discrete Convex Analysis, Number theory and the analysis of Greedy algorithms in Computer Science. Many different characterizations are known for this class, but providing a constructive description remains a major open problem. The construction problem asks how to construct all gross substitutes from a class of simpler functions using a set of operations. Since gross substitutes are a natural generalization of matroids to real-valued functions, matroid rank functions form a desirable such class of simpler functions. Shioura proved that a rich class of gross substitutes can be expressed as sums of matroid rank functions, but it is open whether all gross substitutes can be constructed this way. Our main result is a negative answer showing that some gross substitutes cannot be expressed as positive linear combinations of matroid rank functions. En route, we provide necessary and sufficient conditions for the sum to preserve substitutability, uncover a new operation preserving substitutability and fully describe all substitutes with at most 4 items.

3 - Discrete Midpoint Convexity

Speaker: Fabio Tardella, Sapienza University of Rome, IT, talk 538
Co-Authors: *Kazuo Murota*, *Akihisa Tamura*, *Satoko Moriguchi*,
For a function defined on the integer lattice, we consider discrete versions of midpoint convexity, which offer a unifying framework for discrete convexity of functions, including integral convexity, $L^\natural$-convexity, and submodularity. By considering discrete midpoint convexity for all pairs of points at infinity distance equal to two or not smaller than two, we identify new classes of discrete convex functions, called locally and globally discrete midpoint convex functions. These functions enjoy nice structural properties. They are stable under scaling and addition, and satisfy a family of inequalities named parallelogram inequalities. Furthermore, they admit a proximity theorem with the same small proximity bound as that for $L^\natural$-convex functions. These structural properties allow us to develop an algorithm for the minimization of locally and globally discrete midpoint convex functions based on the proximity-scaling approach and on a novel 2-neighborhood steepest descent algorithm.

4 - Scaling, proximity, and optimization of integrally convex functions

Speaker: Satoko Moriguchi, Tokyo Metropolitan University, JP, talk 700
Co-Authors: *Akihisa Tamura*, *Fabio Tardella*, *Kazuo Murota*,
In discrete convex analysis, the scaling and proximity properties for the class of $\mathrm{L}^\natural$-convex functions were established more than a decade ago and have been used to design efficient minimization algorithms. For the larger class of integrally convex functions of n variables, we show here that the scaling property only holds when $n \leq 2$, while a proximity theorem can be established for any n, but only with a superexponential bound. This is, however, sufficient to extend the classical logarithmic complexity result for minimizing a discrete convex function of one variable to the case of integrally convex functions of any fixed number of variables.

Chance Constraint and Its Applications

Optimization under Uncertainty
Stoch - We 8:30am-10:30am, Format: 4x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 253
Organizer: Jianqiang Cheng, University of Arizona, US

1 - Joint chance constrained general sum games

Speaker: Abdel Lisser, Université Paris Sud, FR, talk 688
Co-Authors: *Shen Peng*, *Vikas Singh*,
We consider an n-player non-cooperative game with continuous strategy sets. The strategy set of each player contains a set

of stochastic linear constraints. We model the stochastic linear constraints of each player as a joint chance constraint. We assume that the row vectors of a matrix defining the stochastic constraints of each player are pairwise independent and each row vector follows a multivariate normal distribution. We show the existence of a Nash equilibrium for this game under some conditions.

2 - Distributionally robust geometric programs with chance constraints

Speaker: Jia Liu, Xi'an Jiaotong university, CN, talk 366

Co-Authors: *Zhiping Chen*, *Abdel Lisser*,

We discuss distributionally robust geometric programs with individual and joint chance constraints. Three groups of uncertainty sets are considered: uncertainty sets with known two first order moments information, uncertainty sets considering the uncertainties in terms of the distribution and the moments, and uncertainty sets constrained by the Kullback-Leibler divergence distance with a normal reference distribution or a data-driven discrete distribution. For the three groups of uncertainty sets, we find reformulations of the distributionally robust geometric programs with individual or joint chance constraints. Convexity and tractability of the reformulations are discussed and numerical tests are carried out on a shape optimization problem.

3 - Bounds for probabilistic constrained problems

Speaker: Francesca Maggioni, University of Bergamo, IT, talk 328

Co-Authors: *Abdel Lisser*, *Shen Peng*,

In this talk we develop bounds for chance constrained optimization problems in the case of single and joint probabilistic constraints with independent matrix vector rows. The deterministic approximations of probability inequalities are based on the one-side Chebyshev inequality, the Berstein's inequality, Chernoff inequality and Hoeffding inequality and allow to reformulate the chance constrained problem considered in a convex and efficiently solvable way under specific conditions. Piecewise linear and tangent approximations are also provided allowing to reduce further the complexity of the problem. Finally numerical results on randomly generated data are provided allowing to identify the tighter deterministic approximations.

4 - Partial Sample Average Approximation Method for Chance Constrained Problems

Speaker: Jianqiang Cheng, University of Arizona, US, talk 793

Co-Authors: *Celine Gicquel*, *Abdel Lisser*,

In this talk, we present a new scheme of a sampling-based method, named Partial Sample Average Approximation (PSAA) method, to solve chance constrained programs. In contrast to Sample Average Approximation (SAA) which samples all of the random variables, PSAA only samples a portion of random variables by making use of the independence of some of the random variables for stepwise evaluation of the expectation. The main advantage of the proposed approach is that the PSAA approximation problem contains only continuous auxiliary variables, whilst the SAA reformulation contains binary ones. Moreover, we prove that the proposed approach has the same convergence properties as SAA. At the end, a numerical study on different applications shows the strengths of the proposed approach, in comparison with other popular approaches, such as SAA and scenario approach.

Optimization under uncertainty

Discrete Optimization & Integer Programming

COMB - We 8:30am-10:30am, Format: 4x30 min

Room: Salle 39 Building: E, 3rd floor, Zone: 1

Invited Session 261

Organizer: Marco Molinaro, PUC-Rio, BR

1 - Online Probabilistic Metric Embedding and its Applications

Speaker: William Umboh, University of Sydney, AU, talk 138

Co-Authors: *Yair Bartal*, *Nova Fandina*,

Probabilistic metric embedding into trees is a powerful technique for designing online algorithms. The standard approach is to embed the entire underlying metric into a tree metric and then solve the problem on the latter. The expected distortion of the embedding is logarithmic in n, the size of the underlying metric. For many online applications, such as online network design problems, it is natural to ask if it is possible to construct such embeddings in an online fashion such that the distortion would be a function of k, the number of requested points. In this work, we show that a simple modification of the probabilistic embedding into trees of Bartal (FOCS 1996) gives an expected distortion of $O(\log k \log \Phi)$, where Φ is the aspect ratio of the requested points, and a nearly-matching lower bound. Unfortunately, this may result in a very bad dependence in terms of k. Surprisingly, we then show how to bypass this limitation, showing that despite the lower bound on distortion, this online probabilistic embedding can still be used to devise an $O(\log^2 k)$-competitive algorithm for online subadditive network design.

2 - Online and Dynamic Algorithms for Set Cover

Speaker: Ravishankar Krishnaswamy, Microsoft Research, IN, talk 358

In this talk, we study the set cover problem in the fully dynamic model. Here, the set of active elements, i.e., those that must be covered at any given time, can change due to element arrivals and departures. The goal is to maintain an algorithmic solution that is competitive with respect to the current optimal solution. This model is popular in both the dynamic algorithms and online algorithms communities: in dynamic algorithms, the running time of the algorithm making updates is bounded, while in online algorithms, the number of updates made to the solution (called recourse) is limited. In our work, we show the following results: In the update time setting, we obtain O(log n)-competitiveness with O(f log n) amortized update time, and O(f^3)-competitiveness with O(f^2) update time. The O(log n)-competitive algorithm is the first one to achieve a competitive ratio independent of f in this setting. In the recourse setting, we show a competitive ratio of O(minlog n,f) with constant amortized recourse. Note that this matches the best offline bounds with just constant recourse, something that is impossible in the classical online model. Our results are based on two algorithmic frameworks in the fully-dynamic model that are inspired by the classic greedy and primal-dual algorithms for offline set cover. We show that both frameworks can be used for obtaining both recourse and update time bounds, thereby demonstrating algorithmic techniques common to these strands of research. Joint work with Anupam Gupta, Amit Kumar and Debmalya Panigrahi.

3 - Algorithms and Adaptivity Gaps for Stochastic Probing
Speaker: Sahil Singla, Carnegie Mellon University, US, talk 115
Co-Authors: *Anupam Gupta*, *Viswanath Nagarajan*,
A stochastic probing problem consists of a set of elements whose values are independent random variables. The algorithm knows the distributions of these variables, but not the actual outcomes. The only way to learn the actual outcomes is to probe these elements. However, there are constraints on which set of elements may be probed. (E.g., we may have to travel in some metric to probe elements but have limited time.) These constraints are called outer constraints. We want to develop an algorithm that picks some set of elements to maximize the (expected) value, subject to the picked subset of elements satisfying some other set of constraints, called the inner constraints. In the past, probing problems were studied for the case when both inner and outer constraints were intersections of matroids; these modeled kidney matching and Bayesian auctions applications. One limitation of past work was their reliance on linear-programming-like techniques, which made going beyond matroid-like structures difficult. In this work, we give a very general adaptivity gap result that holds for all prefix-closed outer constraints, as long as the inner constraints are intersections of matroids. The adaptivity gap is O(1) for any constant number of inner matroid constraints. The prefix-closedness captures most "reasonable" outer constraints, like orienteering, connectivity, and precedence. Based on this we obtain the first approximation algorithms for a number of stochastic probing problems, which have applications, e.g., to path-planning and precedence-constrained scheduling.

4 - Online and Random-order Load Balancing Simultaneously
Speaker: Marco Molinaro, PUC-Rio, BR, talk 116
We consider the problem of online load balancing under ℓ_p-norms: sequential jobs need to be assigned to one of the machines and the goal is to minimize the ℓ_p-norm of the machine loads. This generalizes the classical problem of scheduling for makespan minimization (case ℓ_∞) and has been thoroughly studied. We provide algorithms with simultaneously optimal* guarantees for the worst-case model as well as for the random-order (i.e. secretary) model, where an arbitrary set of jobs comes in random order. One of the main components is a new algorithm with improved regret for Online Linear Optimization (OLO) over the non-negative vectors in the ℓ_q ball. Interestingly, this OLO algorithm is also used to prove a purely probabilistic inequality that controls the correlations arising in the random-order model, a common source of difficulty for the analysis. A property that drives both our load balancing algorithms and our OLO algorithm is a smoothing of the the ℓ_p-norm that may be of independent interest.

Numerically Efficient Methods for Piecewise Algorithmic Differentiation I

Specific Models, Algorithms, and Software
Algo - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

Invited Session 269
Organizer: Torsten Bosse, FSU Jena, DE

1 - Study of the numerical efficiency of structured abs-normal forms
Speaker: Sri Hari Narayanan, Argonne National Laboratory, US, talk 1505
Co-Authors: *Torsten Bosse*,
The abs-normal form (ANF) can be used to represent almost any piecewise linear function. Several of these piecewise linear functions exhibit a certain structure that has an impact on the numerical efficiency of the ANF representation. In this talk, three common structures are investigated that typically arise in applications and require special numerical treatment: the sum, the composition, and the componentwise maximum/minimum of several functions. For these structures, the corresponding expressions of the resulting abs-normal form are provided, as well as some alternatives. The theoretical observations are supported by numerical results.

2 - (Almost) Matrix-free solver for piecewise linear functions in Abs-Normal form
Speaker: Torsten Bosse, FSU Jena, DE, talk 962
The abs-normal form (ANF) is a compact algebraic representation for piecewise linear functions. The piecewise linear functions can be used to approximate piecewise smooth functions and usually contain important information about the non-smoothness of the investigated function. These information help to define step directions within general Newton methods that obey the non-smoothness of the original function and typically yield better convergence. However, the computation of these generalized Newton directions requires the solution of a piecewise linear equation in ANF. It was observed that the ANF can become very large, even for very simple functions. Hence, any solver that is based on the ANF and uses the (Schur-complement) matrices of the explicit ANF representation has to be considered as computational expensiv. In this talk, we will address this question and present the first (almost) matrix-free versions of some solver for ANFs. The theoretical discussion is supported by some numerical run-time experiments.

3 - An active signature method for piecewise differentiable/linear optimization.
Speaker: Andreas Griewank, Yachay Tech, EC, talk 1545
Co-Authors: *Andrea Walther*, *Lisa Hegerhorst*,
Many optimization problems, e.g. from machine learning, involve functions that are piecewise smooth due to the occurrence of absolute values, mins and maxes in their evaluation procedures. For such unconstrained objective functions we derived earlier first order (KKT) and second order (SSC) optimality conditions, which can be checked on the basis of a local piecewise linearization that can be computed in an AD like fashion, e.g. using ADOL-C or Tapenade. In this talk we first extend these necessary and sufficient optimality conditions to the constrained case giving particular consideration to complementarity constraints. To iteratively approximate points that satisfy the first and second order necessary conditions, we employ a natural successive piecewise linear optimization approach (SPLOP). From within bounded level sets all cluster points of these methods are at least first order optimal and under certain conditions the local rate of convergence can be shown to be linear, quadratic, or superlinear. To realize the good convergence properties of the outer iteration we have developed a QOP like method for the inner problem, i.e. the minimiztion of the sum of a piecewise linear functions and a quadratic term subject to piecewise linear constraints. Apart

from activating an deactivating inequalities one also has to add active kinks or drop them in one of two directions, which suggests the name active signature method. The efficacy of the current implementations is demonstrated on a variety of test problems including Fuzzy Pattern Trees from machine learning.

4 - Solving l_1 regularized minimax problems by successive piecewise linearization

Speaker: Angel Rojas, Yachay Tech, EC, talk 1549

Co-Authors: *Andreas Griewank*,

The majority of non-smooth test problems as well as some machine learning applications can be written in terms of one l_1 and one l_∞ norm applied to smooth functions. We also allow for both box constraints and smooth equality constraints. For this large class of optimization problems, local piecewise linear models are easily obtained in the so-called abs-normal form. This compact representation yields constructive local optimality conditions that are specializations of a more general theory developed by Griewank et al. Exploiting the special structure we develop an efficient algorithm based on successive piecewise linearization. It is shown to be very competitive with classical methods on the well-known test set of Karmitsa et al. and other applications. Finally, we sketch the treatment of arbitrary AMPL models by their transformation to C++ code and subsequent piecewise linearization by operator overloading.

Learning in CP

Discrete Optimization & Integer Programming

CP - We 8:30am-10:30am, Format: 4x30 min

Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 301

Organizer: Arnaud Lallouet, Huawei Technologies France, FR

1 - Constraint acquisition

Speaker: Nadjib Lazaar, LIRMM - U. of Montpellier, FR, talk 539

Constraint programming is used to model and solve complex combinatorial problems. The modeling task requires some expertise in constraint programming. This requirement is a bottleneck to the broader uptake of constraint technology. Several approaches have been proposed to assist the non-expert user in the modeling task. In this talk, I will present the recent results on constraint acquisition obtained by the Coconut team and their collaborators. In a first part I will show how to learn constraint networks by asking the user partial queries. That is, we ask the user to classify assignments to subsets of the variables as positive or negative.We provide an algorithm, called QUACQ, that, given a negative example, finds a constraint of the target network in a number of queries logarithmic in the size of the example. In a second part, I will show how to make constraint acquisition more efficient in practice (new kind of queries, the use of some background knowledge, more elicitation…).

2 - Reasoning with Learned Constraints

Speaker: Arnaud Lallouet, Huawei Technologies France, FR, talk 814

A binary classifier in Machine Learning can be seen as closing the definition partially given by a set of examples and counter-examples of a relation. After the learning phase, we obtain a classifier which closes the relation and may be used as a constraint. We show that from a classifier defining satisfiability we can provide a propagator for arc-consistency in the case of decision trees and bound consistency for neural networks. These learned constraints are particularly important in problems where no exact description of the constraint is available, like for modeling user preferences.

3 - Boundary Estimation: Learning Boundaries for Constraint Optimization Problems

Speaker: Arnaud Gotlieb, Simula Research Lab., NO, talk 1663

Co-Authors: *Helge Spieker*,

Solving Constraint Optimization Problems (COPs) can be dramatically simplified by providing tight boundaries of cost functions. By feeding a supervised Machine Learning model with data composed of known boundaries and extracted features of COPs, it is possible to train the model to estimate boundaries of a new COP instance. To tackle the absence of guarantee on estimated boundaries, the Machine Learning model is only seen as a helper for the constraint solver. We performed a large-scale experimental study of this AI-powered helper with distinct Constraint Programming solvers over seven COPs. Our results show that near-optimal boundaries can be learned for these COPs with a small overhead and, these estimated boundaries can help the solver in some cases.

4 - Empirical Model Learning: boosting optimization through machine learning

Speaker: Michela Milano, Università di Bologna, IT, talk 1664

One of the biggest challenges in the design of decision support and optimization tools for complex, real-world, systems is coming up with a good combinatorial model. The traditional way to craft a combinatorial model is through interaction with domain experts: this approach provides model components (objective functions, constraints), but with limited accuracy guarantees. Often enough, accurate predictive models (e.g. simulators) can be devised, but they are too complex or too slow to be employed in combinatorial optimization. In this talk, we propose a methodology called Empirical Model Learning (EML) that relies on Machine Learning for obtaining decision model components that link decision variables and observables, using data either extracted from a predictive model or harvested from a real system. We show how to ground EML on a case study of thermal-aware workload allocation and scheduling. We show how to encapsulate different machine learning models in a number of optimization techniques. We demonstrate the effectiveness of the EML approach by comparing our results with those obtained using expert-designed models.

First Order Methods for Non-Smooth Constrained Optimization

Continuous Optimization

RandomM - We 8:30am-10:30am, Format: 4x30 min

Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 305

Organizer: Qihang Lin, University of Iowa, US

1 - On the Non-Ergodic Convergence Rate of an Inexact Augmented Lagrangian Framework
Speaker: Shiqian Ma, UC Davis, US, talk 805
Co-Authors: *Ya-Feng Liu*, *Xin Liu*,
We consider the linearly constrained composite convex optimization problem, whose objective is a sum of a smooth function and a possibly nonsmooth function. We propose an inexact augmented Lagrangian (IAL) framework for solving the problem. The stopping criterion used in solving the augmented Lagrangian subproblem in the proposed IAL framework is weaker and potentially much easier to check than the one used in most of the existing IAL frameworks/methods. We analyze the global convergence and the non-ergodic convergence rate of the proposed IAL framework. Preliminary numerical results are presented to show the efficiency of the proposed IAL framework and the importance of the non-ergodic convergence and convergence rate analysis.
2 - A level-set method for stochastic optimization with expectation constraints
Speaker: Selvaprabu Nadarajah, Univ. of Illinois and Chicago, US, talk 743
Co-Authors: *Qihang Lin*, *Negar Soheili*,
Stochastic optimization problems with expectation constraints (SOECs) arise in several operations research and financial engineering applications. Only recently has an efficient stochastic subgradient method been developed for solving an SOEC defined by an objective and a single inequality constraint, where both are defined by expectations of stochastic convex functions. We develop a level-set method for computing near-optimal solutions to a generalization of this SOEC containing multiple inequality constraints, each involving an expectation of a potentially different stochastic convex function. We establish convergence guarantees for this method under different convexity assumptions.
3 - Fast method for non-smooth non-convex minimization
Speaker: Peng Zheng, University of Washington, US, talk 416
Co-Authors: *Aleksandr Aravkin*,
We propose a new class of algorithms for non-smooth, non-convex problems that are expressible as compositions of non-smooth non-convex functions with smooth maps. In many cases, these algorithms require only (1) least squares solvers and (2) proximal operators. An immediate consequence is that direct factorization, e.g. SVDs, as well as accelerated iterative methods such as preconditioned CG, fast-gradient methods, and (L)BFGS can be leveraged to solve non-smooth non-convex problems. We provide a convergence analysis and empirical results for a selected set of representative applications, including phase retrieval, stochastic shortest path, semi-supervised support vector machines (S^3VM), and exact robust PCA. In all of these applications, we see linear and superlinear empirical rates of convergence. In particular, we need fewer than 20 itera- tions to solve both exact RPCA and large-scale robust phase retrieval problems. As far as we know, the proposed algorithm is the first available for solving Kernel S^3VM problems.
4 - Stochastic Primal-Dual Coordinate Method for Nonlinear Convex Cone Programs
Speaker: DaoLi Zhu, Shanghai Jiaotong University, CN, talk 1637
Co-Authors: *Lei Zhao*,
Block coordinate descent (BCD) methods and their variants have been widely used in coping with large-scale nonconstrained optimization problems in many fields such as imaging processing, machine learning, compress sensing and so on. For problem with coupling constraints, Nonlinear convex cone programs (NCCP) are important problems with many practical applications, but these problems are hard to solve by using existing block coordinate type methods. This paper introduces a stochastic primal-dual coordinate (SPDC) method for solving large-scale NCCP. In this method, we randomly choose a block of variables based on the uniform distribution. The linearization and Bregman-like function (core function) to that randomly selected block allow us to get simple parallel primal-dual decomposition for NCCP. The sequence generated by our algorithm is proved almost surely converge to an optimal solution of primal problem. Two types of convergence rate with different probability (almost surely and expected) are also obtained. The probability complexity bound is also derived in this paper.

Stochastic optimization

Invited Talks
INTERFACE - We 8:30am-10:30am, Format: 4x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

Contributed Session 314
Chair: Alexei Gaivoronski, NTNU, NO

1 - Using disjunctive programming to represent Risk Aversion policies
Speaker: Bernardo Costa, UFRJ, BR, talk 790
Co-Authors: *Filipe Cabral*, *Joari Costa*,
We propose a methodology to represent the operational procedures of power system planning focused on the security of energy supply, taking into account the fundamental difference between conservation laws (physical limits) and operational rules. The former are hard constraints while the latter are soft constraints that must be imposed if the problem is feasible, but if not, a weaker alternative must be considered. For instance, hydraulic balance equations are hard constraints while minimum storage targets are soft constraints. A standard approach to deal with operational constraints in power systems planning resorts to artificial penalties. However, this approach often leads to decisions that are not always the aimed ones and also misrepresents the economic interpretation of total and marginal costs. The proposed methodology, using disjunctive programming, describes the feasible region of operation as a union of polyhedral sets. It does not make use of artificial prices and represents soft constraints more accurately than traditional penalty schemes. Under special circumstances, the polyhedra are ordered by cost, and thus exactly describe the ordering of the operational rules. The resulting formulation includes binary variables, and recent algorithmic advances in multistage mixed integer stochastic programming (SDDiP, by Zou, Ahmed and Sun) make the solution of the model computationally tractable. We illustrate the consistency of this proposal with a case study considering a long-term operational planning problem of the Brazilian Interconnected Power System.
2 - SDDP with stagewise-dependent objective coefficient uncertainty
Speaker: Anthony Downward, University of Auckland, NZ, talk 1187

Co-Authors: *Oscar Dowson*, *Regan Baucke*,

In this talk we present a modification of the SDDP algorithm for multi-stage stochastic programmes to enable stagewise-dependent cost-coefficient uncertainty to be dealt with efficiently, without the need to discretize the state space using, e.g. a Markov chain. This work draws upon the recent paper from Baucke et al. which details a simple method for approximating lower-bounds of saddle-functions. We present a proof that our proposed algorithm converges to the optimal policy, and provide some examples, which demonstrate the intuitive policies that are computed for a hydro-agent bidding problem over a river chain. Finally we will examine some computation results in comparison with some alternative solution methods.

3 - Stochastic optimization of simulation models: management of

Speaker: Alexei Gaivoronski, NTNU, NO, talk 1416

Co-Authors: *Giovanni Sechi*, *Paola Zuddas*,

We consider a complex dynamical system, which depends on decision variables and random parameters. The state of this system evolves according to a set of complex rules, which may involve the solution of optimization or game theoretical problems. The evolution of the system over some time horizon is described by a simulation model implementing these rules. Some performance criterion is defined on the sample paths of this simulation model and we are interested in finding such values of decision variables, which yield the optimal expected value of this criterion, possibly under some risk constraints. We show how stochastic gradient methods can be employed in order to achieve this aim. We apply this methodology to the optimal management of water resources network in Southern Sardinia. This network consists of several interconnected reservoirs and operates under substantial uncertainty about water inflows and general scarcity of water resources. The purpose of this network is to satisfy several different types of demand: agricultural, industrial, public, observing at the same time certain environmental constraints. In order to satisfy this demand the water should be transported upstream under certain circumstances, which generates substantial pumping costs. We simulate the operation of this system and apply stochastic gradient methods in order to find the optimal rules, which trigger the water transfer

4 - Demand Response To Electricity Prices In Flexible Manufacturing

Speaker: Kazem Abbaszadeh, UoA, NZ, talk 794

Co-Authors: *Golbon Zakeri*, *Geoffrey Pritchard*,

In New Zealand Electricity Market (NZEM), a major consumer of electricity deals with two main issues. First, an acceptable real time electricity price prediction is needed to make instant decisions. Second, a comprehensive model is needed to estimate electricity prices distributions in medium-long term planning horizon in order to get the optimal production scheduling. To do so, we model the electricity prices with two different approaches for short and medium time horizons. Moreover, we model a steel mill production process in New Zealand and develop a stochastic dynamic programming approach to optimize production costs.

First-Order Methods for Machine Learning

Specific Models, Algorithms, and Software

Learning - We 9:00am-10:30am, Format: 3x30 min

Room: Salle 16 Building: I, 2nd floor, Zone: 7

Invited Session 319

Organizer: Fabian Pedregosa, UC Berkeley, US

1 - Stochastic Composite Least-Squares Regression with convergence rate O(1/n)

Speaker: Nicolas Flammarion, UC Berkeley, US, talk 1114

We consider the minimization of composite objective functions composed of the expectation of quadratic functions and an arbitrary convex function. We study the stochastic dual averaging algorithm with a constant step-size, showing that it leads to a convergence rate of O(1/n) with- out strong convexity assumptions. This thus extends earlier results on least-squares regression with the Euclidean geometry to (a) all convex regularizers and constraints, and (b) all geome- tries represented by a Bregman divergence. This is achieved by a new proof technique that relates stochastic and deterministic recursions.

2 - Adaptive Three Operator Splitting

Speaker: Fabian Pedregosa, UC Berkeley, US, talk 527

Co-Authors: *Gautheir Gidel*,

We propose and analyze a novel adaptive step size variant of the Davis-Yin three operator splitting, a method that can solve optimization problems composed of a sum of a smooth term for which we have access to its gradient and an arbitrary number of potentially non-smooth terms for which we have access to their proximal operator. The proposed method leverages local information of the objective function, allowing for larger step sizes while preserving the convergence properties of the original method. It only requires two extra function evaluations per iteration and does not depend on any step size hyperparameter besides an initial estimate. We provide a convergence rate analysis of this method, showing sublinear convergence rate for general convex functions and linear convergence under stronger assumptions, matching the best known rates of its non adaptive variant. Finally, an empirical comparison with related methods on 6 different problems illustrates the computational advantage of the adaptive step size strategy.

3 - Approximate Composite Minimization: Convergence Rates and Examples

Speaker: Sebastian Stich, EPFL, CH, talk 1016

Co-Authors: *Sai Praneeth Karimireddy*, *Martin Jaggi*,

First-order optimization methods comprise two important primitives: i) computation of gradient information and ii) computation of the update that leads to the next iterate. In practice there is often a mismatch between the time required for the two steps, leading to underutilization of resources. In this work, we propose a new framework, Approximate Composite Minimization (ACM) that uses approximate update steps to ensure balance between the two operations, and thus shortens the total computation time. Numerical experiments demonstrate the effectiveness of these adaptive schemes. We consider composite objective functions $f + g$, where f is smooth and convex and g is just convex. An algorithm is comprised in the ACM framework if in each iteration, the algorithm computes an approximate minimizer of a model $m = u + g$ of the objective function, where u is a quadratic over-approximation of f. To achieve this, the algorithm does not necessarily need to explicitly construct the full model m, this point of view is merely an interpretation of the update step that is convenient for the analysis. Moreover, the (relative) accuracy of the solution can change between iterations and has not to be fixed a priori. We present a unified convergence analysis for the ACM framework. We recover the sublinear rate of standard proximal-gradient algorithms, and the linear rate if we assume strong convexity of the smooth part f. For both settings we obtain sharper bounds than previous work. We will discuss a few examples (Random Pursuit, (parallel) coordinate descent) in detail.

Structured Optimization for Machine Learning and Signal Processing

Specific Models, Algorithms, and Software Learning - We 8:30am-10:30am, Format: 4x30 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 330
Organizer: Lin Xiao, Microsoft Research, US

1 - Training neural networks using ADMM for multi-affine constrai
Speaker: Donald Goldfarb, Columbia University, US, talk 665
Co-Authors: *Wenbo Gao*, *Frank Curtis*,
We have developed a version of the alternating direction method of multipliers (ADMM) for multiaffine constrained optimization that can be applied to training neural networks. Our approach decouples the linear and nonlinear elements of the network, resulting in subproblems, all of which have closed-form solutions. Our method can be shown to converge to the set of constrained stationary points and is readily parallelized. If there is time we will show how our method can also be applied to sparse representation learning, such as inexact dictionary learning.

2 - Generalized Conditional Gradient for Structured Sparsity and Convex Deep Network
Speaker: Xinhua Zhang, University of Illinois Chicago, US, talk 807
Co-Authors: *Yaoliang Yu*,
Structured sparsity is an important modeling tool that expands the applicability of convex formulations for data analysis, however it also creates significant challenges for efficient algorithm design. We propose the generalized conditional gradient (GCG) algorithm which extends the standard Frank-Wolfe (FW) algorithms from constrained optimization to gauge function penalized setting, enabling a further acceleration by interleaving GCG with fixed-rank local subspace optimization. We provide a comprehensive overview of the convergence properties of GCG for both convex and nonconvex problems with $1/\epsilon$ rates for smooth losses, and establish the additive and multiplicative robustness under the inexactness of the underlying Linear Minimization Oracle (LMO). Applications are shown on multi-view matrix factorization, tensor completion and multitask learning with tensor trace norm regularization, and a completely positive relaxation of multi-layer neural network with parametric transfer. Further acceleration may be achieved by extending LMO to face restricted oracles, allowing the rates to leverage the sparsity of the optimal solution.

3 - Proximal methods for optimization over nonnegative trigonometric polynomials
Speaker: Lieven Vandenberghe, UCLA, US, talk 1092
Co-Authors: *Hsiao-Han Chao*,
Optimization problems over the convex cone of nonnegative trigonometric polynomials or its dual cone, the cone of positive semidefinite Toeplitz matrices, have applications in signal processing, time series analysis, system identification, and control. Recent examples include continuous sparse optimization techniques for superresolution and gridless compressed sensing. Interior-point methods for semidefinite optimization handle these conic constraints with a complexity that it is at least cubic in the degree of the polynomial. The talk will examine first-order proximal methods with a lower complexity per iteration. The methods are based on generalized or entropic proximal mappings, with the Itakura-Saito distance measure used as a Bregman divergence. The choice for the Itakura-Saito distance is motivated by the fact that the associated generalized projection on the set of normalized nonnegative trigonometric polynomials can be computed by solving a small number of positive definite Toeplitz systems. This makes it possible to define proximal algorithms with a complexity per iteration that is roughly quadratic in the degree of the polynomial.

4 - Fast convex optimization for eigenproblems and beyond
Speaker: Mikael Johansson, KTH, SE, talk 1645
Co-Authors: *Vien Van Mai*,
We introduce an efficient algorithm for finding the dominant generalized eigenvectors of a pair of symmetric matrices. Combining tools from approximation theory and convex optimization, we develop a simple scalable algorithm with strong theoretical performance guarantees. The algorithm retains the simplicity of the well-known power method but enjoys the asymptotic iteration complexity of the powerful Lanczos method. Unlike these classic techniques, our algorithm is designed to decompose the overall problem into a series of subproblems that only need to be solved approximately. The combination of good initializations, fast iterative solvers, and appropriate error control in solving the subproblems lead to a linear running time in the input sizes compared to the super-linear time for the traditional methods. The improved running time immediately offers acceleration for several applications. We apply the proposed algorithm to canonical correlation analysis, which is a fundamental statistical tool for learning of a low dimensional representation of high dimensional objects, and demonstrate improved performance over current state-of-the art algorithms. If time permits, we will also explain how the ideas extend to convex optimization problems with nuclear norm constraints.

Primal Algorithms for Integer Programming Problems

Discrete Optimization & Integer Programming
IPtheory - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 42 Building: C, 3rd floor, Zone: 1

Invited Session 338
Organizer: Daniel Aloise, Polytechnique Montreal, CA

1 - Integral Column Generation Algorithm for Set Par-

titioning Type Problems
Speaker: Adil Tahir, Polytechnique Montréal and Gerad, CA, talk 1346
Co-Authors: *Issmail El Hallaoui*, *Guy Desaulniers*,
We present an integral column generation (ICG) heuristic that combines the integral simplex and column generation to solve set partitioning type problems with very large number of variables. ICG finds a sequence of integer solutions, with non-increasing cost, leading to high quality solutions in reasonable times. Computational experiments on instances of the airline crew pairing problem involving up to 1700 flights show that ICG clearly outperforms two popular column generation heuristics (the restricted master heuristic and the diving heuristic). ICG can yield optimal or near-optimal solutions in less than one hour of computational time, generating more than 200 integer solutions during the solution process

2 - Distributed Integral Simplex Using Decomposition for Set Partitioning Problems
Speaker: Omar Foutlane, GERAD Montréal, CA, talk 916
Co-Authors: *Issmail El Hallaoui*, *Pierre Hansen*,
The aim of this work is to propose a distributed version DISUD of the integral simplex using decomposition algorithm ISUD using multiple agents. We have been motivated by computer science trend to use network of computers. To do so, we implement a team of agents where each agent dynamically splits the overall set partitioning problem into sub-problems and solve them in parallel on a single machine. The new algorithm DISUD improves at each iteration the current integer solution until (near) optimality. It works better on set partitioning instances from the airline industry than the distributed version of CPLEX (DCPLEX).

3 - A Polyhedral Study of the Shortest Path Problem with Resource Constraints
Speaker: Ilyas Himmich, Polytechnique Montréal, CA, talk 524
Co-Authors: *Issmail El Hallaoui*, *Francois Soumis*, *Hatem Ben Amor*,
The shortest path problem with resource constraints (SPPRC) is often used as a subproblem within a column generation approach for routing and scheduling problems. It aims to find a least cost path between the source and the destination nodes in a network while satisfying the resource consumption limitations on every node. The SPPRC is usually solved using dynamic programming. Such approaches are effective in practice, but they can be inefficient when the network is large and especially when the number of resources is high. To cope with this major drawback, we propose a new exact primal algorithm that explores the solution space iteratively using a path-adjacency-based partition. Numerical experiments for vehicle and crew scheduling instances demonstrate that the new approach outperforms both the standard dynamic programming and the multi-directional dynamic programming methods.

4 - A scalable algorithm for the solution of large clustering problems
Speaker: Daniel Aloise, Polytechnique Montreal, CA, talk 559
Co-Authors: *Claudio Contardo*,
Clustering consists in finding homogeneous and well-separated subsets, called clusters, from a set of given objects. The literature presents numerous clustering criteria to be maximized for separation and minimized for homogeneity. In this paper, we propose a global optimization method for clustering problems with respect to clustering criteria that satisfy three simple properties. We exemplify the use of our method on the diameter minimization clustering problem, which is strongly NP-hard. Our algorithm can solve problems containing more than 500,000 objects while consuming only moderate amounts of time and memory. The size of the problems that can be solved using our algorithm is two orders of magnitude larger than the largest problems solved by the previous state-of-the-art exact methods.

Dynamical Systems and Optimization

Continuous Optimization
NonSmooth - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 8 Building: N, 4th floor, Zone: 12
Invited Session 351
Organizer: Hedy Attouch, Université Montpellier, FR

1 - The continuous proximal-gradient approach in the nonconvex setting
Speaker: Radu Ioan Bot, University of Vienna, AT, talk 1279
We approach the minimization of the sum of a proper, convex and lower semicontinuous function with a possibly nonconvex smooth function from a continuous perspective via first and second order implicit dynamical systems of proximal-gradient type. We prove that the generated trajectory asymptotically converges to a critical point of the objective, provided that a regularization of the objective function is a so-called KL function; in other words, it satisfies the Kurdyka-Lojasiewicz inequality. To the class of KL functions belong semialgebraic, real subanalytic, uniformly convex and convex functions satisfying a growth condition. Convergence rates for the trajectory in terms of the Lojasiewicz exponent are also derived.

2 - Accelerated Forward-Backward Algorithms
Speaker: Alexandre Cabot, Universite de Bourgogne, FR, talk 1565
Co-Authors: *Hedy Attouch*,
We are interested in the problem of minimizing the sum of two convex functions f and g defined on a Hilbert space. The function f is supposed to be differentiable with Lipschitz gradient, while g is lower semicontinuous. The forward-backward algorithm consists in doing at each iteration a gradient step with respect to f and a proximal step with respect to g. In this presentation, we study an inertial forward-backward algorithm, corresponding to some additional extrapolation operation. Inertial methods have known a great success over these last decades with the heavy ball method, due to Polyak (1964) and the accelerated gradient method due to Nesterov (1983). The FISTA algorithm, very popular in image processing, is a forward-backward method based on the Nesterov acceleration. The goal of this presentation is to provide a unified framework allowing us to recover many existing results on inertial forward-backward methods. Under suitable conditions, we obtain weak convergence of the iterates, together with the speed of convergence $o(1/k^2)$ for the values. In a second part, we extend these acceleration techniques to the case of structured monotone inclusions. The corresponding papers were co-authored with H. Attouch (U. Montpellier).

3 - Inertial proximal algorithms for maximally monotone operators
Speaker: Juan Peypouquet, Universidad de Chile, CL, talk

1571
Co-Authors: *Hedy Attouch*,
We present a Regularized Inertial Proximal Algorithm to solve convex optimization problems and variational inequalities. It is obtained by means of a convenient finite-difference discretization of a second-order differential equation with vanishing damping, governed by the Yosida regularization of a maximally monotone operator with time-varying index. These systems are the counterpart to accelerated forward–backward algorithms in the context of maximally monotone operators. A simple example illustrates the behavior of these systems compared with some of their close relatives.

4 - A dual diagonal iterative regularization method
Speaker: Silvia Villa, Politecnico di Milano, IT, talk 1572
Co-Authors: *Guillaume Garrigos*, *Lorenzo Rosasco*,
In inverse problems, regularization is classically imposed by penalizing a data fidelity term. In this talk I explore a different regularization principle based on early stopping a computational procedure used to solve the noisy problem. In large scale scenarios such an approach could be advantageous, since it links together estimation and computational considerations. I will discuss in particular the regularization properties of a dual diagonal descent procedure, based on a forward-backward optimization algorithm, which allows to consider large classes of data-fit terms and regularizers.

Robust network optimization

Specific Models, Algorithms, and Software
Network - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 18 Building: I, 1st floor, Zone: 7
Invited Session 357
Organizer: Dimitri Papadimitriou, Nokia Bell Labs, BE

1 - Decomposition Approach for Robust Network Interdiction
Speaker: Joe Naoum-Sawaya, Ivey Business School, CA, talk 429
We present a decomposition approach for the Robust Stochastic Optimization of the Maximum Network Flow Interdiction Problem. The proposed approach considers fairly general uncertainty sets. Computational results are presented to compare the performance of the proposed approach over the solution of the full problem in standard optimization solvers.

2 - Robust network slice design under correlated demand uncertainties
Speaker: Varun Reddy, TU Chemnitz, DE, talk 1263
Co-Authors: *Fabio D Andreagiovanni*, *Andreas Baumgartner*, *Thomas Bauschert*,
Network Slicing denotes the partitioning of a physical substrate network into different virtual networks. The individual control of the allocated resources enables the concurrent operation of multiple logical networks with diverging requirements on the same physical substrate network infrastructure. The problem of optimally designing the individual logical network slices and mapping them onto the substrate network is denoted as the network slice design problem. In this work, we consider extensions of the general network slice design problem to take into account traffic demand uncertainties and correlations. By employing the Γ-robust uncertainty set proposed by Bertsimas and Sim, we devise two novel formulations i) for handling traffic demand uncertainties and ii) for considering correlations among the uncertain traffic demands. We present an extensive performance evaluation of the proposed formulations using realistic network instances from SNDlib.

3 - Equilibria for Robust Routing of Atomic Players
Speaker: Xudong Hu, Chinese Academy of Sciences, CN, talk 396
Co-Authors: *Xujin Chen*, *Chenhao Wang*,
Atomic routing games have attracted a great deal of attention over decades due to their various real-world applications, e.g., routing packets (vehicles) in communication (transportation) networks. We study the setting under incomplete information about edge costs, which is given by interval estimates. The players when making their path choices only know the interval estimates on edge costs, while the actual realization of each edge's cost can take any value from the corresponding interval, regardless of the values realized for other edges. Each player would select a path that is robust against the worst-case realization of uncertain edge costs which could happen to her. We adopt the minmax-regret criterion to model the robustness. Given a path (strategy) profile of the game, the maximum regret of a player is the worst-case difference between her total cost or her bottleneck cost and the optimum she could attain given a priori knowledge about actual realization of edge costs. The routing game is referred to as a robust routing game if every players aims at minimizing her maximum regret. An NE of this game, termed as robust Nash equilibrium (RNE), is a path profile under which no player can reduce her maximum regret by unilateral deviation. Concerning this problem with bottleneck-type objective, in view of the general NP-hardness for determining the RNE existence, we study the special case where all intervals of edge costs have the same length. We prove that every RNE of this special case is an NE of the corresponding bottleneck routing games under complete information.

4 - Reliable Multi-level Facility Location Problem (MFLP)
Speaker: Dimitri Papadimitriou, Nokia Bell Labs, BE, talk 1526
Given a set of demands and a set of potential facility locations partitioned into K levels, the goal of the MFLP is to determine per-level the locations where to simultaneously open facilities so that customer demands are assigned to one or multiple sequences of opened facilities while minimizing the facility opening and the edge utilization/transportation costs. In the capacitated case, the objective is to be met without violating opened facilities (and edges) capacities. The reliable MLFP generalizes the facility capacity constraints since, in case of facility failure at a certain level k, the remaining facilities at that level shall collectively provide sufficient capacity to satisfy the customer demands. Moreover, compared to the single-level case, in the multi-level context, a facility failure occurring at a given level k may propagate its effects upward to upper levels (from k up to K) but also downward to lower levels (from k-1 to 1), independently of the coherence of the setting. Starting from the assumption that each potential facility/location may experience failure with the same probability, we propose a MIP formulation for both MFLP variants. For their solving, a Benders decomposition method is proposed that relies on high density cut generation to reduce the CPU time and the number of iterations of the algorithm (thus, its convergence properties). Computational study aims at eval-

uating and comparing its performance against the standard Benders decomposition method for both unreliable and reliable variants of the MFLP.

Variational Analysis 1

Continuous Optimization
Variat - We 8:30am-10:30am, Format: 4x30 min
Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Invited Session 364
Organizer: Samir Adly, Laboratoire XLIM, FR

1 - Second Order Optimality Conditions for Cardinality Constrained Problems
Speaker: Alexandra Schwartz, TU Darmstadt, DE, talk 292
Co-Authors: *Max Bucher*,
It has been shown that cardinality constrained optimization problems can be reformulated as a continuous optimization problem with a complementarity-type constraint. Since classical MPCC theory cannot be applied directly to this reformulation, special first order necessary optimality conditions and relaxation schemes have been developed. In this presentation we complement the existing knowledge by developing necessary and sufficient second order optimality conditions for the continuous reformulation, from which we can also obtain necessary and sufficient second order optimality conditions for the original cardinality constrained problem. Furthermore, we show how these second order results can be used to improve the convergence theory of the relaxation methods by locally guaranteeing the existence of solutions of the relaxed problems as well as their convergence.

2 - Stability Analysis for Parameterized Equilibria with Conic Constraints
Speaker: Helmut Gfrerer, Johannes Kepler University, AT, talk 719
Co-Authors: *Matus Benko*, *Boris Mordukhovich*,
We consider parameterized equilibria governed by generalized equations whose multivalued parts are modeled via regular normals to nonconvex conic constraints. The main goal is to derive characterizations for a certain Lipschitzian behavior of the solution maps like calmness, the Aubin property or tilt stability.

3 - Stability and Sensitivity Analysis of Parametrized Optimization Problems
Speaker: Michel Thera, University of Limoges, FR, talk 483
Co-Authors: *Van Huynh*, *Huu Nguyen*,
In this talk, we will report some new results on regularity of multifunctions through various characterizations of directional Holder/Lipschitz metric regularity. The results are based on the concepts of slope and coderivative. By using these characterizations, we show that directional Holder/Lipschitz metric regularity is stable, when the multifunction under consideration is perturbed suitably. Applications of directional Holder/Lipschitz metric regularity to investigate the stability and the sensitivity analysis of parametrized optimization problems will be also discussed.

4 - Sensitivity analysis of parameterized nonlinear variational inequalities.
Speaker: Samir Adly, Laboratoire XLIM, FR, talk 832
In this talk, we investigate the sensitivity analysis of parameterized nonlinear variational inequalities of second kind in a Hilbert space. The challenge of the present presentation is to take into account a perturbation on all the data of the problem. This requires special adjustments in the definitions of the generalized first- and second-order differentiations of the involved operators and functions. Precisely, we extend the notions, introduced and thoroughly studied by R.T. Rockafellar, of twice epi-differentiability and proto-differentiability to the case of a parameterized lower semi-continuous convex function and its subdifferential respectively. These tools allow us to derive an exact formula of the proto-derivative of the generalized proximity operator associated to a parameterized variational inequality, and deduce the differentiability of the associated solution with respect to the parameter. Furthermore, the derivative is shown to be the solution of a new variational inequality involving semi- and second epi-derivatives of the data. An application is given to parameterized convex optimization problems involving the sum of two convex functions (one of them being smooth). Talk based on the following paper: [AB] S. Adly and L. Bourdin, Sensitivity analysis of variational inequalities via twice epi-differentiability and proto-differentiability of the proximity operator. arXiv:1707.08512.

Risk and Financial Markets

Optimization under Uncertainty
Game - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 377
Chair: Markku Kallio, Aalto Univ. School of Business, FI

1 - Bilevel programming approach for investment strategies under intermediation
Speaker: Stefano Nasini, IESEG School of Management, FR, talk 45
Co-Authors: *F. López-Ramos*, *Stefano Nasini*,
Most mathematical programming models for investment selection and portfolio management rely on centralized decisions about both budget allocation in different (real and financial) investment options and portfolio composition within the different options. However, in more realistic market scenarios investors do not directly select the portfolio composition, but only provide guidelines and requirements for the investment procedure. Financial intermediaries are then responsible for the detailed portfolio management, resulting in a hierarchical investor-intermediary decision setting. In this work, a bilevel mixed-integer quadratic optimization problem is proposed for the decentralized selection of a portfolio of financial securities and real investments. Two single-level reformulations are analyzed along with valid-inequalities which allow speeding-up their resolution procedure: (i) the KKT-based reformulation, and; (ii) the strong-duality-based reformulation. We conducted computational experiments on large historical stock market data from the Center for Research in Security Prices to validate and compare the the proposed bilevel investment framework (and the resulting single-level reformulations), under different levels of investor's and intermediary's risk aversion and control. The empirical tests reveled the impact of decentralization on the investment performance, and provide a comparative analysis of the computational effort

corresponding to the proposed solution approaches.

2 - A smooth path-following method for computing equilibria in incomplete markets

Speaker: Yang Zhan, City University of Hong Kong, HK, talk 674

Co-Authors: *Chuangyin Dang*,

In incomplete asset markets, trading across contingent commodities is in effect constrained because there is an insufficient number of contingent claims instruments to provide households with all potentially desirable credit arrangements. This insufficiency can cause discontinuity of the excess demand function at prices for which the asset return matrix loses its full rank. To overcome this discontinuity, we make use of the product of the return matrix and its transpose as a new return matrix. With the introduction of an extra variable, we establish an artificial incomplete asset market, which deforms continuously from a trivial market to the original market as the extra variable increases from zero to one. This artificial market assures the existence of a smooth path to an economic equilibrium.

3 - Cooperative Mitigation of Contagion in Financial Networks

Speaker: Markku Kallio, Aalto Univ. School of Business, FI, talk 326

Co-Authors: *Aein Khabazian*,

Since the beginning of the financial crisis in 2007-2008, several mitigation policies have been considered in order to monitor and stabilize the financial system in the event of a shock. Unlike most commonly in the literature, in this paper we examine the financial network of systemically important banks as a cooperative game. Governments can act as facilitators enforcing incentives for banks to cooperate and prevent the escalation of a financial crisis. To determine the characteristic function of the cooperative game, we develop clearing payment models for alternative coalitions competing in the market and show that the proposed models have unanimously preferred equilibrium solutions satisfying the clearing conditions. As a solution concept, we use nucleolus which implies a possible subsidizing pattern among the banks. For a demonstration, we use major European banks and a scenario which is linked to the adverse economic scenario used in 2016 EU-wide stress testing.

4 - Stable Risk Sharing and Its Monotonicity

Speaker: Zhenyu Hu, NUS Business School, SG, talk 395

Co-Authors: *Xin Chen*, *Shuanglong Wang*,

We consider a risk sharing problem in which agents pool their random costs together and seek an allocation rule to redistribute the risk back to each agent. The problem is put into a cooperative game framework and we focus on two salient properties of an allocation rule: stability and monotonicity employing concepts of core and population monotonicity from cooperative game theory. When the risks of the agents are measured by coherent risk measures, we construct a risk allocation rule based on duality theory and establish its stability. When restricting the risk measures to the class of distortion risk measures, the duality-based risk allocation rule is population monotonic if the random costs are independent and log-concave. For the case with dependent normally distributed random costs, a simple condition on the dependence structure is identifi ed to ensure the monotonicity property.

Interfaces of Applied Probability and Optimization

Optimization under Uncertainty

Robust - We 8:30am-10:30am, Format: 4x30 min

Room: Salle 37 Building: B, Intermediate, Zone: 4

Invited Session 409

Organizer: Omar El Housni, Columbia University, US

1 - Robust Markov Decision Process: Beyond (and back to) Rectangularity

Speaker: Julien Grand Clement, Columbia University, US, talk 749

Co-Authors: *Vineet Goyal*,

Markov decision processes (MDPs) are a common approach to model dynamic optimization problems in many applications. However, in most real world problems, the model parameters that are estimated from noisy observations are uncertain, and the optimal policy for the nominal parameter values might be highly sensitive to even small perturbations in the parameters leading to significantly suboptimal outcomes. We consider a robust approach where the uncertainty in probability transitions is modeled as an adversarial selection from an uncertainty set. Most prior work considers the case where uncertainty on parameters related to different states is unrelated and the adversary is allowed to select worst possible realization for each state unrelated to others, potentially leading to highly conservative solutions. On the other hand, the case of general uncertainty sets is known to be intractable. We consider a factor model for probability transitions where the transition probability is a linear function of a factor matrix that is uncertain and belongs to a factor matrix uncertainty set. This a significantly less conservative approach to modeling uncertainty in probability transitions while allowing to model dependence between probability transitions across different states. We show that under a certain rectangularity assumption, we can efficiently compute the optimal robust policy under the factor matrix uncertainty model. We also present a computational study to demonstrate the usefulness of our approach and give an FPTAS for the case of related non-rectangular factor matrix.

2 - Beyond Worst-case: A Probabilistic Analysis of Affine Policies

Speaker: Omar El Housni, Columbia University, US, talk 875

Co-Authors: *Vineet Goyal*,

Affine policies are widely used in dynamic optimization where computing an optimal adjustable solution is usually intractable. While the worst case performance of affine policies can be significantly bad, the empirical performance is observed to be near-optimal for a large class of problem instances. In this paper, we aim to address this stark-contrast. In particular, we consider a two-stage dynamic robust optimization problem with linear covering constraints and uncertain right hand side and show that affine policies give a good approximation on random instances generated from a large class of distributions including the commonly used distributions such as uniform and Gaussian.

3 - Sustainable Inventory With Robust Periodic-affine Policies and Med. Supply Chains

Speaker: Omid Nohadani, Northwestern University, US, talk 896

Co-Authors: *Eojin Han*, *Chaithanya Bandi*, We introduce a new class of adaptive policies called periodic-affine policies, that allows a decision maker to optimally manage and control large- scale newsvendor networks in the presence of uncertain demand without distributional assumptions. These policies are data-driven and model many features of the demand such as correlation, and remain robust to parameter mis-specification. We present a model that can be generalized to multi-product settings and extended to multi-period problems. This is accomplished by modeling the uncertain demand via sets. In this way, it offers a natural framework to study competing policies such as base-stock, affine, and approximative approaches with respect to their profit, sensitivity to parameters and assumptions, and computational scalability. We show that the periodic-affine policies are sustainable, i.e. time consistent, because they warrant optimality both within subperiods and over the entire planning horizon. This approach is tractable and free of distributional assumptions, and hence, suited for real-world applications. We provide efficient algorithms to obtain the optimal periodic-affine policies and demonstrate their advantages on the sales data from one of India's largest pharmacy retailers.

4 - Distributionally Robust Markovian Traffic Equilibrium

Speaker: Karthik Natarajan, SUTD, SG, talk 693

Co-Authors: *Selin Ahipasaoglu*, *Ugur Arikan*,

Stochastic user equilibrium models are fundamental to the analysis of transportation systems. In this paper, we propose a distributionally robust Markovian traffic equilibrium model and a corresponding choice model under the assumption that the marginal distributions of the link utilities are known but the joint distribution is unknown. By using a distributionally robust approach, we develop a new convex optimization formulation and propose an efficient algorithm to compute equilibrium flows. Our numerical experiments indicate that this provides modeling flexibility and computational tractability for system planners interested in calculating traffic equilibrium.

Computational advances in NLP

Continuous Optimization

NLP - We 8:30am-10:30am, Format: 4x30 min

Room: Salle KC7 Building: K, Intermediate 2, Zone: 10

Contributed Session 434

Chair: Jeffrey Pang, NUS, SG

1 - Optimal Bidding, Allocation, and Budget Spending for a Demand-Side Platform.

Speaker: Alfonso Lobos Ruiz, UC, Berkeley, US, talk 1594

Co-Authors: *Paul Grigas*, *Zheng Wen*, *Kuang-chih Lee*,

We develop an optimization model and corresponding algorithm for the management of a Demand-Side Platform (DSP), whereby the DSP acquires valuable impressions for its advertiser clients. The DSP aims to maximize its profit while having a proper budget spending for its advertisers, the latter represented by the usage of a utility over the budget spending. The DSP interacts with ad exchanges in a real-time bidding environment in a cost-per-click/cost-per-action pricing model. Our proposed formulation leads to a nonconvex optimization problem due to the joint optimization over both impression allocation and bid price decisions. We proposed a dual of our problem and show conditions under which our dual formulation obtain the same optimal value as the original non-convex formulation. We apply these condition to important cases of first and second price auctions. In addition, we proved that a primal-dual scheme would recover a close to optimal solution for the non-convex problem. Experimental results show how our methodology is able to trade off DSP profitability for better budget spending for its advertisers and that it outperforms an heuristic that is optimal for the case of infinite budgets.

2 - Distributed deterministic asynchronous optimization using Dykstra's splitting

Speaker: Jeffrey Pang, NUS, SG, talk 932

Many distributed optimization algorithms in undirected graphs $G = (V, E)$ either needs to be synchronized with a global clock, or involve randomization. For the problem $\min_x \sum_{i\in V}[f_i(x) + \frac{1}{2}\|x - \bar{x}_i\|^2]$, where each $f_i(\cdot)$ is proximable, we propose a distributed deterministic asynchronous optimization algorithm using Dykstra's splitting (or dual block coordinate ascent). Our algorithm can allow for time-varying graphs with partial data communications. Furthermore, as many dual variables can be chosen to be maximized over to achieve a greedier decrease. We discuss acceleration methods if the computations are coordinated by a global clock, and how to incorporate greedy ascent with asynchronous steps. We discuss how to incorporate bundle-like methods if some of the $f_i(\cdot)$ are subdifferentiable, and look at convergence rates of the algorithm.

3 - Decompositions and optimizations of symmetric conjugate complex forms

Speaker: Zhening Li, University of Portsmouth, GB, talk 1316

Co-Authors: *Taoran Fu*, *Bo Jiang*,

A symmetric conjugate form is an even-order homogenous complex polynomial function of some complex variables as well as their conjugates, with the degree of normal variables being the same to the degree of their conjugates. It arises in various complex polynomial optimization models including radar signal processing and quantum entanglement. We study symmetric conjugate complex forms in terms of decompositions and optimizations over the spherical constraint. The analysis is conducted in the frame work of its tensor representations, called conjugate partial-symmetric (CPS) tensors. We prove and propose a constructive algorithm to decompose any CPS tensor into a sum of rank-one CPS tensors. We study rank-one approximations and matricizations of CPS tensors. By carefully unfolding CPS tensors to Hermitian matrices, rank-one equivalence can be preserved. This enables us to develop new convex optimization models and algorithms to compute the extreme eigenvalue of a CPS tensor, i.e., optimization of a symmetric conjugate form over the spherical constraint. Numerical experiments from various data are performed to justify the capability of our methods.

4 - An inexact Newton-like conditional gradient method for constrained systems

Speaker: Max Goncalves, Federal University of Goias, BR, talk 237

Co-Authors: *Fabricia Oliveira*,

In this talk, we will propose an inexact Newton-like conditional gradient method for solving constrained systems of nonlinear equations. The local convergence of the new method as well as results on its rate will be established by using a general majorant condition. Two applications of such condition will be provided: one is for functions whose derivatives satisfy a Hölder-like condition and the other is for functions that satisfy a Smale condition, which includes a substantial class of analytic functions. Some preliminary numerical experiments illustrating the applicability of the proposed method will be also presented.

Fixed Point Approaches

Continuous Optimization
NLP - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 9 Building: N, 4th floor, Zone: 12

Contributed Session 435
Chair: Poom Kumam, KMUTT, TH

1 - Convergence analysis of S-iteration process for discontinuous operators
Speaker: Konrawut Khammahawong, KMUTT, TH, talk 724
Co-Authors: *Poom Kumam*,
In this paper, we introduce a new discontinuous operator and investigate the existence and uniqueness of fixed point in complete metric spaces. Also, we provide rate of convergence and data dependency of S-iterative method for these discontinuous operators. Moreover, we prove the estimation Collage theorem and compare error estimate between data dependency and Collage theorem. Example and Numerical example are provided to support our results.

2 - A new lgorithms for split feasibility problems involving paramonotone equilibria
Speaker: Poom Kumam, KMUTT, TH, talk 577
Co-Authors: *Wiyada Kumam*,
In this paper, by expanding the domain of the function f, we introduce a new algorithm which just involves a projection onto C. Also, we revisit the split feasibility problem and replace the unconstrained convex optimization by a constrained convex optimization. Further, we introduce two iterative algorithms to solve the new model and prove some strong convergence results of the proposed algorithms.

3 - Fixed point and convergence theorems for monotone (α,β)-nonexpansive
Speaker: Khanitin Muangchoo-in, KMUTT, TH, talk 1068
Co-Authors: *Poom Kumam*,
we introduce the notion of a monotone (α,β)-nonexpansive mapping in an ordered Banach space $(E,\leq)$ and prove some existence theorems of fixed points for the mapping in a uniformly convex ordered Banach space. Also, we prove some strong and weak convergence theorems of Ishikawa type iteration under some control condition. Finally, we give an numerical example to illustrate the main result.

4 - Monotone generalized almost contraction on weighted graph
Speaker: Wudthichai Onsod, KMUTT, TH, talk 946
Co-Authors: *Poom Kumam*,
In this paper, by using the concept of monotone almost contraction, we generalized the notion of monotone almost contraction on weighted directed graph and prove some fixed point results for this contractions. Also, we gave some examples of graph and the application to illustrate the main result.

Robust combinatorial optimization IV

Optimization under Uncertainty
Robust - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 33 Building: B, Ground Floor, Zone: 5

Contributed Session 449
Chair: Arie Koster, RWTH Aachen University, DE

1 - The vehicle routing problem under uncertainty via robust optimization
Speaker: Pedro Munari, UFSCar, BR, talk 1471
Co-Authors: *Alfredo Moreno*, *Jonathan De La Vega*, *Douglas Alem*, *Jacek Gondzio*, *Reinaldo Morabito*,
In this talk, we use robust optimization (RO) to incorporate data uncertainty into the vehicle routing problem (VRP). In real-life settings, different input parameters may be subject to uncertainty, such as customer demands and travel times, and it is important to design routes that can absorb deviations in the nominal values of these parameters, without becoming infeasible. We present a novel compact RO model based on polyhedral-interval uncertainty sets. The proposed model is derived from the incorporation of dynamic programming recursive equations into a standard deterministic VRP formulation. This strategy, which has never been used to obtain RO counterparts, is appealing because we do not need to formulate the adversary robust problem, thus avoiding the classical dualization scheme commonly used in the RO literature. This, in turn, means that we can write a robust counterpart model using fewer additional decision variables and constraints. Computational experiments with the VRP with time windows show that the proposed model yields robust optimal solutions within reasonable running times regardless the budgets of uncertainty and deviations. We also assess the trade-off between robustness and performance using a Monte Carlo simulation and illustrate the importance of providing robust routes towards a reliable decision-making process in practice.

2 - A time-dependent version of the robust TSP and SPP.
Speaker: Marina Leal, University of Seville, ES, talk 982
Co-Authors: *Eduardo Conde*, *Justo Puerto*,
Motivated by real life applications, as schedulling or task sequencing, we consider a Shortest Path Problem (SPP) or a Traveling Salesman Problem (TSP) where the arc costs depend on their relative position on the given path and there exist uncertain cost parameters. We study a minmax regret version of the problem under different types of uncertainty of the involved parameters. First, we provide a Mixed Integer Linear Programming (MILP) formulation by using strong duality in the uncertainty interval case for the shortest path problem. Second, we develop three algorithms, based on Benders decomposition, for a new and more general case in which we consider polyhedral sets of uncertainty for both problems. In order to make the algorithms faster we use constant factor approximations to initialize them, extending existing results. Finally, we report some computational experiments for different uncertainty sets in order to compare the behavior of the proposed algorithms.

3 - Scheduling Jobs under Uncertainty: A Customer-oriented Approach
Speaker: Arie Koster, RWTH Aachen University, DE, talk 1380
Co-Authors: *Cole Smith*,
From a mathematical optimization point of view, many (pro-

duction) planning problems can be modelled as scheduling jobs on a single machine. Here, the processing times are often uncertain and a schedule have to be prepared without complete knowledge about them. Recently, there have been an increasing interest in applying robust optimization to these and related problems. For this, an uncertainty set has to be defined containing all considered processing time vectors. Goal is to determine a processing sequence of the jobs that yields good performance in the worst case. The completion times of the jobs can only be determined after the actual processing times are revealed. After a review of the developing literature on the topic, we follow a customer oriented approach in this talk. Here, we have to determine guarenteed delivery times, i.e., the jobs have to be completed by their delivery time regardless the actual processing times of the jobs. In contrast to earlier studies, the order of the jobs need not to be predetermined, but can be adapted after the actual processing times become known. For the objective to minimize the weighted sum of delivery times, we present first formulations for this problem setting as well as a combinatorial heuristic algorithm, extending the well-known Smith's rule for the sum of weighted completion times.

4 - Optimizing the electricity production planning with stochastic outage durations

Speaker: Roberto Wolfler Calvo, Université Paris13, FR, talk 1581

Co-Authors: *Antoine Rozenknop*, *Marc Porcheron*, *Pascale Bendotti*, *Clement Pira*,

We study a scheduling problem of nuclear power plants. We address a generalization of the problem posed during the Roadef 2010 conference. In addition to the scenario on the demand, we deal with scenario on the outage durations. We propose a nested decomposition scheme where a Benders decomposition manage the stochastic scenarios on the demand, while the sub-problem use a Dantzig-Wolfe approach. This latter allows to coordinate a set of power plants in order to meet an energetic demand as well as some resource constraints on the schedule. Computational results prove the effectiveness of our approach. This approach can be viewed as alternative/complementary to the one described in "Planification des arrêts pour rechargement du parc nucléaire d'EDF : prise en compte de la stochasticité de la demande et de la disponibilité des centrales", presented by R. Griset et al. at Roadef 2018, dealing with the same problem, but based on a different coupling of Benders/Dantzig-Wolfe decomposition and on a different approach to implement robustness facing random parameters.

Sampling and stability in stochastic optimization

Optimization under Uncertainty

Stoch - We 9:00am-10:30am, Format: 3x30 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Contributed Session 488

Chair: Harsha Honnappa, Purdue University, US

1 - Distributional Robustness and Sample Average Approximation

Speaker: Edward Anderson, University of Sydney, AU, talk 367

Co-Authors: *Andy Philpott*,

We consider optimizing the expected value of an objective function $f(x, y)$ depending on a decision variable x and a random variable Y given N samples $y_1, ..., y_N$ drawn from Y. The standard approach of sample average approximation (SAA) is simply to minimize $(1/N)\Sigma f(x, y_i)$. However, a number of authors have observed that the solution of a distributionally robust form of this problem can often give better out-of-sample performance than SAA. For example, one may optimize using worst-case weights on the sample points using a ϕ-divergence approach, or consider minimizing the worst outcome achieved using a Wasserstein metric to bound the change in distribution (which amounts to allowing changes in the sample points). By studying the behaviour of the function f and the underlying distribution of Y, we seek conditions on the problem data under which robustification will improve out-of-sample performance. Explicit results can be obtained in the case of a univariate x for simple functions f. We also demonstrate problems for which robustification makes the SAA solution worse.

2 - On stability of stochastic bilevel programs with risk aversion

Speaker: Matthias Claus, University Duisburg-Essen, DE, talk 268

Co-Authors: *Johanna Burtscheidt*, *Stephan Dempe*,

Two-stage stochastic programs and bilevel problems under stochastic uncertainty bear significant conceptual similarities. However, the step from the first to the latter mirrors the step from optimal values to optimal solutions and entails a loss of desirable analytical properties. The talk focuses on mean risk formulations of stochastic bilevel programs where the lower level problem is quadratic. Based on a growth condition, weak continuity of the objective function with respect to perturbations of the underlying measure is derived. Implications regarding stability for a comprehensive class of risk averse models are pointed out.

3 - From Estimation to Optimization via Shrinkage

Speaker: Gerard Cornuejols, Carnegie Mellon University, US, talk 1649

Co-Authors: *Danial Davarnia*,

We study a class of quadratic stochastic programs where the distribution of random variables has unknown parameters. A traditional approach is to estimate the parameters using a maximum likelihood estimator (MLE) and to use this as input in the optimization problem. For the unconstrained case, we show that an estimator that "shrinks" the MLE towards an arbitrary vector yields a uniformly better risk than the MLE. In contrast, when there are constraints, we show that the MLE is admissible.

New trends II

Continuous Optimization

SDP - We 8:30am-10:30am, Format: 4x30 min

Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

Contributed Session 500

Chair: Frank Permenter, Toyota Research Institute, US

1 - An L^2-approach to Copositivity

Speaker: Claudia Adams, Trier University, DE, talk 331

Co-Authors: *Mirjam Duer*, *Leonhard Frerick*,
It is well known that many combinatorial optimization problems on finite graphs can be formulated as conic convex optimization problems. In particular, many NP-hard problems can be written as copositive programs, i.e. linear optimization problems over the cone of copositive matrices. In this formulation the hardness is moved totally into the copositivity constraint. We show how to lift this theory in order to deal with infinite graphs. To this end, we develop a new theory of semidefinite and copositive optimization in infinite dimensional spaces, especially in L^2. We propose a generalization of the completely positive matrix cone (i.e., the dual of the copositive matrix cone) in infinite dimensional space and we give a representation by its extreme rays. We also investigate L^p for $p \neq 2$ and show that the cases $p \notin \{1, 2\}$ are intractable. Understanding these cases and special properties is essential for developing solution approaches for problems of this kind.

2 - On algorithms to optimize homogeneous polynomial over the simplex and the sphere
Speaker: Faizan Ahmed, Institute of Space Technology, PK, talk 1363
Co-Authors: *Georg Still*,
In this paper, we describe algorithms to maximize a homogeneous polynomial (in general nonconvex) over the sphere and the simplex. The algorithms are based on iteration function. The monotonicity of these iteration functions is used to show that there always exists an ascent direction. We show the finiteness of these algorithms. Some numerical examples are also discussed to show the usability of the algorithms. The examples are drawn from the application areas such as evolutionarily stable strategies from population biology and maximum clique problem in the hyper-graphs for the case of polynomial optimization over the simplex. While for the case of polynomial optimization over sphere we have used the algorithm to approximate maximum eigenvalue of a tensor. Comparison of algorithm with other existing algorithm is also provided.

3 - Complementarity formulations of rank minimization problems
Speaker: John Mitchell, RPI, US, talk 904
Co-Authors: *April Sagan*, *Xin Shen*,
We investigate rank minimization problems in both symmetric and nonsymmetric matrices. Rank minimization problems can be formulated equivalently as semidefinite programs with complementarity constraints (SDCMPCC), as shown by Ding, Sun, and Ye. These are challenging nonconvex problems. We present penalty and relaxation approaches to the SDCMPCC formulations. We describe proximal alternating linearization minimization (PALM) methods for finding stationary points of these formulations. Computational results are given.

4 - Interior-point methods via the exponential map
Speaker: Frank Permenter, Toyota Research Institute, US, talk 1483
We propose new interior-point methods for semidefinite programming and, more generally, symmetric cone programming. The main idea is to replace the primal and dual decision variables with their images under the exponential map, a change-of-variables that linearizes complementary slackness. As we show, this leads to path-following algorithms whose per-iteration complexity is the same as current approaches. We describe a simple implementation that is competitive with state-of-the-art solvers.

Distribution and Demand Flexibility

Specific Models, Algorithms, and Software
Energy - We 8:30am-10:30am, Format: 4x30 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6
Contributed Session 510
Chair: Golbon Zakeri, University of Auckland, NZ

1 - A Data–Driven Robust Power Management in Active Distribution Systems
Speaker: Alejandro Angulo, UTFSM, CL, talk 1491
Co-Authors: *Fernando Mancilla-David*, *Alexandre Street*,
Under the smart grid paradigm, distribution systems with large penetrations of renewable energy sources could optimize their operation in order to make it more efficient and reliable. In this context, and based on conic mixed-integer formulations, we propose a new multi-period model to emulate the nonlinear operation of active distribution systems, where network physical behavior, discrete control equipment (as under load tap changers and mechanically switched capacitors), maximum allowable daily switching operation number constraints, photovoltaic inverter operation and stochastic nature of the solar energy resources are considered. A two stage robust optimization framework is used to include uncertainty into the model, where discrete and continuous control actions are assumed to be part of the first and second stage of this model, respectively. Necessary uncertainty sets for our robust approach are constructed directly from the data, defining them as the convex hull of a set of historical samples (data driven). Extensive computational experiments are performed utilizing modified versions of various IEEE test feeders. We evaluate the performance of the proposed model against the determinist case, using a rolling window evaluation methodology. When we seek for minimal losses operation, results shows: weak temporal coupling of multiperiod problem (short planning horizon is needed); reduction of approximately 20 percent in losses when the penetration of renewables is moderate; and reduction of 800 percent in hourly number of voltage violations when the penetration of renewables is high.

2 - Exploiting Flexibility in Loads for Balancing Power in Electrical Grids
Speaker: Anja Hähle, TU Chemnitz, DE, talk 572
Co-Authors: *Christoph Helmberg*,
The increased inclusion of regionally available renewable energies into the existing electricity system may cause infeasibilities in the load balancing problem of power grids. Resolving these by expanding the grid often meets societal and environmental opposition. We present a model and an algorithmic framework that exploits flexible loads from geographically distributed data centers to improve grid stability in order to avoid grid expansions. In this we use coupled time-expanded networks to model the shifting of virtual machines (VMs) as well as to control the on-off status of servers. In the end, the arising discrete multi-commodity flow problems enable the integration of flexible loads into the classical Optimal-Power-Flow problem (OPF). Finally, we present first computational results based on simulated networks.

3 - Analysis of a Routing Game Model for Demand Side Management
Speaker: Paulin Jacquot, EDF Lab - Inria Saclay, FR, talk

993
Co-Authors: *Olivier Beaude*, *Stephane Gaubert*, *Nadia Oudjane*,
Demand Side Management of a set of strategic electricity consumers is modeled with a splittable routing congestion game on a parallel network. Each consumer splits her energy demand on her set of available time periods, according to her feasibility constraints. We answer to several theoretical and practical questions on this model. We give existence and uniqueness theorems of an equilibrium of the routing game. We address the computational issue of determining an equilibrium and study two intuitive algorithms: the cycling best response dynamics and a projected gradient descent method. We give convergence results of those algorithms in specific cases, in which the equilibrium can be computed at an arbitrary precision in polynomial time. Last, we address the questions of the stochasticity of parameters and the efficiency of the pricing in this model.

4 - Demand response in electricity markets
Speaker: Golbon Zakeri, University of Auckland, NZ, talk 914
Co-Authors: *Mahbubeh Habibian*, *Anthony Downward*,
We will present a model and its solution procedure for constructing an optimal offer curve, in conjunction with a interruptible load reserve curve for a large consumer of electricity who is capable of responding to price. Our model is a bilevel stochastic optimization model that delivers the optimal action for a single time period. We will also discuss extensions to a multi-period model.

Monotone Operator Theory in Convex Optimization

Invited Talks
KEYNOTE - We 11:00am-12:00am, Format: 1x60 min
Room: BROCA Building: W, 3rd floor, Zone: 0

Invited Session 537
Organizer: Samir Adly, Laboratoire XLIM, FR

1 - Monotone Operator Theory in Convex Optimization
Speaker: Patrick Combettes, North Carolina State Univ., US, talk 1552
Several aspects of the interplay between monotone operator theory and convex optimization are discussed. The crucial role played by monotone operators in the analysis and the numerical solution of convex minimization problems is emphasized. We review the properties of subdifferentials as maximally monotone operators and, in tandem, investigate those of proximity operators as resolvents. In particular, we study transformations which map proximity operators to proximity operators, and establish connections with self-dual classes of firmly nonexpansive operators. In addition, algorithmic considerations are discussed.

Online Competitive Algorithms for Resource Allocation

Invited Talks
KEYNOTE - We 11:00am-12:00am, Format: 1x60 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 539
Organizer: Frank Curtis, Lehigh University, US

1 - Online Competitive Algorithms for Resource Allocation
Speaker: Maryam Fazel, Univ. of Washington, US, talk 1684
In online optimization with budgets, the data in the optimization problem is revealed over time, and at each step a decision variable needs to be set without knowing the future inputs, while there is a budget constraint that couples the decisions across time. In this talk, we consider an online optimization setup that includes problems such as online (budgeted) resource allocation with a fixed inventory, and the 'Adwords' problem popular in online advertising. We examine two classes of primal-dual algorithms, with a focus on the competitive ratio, i.e., the ratio of the objective achieved by the algorithm to that of the optimal offline sequence of decisions. We give a bound on this ratio and show how certain smoothing of the objective function can improve the bound, and how to seek the optimal smoothing by solving a convex design problem. This approach allows us to design effective smoothing customized for a given cost function and problem structure. We will illustrate this approach in several classical examples, as well as a few new ones.

Model-Based Methods, Sampling Models, and A New Second-Order Model-Based Method

Invited Talks
KEYNOTE - We 11:00am-12:00am, Format: 1x60 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 546
Organizer: Stefan Wild, Argonne National Laboratory, US

1 - Model-Based Methods, Sampling Models, and A New Second-Order Model-Based Method
Speaker: Luis Nunes Vicente, University of Coimbra, PT, talk 1582
The use of modeling in numerical optimization is ubiquitous. The accuracy of a model depends on how much we know about the problem function, in particular about its derivatives. A model can be used as a surrogate either to directly compute an approximate solution to the problem at hand or in a subproblem for the step computation of some iterative method, such as a trust-region method. In this talk we will first review new complexity results for trust-region methods when the exact gradient is not available, covering the cases of inexact gradients, random models whose accuracy is provided with some probability, and derivative-free optimization where models are recovered using only function values. Such a rich background can deliver a model recovery in other scenarios. One can sample Hessian vector products where we do function values to build models with approximate curvature. Based on this idea, we will present a new Hessian free second-order model-based method.

Organizer: Markus Schweighofer, Universität Konstanz, DE

1 - The power and limits of convex relaxations for general-valued CSPs
Speaker: Standa Zivny, University of Oxford, GB, talk 37
Co-Authors: *Johan Thapper*,
We will present a characterisation of general-valued CSPs that can be solved to optimality using convex relaxations. In particular, we show that either such problems can be solved by the third level of the Sherali-Adams LP hierarchy, or they cannot be solved by linear levels of the Lasserre SDP hierarchy. The criterion distinguishing the two cases is in terms of certain algebraic objects known as fractional polymorphisms, which have been instrumental in obtaining several complexity classifications for CSPs.

2 - On the convergence of the Lasserre/SoS hierarchy for 0/1 optimization problems.
Speaker: Adam Kurpisz, ETH Zurich, CH, talk 175
Co-Authors: *Samuli Leppänen*, *Monaldo Mastrolilli*,
The Lasserre/Sum-of-Squares (SoS) hierarchy is a systematic procedure for constructing a sequence of increasingly tight semidefinite relaxations. It is known that the hierarchy converges to the 0/1 polytope in n levels. We start with characterizing the set of 0/1 problems that might not still converge at level n-1. These problems are the hardest for the hierarchy in this sense. Moreover, we study a conjecture by Laurent, who considered the linear representation of a set with no integral points and believed that the Lasserre/SoS rank is n-1. We disprove this and derive lower and upper bounds for the rank. We do this by introducing a method for proving Lasserre/SoS bounds when the initial problem formulation exhibits a high degree of symmetry. Finally, we show applications of this technique in 0/1 polynomial optimization.

3 - High Degree SOS Proofs, Bienstock-Zuckerberg hierarchy and Chvatal-Gomory cuts
Speaker: Monaldo Mastrolilli, IDSIA, CH, talk 39
Chvatal-Gomory (CG) cuts and the Bienstock-Zuckerberg hierarchy capture useful linear programs that the standard bounded degree Lasserre/Sum-of-Squares (SOS) hierarchy fails to capture. In this paper we present a novel polynomial time SOS hierarchy for 0/1 problems with a custom subspace of high degree polynomials (not the standard subspace of low-degree polynomials). We show that the new SOS hierarchy recovers the Bienstock-Zuckerberg hierarchy. Our result implies a linear program that reproduces the Bienstock-Zuckerberg hierarchy as a polynomial sized, efficiently constructible extended formulation that satisfies all constant pitch inequalities. The construction is also very simple, and it is fully defined by giving the supporting polynomials (one paragraph). Moreover, for a class of polytopes (e.g. set covering and packing problems) it optimizes, up to an arbitrarily small error, over the polytope resulting from any constant rounds of CG cuts. Arguably, this is the first example where different basis functions can be useful in asymmetric situations to obtain a hierarchy of relaxations.

Insights via volumetric comparison of polyhedral relaxations

Invited Talks
SEMI - We 11:00am-12:00am, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 548
Organizer: Andrea Lodi, Polytechnique Montreal, CA

1 - Insights via volumetric comparison of polyhedral relaxations
Speaker: Jon Lee, University of Michigan, US, talk 1548
I will survey some mathematical results (many quite recent) concerning volumes of polytopes of interest in non-convex optimization. The motivation is in geometrically comparing relaxations in the context of mixed-integer linear and nonlinear optimization, with the goal of gaining modeling and algorithmic insights. We consider relaxations of: fixed-charge formulations, vertex packing, boolean-quadric polytopes, and relaxations of graphs of monomials on box domains. Besides surveying the area, I will highlight some good open problems.

Relaxations and Approximations of Chance Constraints

Invited Talks
PLENARY - We 1:30pm-2:30pm, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 525
Organizer: Simge Kucukyavuz, University of Washington, US

1 - Relaxations and Approximations of Chance Constraints
Speaker: Shabbir Ahmed, Georgia Tech, US, talk 912
A chance constrained optimization problem involves random constraints that are required to be satisfied with a prespecified probability. Such constraints are used to model reliability requirements in a variety of application areas such as finance, energy, service and manufacturing. Except under very special conditions, chance constraints impart severe nonconvexities making the optimization problem extremely difficult. In this talk we will review results on constructing tractable relaxations and approximate solutions for this hard class of problems. Extensions to distributionally robust chance constrained problems will also be discussed.

The power and limits of the Lasserre hierarchy

Continuous Optimization
NLP - We 3:15pm-4:45pm, Format: 3x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

Invited Session 9

SDP approaches to combinatorial and global optimization problems

Continuous Optimization

SDP - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 20 Building: G, 1st floor, Zone: 6

INVITED SESSION 15
Organizer: Etienne De Klerk, Tilburg University, NL

1 - Semidefinite Programming Relaxations of the Traveling Salesman Problem
Speaker: Samuel Gutekunst, Cornell University, US, talk 80
Co-Authors: *David Williamson*,
We analyze the integrality gap of a semidefinite programming relaxation of the traveling salesman problem due to de Klerk, Pasechnik, and Sotirov. We show that the integrality gap is unbounded by searching for highly structured feasible solutions; the problem of finding such solutions reduces to finding feasible solutions for a related linear program. These solutions imply several corollaries that help us better understand the semidefinite program and its relationship to other relaxations of the traveling salesman problem.

2 - On Solving the Quadratic Shortest Path Problem.
Speaker: Hao Hu, Tilburg University, NL, talk 121
Co-Authors: *Renata Sotirov*,
The quadratic shortest path problem is the problem of finding a path in a directed graph such that the sum of interaction costs over all pairs of arcs on the path is minimized. In this talk we present several semidefinite programming relaxations for the quadratic shortest path problem with a matrix variable of order equal to the number of arcs in the graph. We test our bounds on different graphs including highly symmetric ones. Numerical results show that our bounds are currently the strongest bounds for the quadratic shortest path problem.

3 - SDP relaxations of polynomial optimization problems with chordal structure
Speaker: Ahmadreza Marandi, Eindhoven University, NL, talk 16
Co-Authors: *Etienne De Klerk*, *Joachim Dahl*,
To solve a sparse optimization problem with only inequalities, Weisser, Lasserre and Toh [Math Prog Compt:1-32, to appear] construct a sequence of lower bounds by solving semi-definite programming (SDP) relaxations. Under some assumptions, it is proved by the authors that the sequence converges to the optimal value. In this talk, we modify the SDP relaxations to deal with problems containing equality constraints directly, without eliminating or replacing them with two inequalities. We show that the convergence results are still valid for the modification. Also, we evaluate this modification on a well-known bilinear programming problem, called the pooling problem, as well as a discrete-time optimal control problem.

Clustering

DISCRETE OPTIMIZATION & INTEGER PROGRAMMING
APPROX - We 3:15pm-4:45pm, Format: 3x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

INVITED SESSION 30
Organizer: Mohammad Salavatipour, University of Alberta, CA

1 - Clustering Mixtures of Well-Separated Gaussians
Speaker: Aravindan Vijayaraghavan, Northwestern University, US, talk 150
Co-Authors: *Oded Regev*,
Gaussian mixture models (GMM) are natural average-case models for k-means clustering problem, and form the most popular framework for clustering data in machine learning and data analysis. We consider the problem of efficiently learning a mixture of a large number of spherical Gaussian components, when the components of the mixture are well-separated. In the first part of the talk, we will consider the following question: what is the minimum order of separation needed for learning a mixture of k spherical Gaussians in d dimensions with polynomial samples? I will give a new iterative algorithm for learning mixtures of k spherical Gaussians, and give sample complexity lower bounds that together essentially characterize the optimal order of separation between components that is needed to learn a mixture of k spherical Gaussians with polynomial samples. Time permitting, I will also introduce a natural semi-random model for k-means clustering that generalizes the Gaussian mixture model, and that we believe will be useful in identifying robust algorithms, and give algorithmic guarantees for this model.

2 - Correlation Clustering
Speaker: Konstantin Makarychev, Northwestern University, US, talk 223
Co-Authors: *Shuchi Chawla*, *Yury Makarychev*, *Tselil Schramm*, *Aravindan Vijayaraghavan*, *Grigory Yaroslavtsev*,
I will talk about the correlation clustering problem. In this problem, our goal is to partition a collection of items into groups of similar items. We assume that we are given a graph on the set of all items, in which every edge (x,y) is marked with a sign "+" or "-" by a noisy classifier. The "+" sign indicates that the objects x and y are similar (and thus should belong to the same cluster); the "-" sign indicates that the objects are dissimilar (and should belong to different clusters). The classifier makes errors and, therefore, the information we get is inconsistent with any clustering. We want to find a clustering that minimizes the number of misclassified edges i.e. the number of "+" edges crossing the boundary of the partition plus the number of "-" edges lying within one partition. Correlation clustering has been extensively studied in theoretical computer science and machine learning communities. It is used for clustering data sets containing complex objects which cannot be embedded into Euclidean space in a natural way and, therefore, cannot be clustered using k-means and other standard algorithms. The problem is NP hard. I will present a 2.06 approximation algorithm for correlation clustering on complete graphs. I will also describe a semi-random model for correlation clustering with partial information, and give a PTAS for semi-random instances.

3 - Analysis of Ward's method
Speaker: Melanie Schmidt, University of Bonn, DE, talk 640
Co-Authors: *Anna Großwendt*, *Heiko Röglin*,
Clustering is an important unsupervised learning method. In recent years, much effort has been spent to analyze classical clustering problems like k-median and k-means, where an input point set is to be partitioned into k clusters, optimizing an objective function. In addition to major improvements regarding the approximability of these problems, seminal results also include the analysis and advancement of popular heuristics like the k-means algorithm. Much less is known about a slightly different domain: hierarchical clustering. Here, instead of looking for one k-clustering, the goal is to find a hierarchy of clusterings. There are many popular algorithms

that produce hierarchical clusterings; most of them agglomerative clustering methods. This means that these algorithms start with singleton clusters and then successivly merge clusters to form a hierarchy. The algorithms differ in the way that they choose the two clusters to be merged in each step. With the k-means objective in mind, the best known heuristic for this problem is Ward's method. It greedily chooses the two clusters that induce the smallest increase in the k-means cost. Although this algorithm has been known for decades, very little is known about the quality of the clusterings it produces. We give lower and upper bounds on the performance of Ward's algorithm, in particular studying it under different clusterability assumptions.

Subspace methods in NLP I

Continuous Optimization
NLP - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 45
Organizer: Michal Kocvara, University of Birmingham, GB

1 - A Space Transformation Framework for Nonlinear Optimization: Part I
Speaker: Zaikun Zhang, Hong Kong Polytechnic Univ., HK, talk 417
Co-Authors: *Serge Gratton*, *Luis Nunes Vicente*,
We present a space transformation framework for nonlinear optimization. Instead of tackling the problem in the original space, each iteration of this framework seeks for a trial step by modeling and approximately solving the optimization problem in another space. We establish the global convergence and worst case iteration complexity of the framework. We show that the framework can be specialized to a parallel space decomposition framework for nonlinear optimization, which can be regarded as an extension of the domain decomposition method for PDEs. A feature of the decomposition framework is that it incorporates the restricted additive Schwarz methodology into the synchronization phase of the method. It can be applied to design parallel algorithms for optimization problems with or without derivatives. This is a joint work with Serge Gratton (IRIT-ENSEEIHT, France) and Luis Nunes Vicente (University of Coimbra, Portugal).

2 - A Space Transformation Framework for Nonlinear Optimization: Part II
Speaker: Serge Gratton, ENSEEIHT, FR, talk 447
Co-Authors: *Luis Nunes Vicente*, *Zaikun Zhang*,
It is well known that efficient solvers and preconditioner for solving optimization problems arising in the numerical solution of elliptic partial differential equations (PDE's) can be based on the overlapping Schwarz domain decomposition algorithm. The main appeal of this type of algorithm is that they enable to introduce parallelism in solvers making them adequate for modern computer architectures. Using a general framework based on space transformation (presented in Part I), we generalize these Schwarz algorithms to nonconvex optimization problems. A key ingredient in the original Schwarz method, and in our approach too, is to find the best strategy for handling the overlap between subdomains: we will discuss here the so-called weighted, and restricted additive Schwarz method for nonconvex optimization. Another feature that will be discussed is the introduction of a coarse space in our approach, which is instrumental for performance in Schwarz methods. On this particular point, will consider here both multiplicative and additive strategies that maintain the convergence properties and complexity of the original method. Several variants of our methods will be compared numerically on two kinds of problems: problems involving differential operators, and more general algebraic problems based on the cutest problems collection.

3 - Quasi-Newton and the Unreduced Matrix in Interior Point Methods
Speaker: Francisco Sobral, State University of Maringa, BR, talk 425
Co-Authors: *Jacek Gondzio*,
In this work we study and implement a quasi-Newton approximation to the unreduced matrix that arises in Interior Point Methods. Given the good structure and huge size of the unreduced matrix, the most common approaches reduce it to Augmented Systems or to Normal equations in order to compute the Newton directions. We show that a quasi-Newton approximation to the inverse of the unreduced matrix has the ability to decrease the overall number of expensive matrix factorizations. This approach can also be inserted into a matrix-free scheme.

Decomposition methods for MINLP

Discrete Optimization & Integer Programming
MINLP - We 3:15pm-4:45pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 55
Organizer: Ivo Nowak, HAW Hamburg, DE

1 - Decomposition-based Successive Approximation Methods for MINLP
Speaker: Ivo Nowak, HAW Hamburg, DE, talk 690
Co-Authors: *Pavlo Muts*, *Eligius Hendrix*,
Motivated by column generation methods for solving transport scheduling problems with over 100 million variables, we present a new deterministic global optimization approach, called Decomposition-based Inner- and Outer-Refinement (DIOR). The new solution approach is based on successively improving approximations by parallel solving submodels. DIOR can be applied to general modular and/or sparse MINLPs. We present preliminary numerical results with Decogo, a new MINLP solver.

2 - Decogo - A new decomposition-based MINLP solver
Speaker: Pavlo Muts, HAW Hamburg, DE, talk 865
Co-Authors: *Ivo Nowak*, *Eligius Hendrix*,
Most modern MINLP-solvers use a branch-and-bound tree, which may grow rapidly. We introduce Decogo, a new MINLP-solver, based on decomposition-based successive approximation, which does not use global branch-and-bound search tree. Before starting the solution method, the original nonconvex MINLP is automatically reformulated as a block-separable and decomposed into subproblems. Then, inner- and outer-approximations are successively improved using column and cut generation. Subproblems are solved using a novel adaptive MIP-outer-approximation method, which is based on a convex-concave reformulation of a MINLP. We

present numerical results obtained with Decogo.

3 - On simplicial monotonicity and dimension reduction in MINLP

Speaker: Eligius Hendrix, Universidad de Málaga, ES, talk 426

Co-Authors: *Leocadio Casado*, *Jose Manuel Salmerón*,

Decomposing MINLP problems may lead to sub-problems which can be handled by simplicial branch and bound methods. The question is, how we can reduce the dimension considering monotonicity in simplicial subsets. We sketch theoretical results on the monotonicity and outline how these results can be used to reduce dimensions. This research has been funded by national project TIN2016-66680 in part financed by the European Regional Development Fund (ERDF).

MINLP (II)

Discrete Optimization & Integer Programming

MINLP - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 66

Organizer: Daniel Bienstock, Columbia University, US

1 - Polyhedral relaxations for nonconvex quadratic functions

Speaker: Akshay Gupte, Clemson University, US, talk 1144

Optimizing a nonconvex quadratic function over a bounded polyhedral domain is a hard problem that arises in many applications and also as a relaxation of more general polynomial optimization problems. We address the question of convexifying a quadratic function f(x), which is square-free (also known as bilinear), over a bounded polyhedral domain. The function f(x) can be equivalently represented by its incidence graph. When this graph is bipartite and the domain is a Cartesian product of polytopes, the convex hull of f(x) is a polytope and we obtain a cut generation procedure using disjunctive programming, which also leads to explicit polynomial-sized extended formulations of the convex hull for some special cases of the domain. When the incidence graph is non-bipartite, the convex hull is polyhedral if the domain is the box [0,1] power n. In this case, it is well-known that the Boolean Quadric Polytope (BQP) is an extended formulation of this convex hull. However, the BQP has a rich combinatorial structure that is not known completely. We propose a systematic study of the properties of f(x) that guarantee that a small subset of some well-known facet-defining inequalities for the BQP is sufficient for an extended formulation. In this regard, we identify three classes of bilinear functions for which polynomial-sized relaxations of the BQP project onto the convex hull. Our proof technique uses a measure-theoretic characterization that we simplify from literature for 0/1 polytopes and establish for graphs of nonlinear functions. We also remark on some computational experiences.

2 - Product convexification: A new relaxation framework for nonconvex programs

Speaker: Mohit Tawarmalani, Purdue University, US, talk 93

Co-Authors: *Taotao He*,

We develop a new relaxation that exploits function structure while convexifying a product of n functions. The function structure is encapsulated using at most d over and under-estimators. We convexify the function product in the space of estimators. The separation procedure generates facet-defining inequalities in time polynomial in d for a fixed n. If the functions are non-negative, the concave envelope can be separated in O(n d log(d)). Then, we extend our construction to infinite families of under and over-estimators. We derive various insights into our relaxation by interpreting it as a nonlinear relaxation obtained by relproduct is first expressed as a telescoping sum and then relaxed. We show that the relaxations are amenable to automatic improvement via the use of discretization variables. We discuss various ways in which the over and under-estimators and their bounds can be obtained. We conclude by showing that our proposed techniques improve and/or generalize current relaxation schemes for factorable programs and naturally lead to a tighter hierarchy of relaxations.

3 - Sparse conic optimization: low-rank solutions and near-linear time algorithms

Speaker: Javad Lavaei, UC Berkeley, US, talk 110

Co-Authors: *Richard Zhang*,

Sparse semidefinite programs (SDPs) play a major role in the formulation, approximation and convex relaxation of many real-world problems with both discrete and continuous parameters. In this talk, we first study the solutions of sparse SDPs and characterize their properties (e.g., rank) as a function of certain graph-theoretic parameters such as OS and treewidth. We then design different second-order algorithms for sparse SDPs. In the case where the SDP is sparse and the couplings among parameters are localized, we develop an algorithm with a guaranteed complexity of near-linear time and memory in both the number of variables and the number of accurate digits. We test the results on real-world systems with over 10,000 variables.

Conic Optimization and Power Systems

Specific Models, Algorithms, and Software

Energy - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 23 Building: G, 3rd floor, Zone: 6

Invited Session 68

Organizer: Jakub Marecek, IBM Research, IE

1 - Degeneracy in Chordal Decomposition of Semidefinite Programs

Speaker: Arvind Raghunathan, Mitsubishi Electric Res. Labs, US, talk 238

Co-Authors: *Lorez Biegler*,

Exploiting sparsity in Semidefinite Programs (SDP) via chordal decomposition has been critical to solving large-scale problems. We show that the maximal clique-based SDP decomposition is primal degenerate when the SDP has a low-rank solution. We also derive conditions under which the multipliers in the maximal clique-based SDP formulation is not unique. Numerical experiments demonstrate that the SDP decomposition results in worse ill-conditioning of the interior point linear system as compared to for the original SDP formulation. We describe a decomposition approach based on the recently proposed LDL^T direction that can avoid the ill-conditioning.

2 - When to switch from a convex relaxation to Newton's method on the non-convex POP

Speaker: Jakub Marecek, IBM Research, IE, talk 4

Co-Authors: *Martin Takac*,

For a polynomial optimization problem (POP), one can derive multiple hierarchies of increasingly strong, but increasingly computationally challenging convex relaxations. We study means of switching from solving a convex relaxation of POP to using Newton's method on the non-convex (augmented) Lagrangian of the POP. We show that Smale's point estimation theory allows for precisely such a test and present an overview of computational results from power systems (cf. 10.1109/TSG.2017.2715282).

3 - Convex restrictions of power flow feasibility sets

Speaker: Konstantin Turitsyn, MIT, US, talk 403

Co-Authors: *Dongchan Lee*, *Hung Nguyen*, *Dvijotham Krishnamurthy*,

Power flow equations are characterized by generally non-convex feasibility sets. Modern optimal power flow algorithms rely heavily on convex relaxations that can be interpreted as convex outer approximations of this set. In here we address the "dual" problem of contructing the inner approximations of this set that formally define a convex restriction. Convex restriction of the power flow feasible set identifies the convex subset of power injections where the solution of power flow is guaranteed to exist and satisfy the operational constraints. In contrast to convex relaxation, convex restriction provides a sufficient condition and is particularly useful for problems involving uncertainty in power generation and demand. In this talk, we present a general framework of constructing convex restriction of an algebraic set defined by equality and inequality constraints, and apply the framework to power flow feasibility problem. The procedure results in a explicitly defined second order cone that provides a nearly tight approximation of the actual feasibility set for some of the IEEE test cases. In comparison to other approaches to the same problem, our framework is not relying on any simplifying assumptions about the nonlinearity and provide an analytical algebraic condition. Applications and open problems will be discussed in the end of the talk.

Dynamic Optimization: Theory and Algorithms

Optimization under Uncertainty

Robust - We 3:15pm-4:45pm, Format: 3x30 min

Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 100

Organizer: Vineet Goyal, Columbia University, US

1 - A Scalable Algorithm for Two-Stage Adaptive Linear Optimization

Speaker: Shimrit Shtern, Technion, IL, talk 66

Co-Authors: *Dimitris Bertsimas*,

The column-and-constraint generation (CCG) method was introduced by Zeng and Zhao (2013) for solving two-stage adaptive optimization. We found that the CCG method is quite scalable, but sometimes, and in some applications often, produces infeasible first-stage solutions, even though the problem is feasible. In this research, we extend the CCG method in a way that (a) maintains scalability and (b) always produces feasible first-stage decisions if they exist. We compare our method to several recently proposed methods and find that it reaches high accuracies faster and is able to solve significantly larger problems.

2 - Data-Driven Multi-Stage Adaptive Optimization

Speaker: Bradley Sturt, MIT, US, talk 1120

Co-Authors: *Dimitris Bertsimas*, *Shimrit Shtern*,

In this talk, we consider multi-stage optimization problems under uncertainty that is stage-wise correlated, where our only knowledge comes from historical data. We propose a simple data-driven framework for solving such problems, which we refer to as "sample robust optimization" (SRO). First, we establish in a general setting that, as more historical data is obtained, SRO prescribes decision rules with asymptotically optimal out-of-sample performance. Second, exploiting similarities between SRO and multi-stage robust optimization (RO), we present a tractable approach for solving SRO problems, which results in a linear optimization problem. Finally, we discuss empirical experiments that compare our approach to existing data-driven distributionally robust optimization approaches.

3 - Optimal Approximation via Affine Policies for Two-stage Robust Optimization

Speaker: Vineet Goyal, Columbia University, US, talk 801

Co-Authors: *Omar El Housni*,

We study the performance of affine policies for two-stage adjustable robust optimization problem under budgeted uncertainty set. This important class of uncertainty sets provides the flexibility to adjust the level of conservatism in terms of probabilistic bounds on constraint violations. The two-stage adjustable robust optimization problem is hard to approximate within a factor better than $\Omega(\log n/\log\log n)$ even for budgeted uncertainty sets where n is the number of decision variables. We show affine policies provide the best possible approximation of $O(\log n/\log\log n)$ for budget of uncertainty sets. We also present strong theoretical guarantees for affine policies when the uncertainty set is given by intersection of budget constraints.

MINLP for Data Science

Discrete Optimization & Integer Programming

MINLP - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 35 Building: B, Intermediate, Zone: 4

Invited Session 108

Organizer: Vanesa Guerrero, University Carlos III, ES

1 - Cost-sensitive SVM

Speaker: Sandra Benítez-Peña, University of Seville, ES, talk 826

Co-Authors: *Rafael Blanquero*, *Emilio Carrizosa*, *Pepa Ramírez-Cobo*,

Support Vector Machine (SVM) is a powerful tool to solve binary classification problems. Many realworld classification problems, such as those found in credit-scoring or fraud prediction, involve misclassification costs which may be different in the different classes. Providing precise values for such misclassification costs may be hard for the user, whereas it may be much easier to identify acceptable misclassification rates values. Hence, we propose here a novel SVM model in which misclassification costs are considered by incorporating performance constraints in the problem formulation. In particular, our target is to seek the hyperplane with maximal margin yielding misclassification rates below given threshold values. This novel model is extended by performing Feature Selection (FS), which is a crucial task in Data Science, making thus the classification procedures more interpretable and more effective. The reported numerical experience demonstrates that our model gives the user control on the misclassification rates in addition to the usefulness of the proposed FS procedure. Indeed, our results on benchmark data sets show that a substantial decrease in the number of features is obtained, whilst the desired trade-off between false positive and false negative rates is achieved.

2 - Optimizing classification trees via non-linear continuous programming

Speaker: Cristina Molero-Río, IMUS, ES, talk 469

Co-Authors: *Rafael Blanquero*, *Emilio Carrizosa*, *Dolores Romero Morales*,

Random Forests are a powerful prediction tool obtained by bagging decision trees. Classic decision trees are defined by a set of orthogonal cuts, i.e., the branching rules are of the form variable X not lower than threshold c. The variables and thresholds are obtained by a greedy procedure. The use of a greedy strategy yields low computational cost, but may lead to myopic decisions. Although oblique cuts, with at least two variables, have also been proposed, they involve cumbersome algorithms to identify each cut of the tree. The latest advances in Optimization techniques have motivated further research on procedures to build optimal classification trees, with either orthogonal or oblique cuts. Mixed-Integer Optimization models have been recently proposed to tackle this problem. Although the results of such optimal classification trees are encouraging, the use of integer decision variables leads to hard optimization problems. In this talk, we propose to build optimal classification trees by solving nonlinear continuous optimization problems, thus avoiding the difficulties associated with integer decision variables. This is achieved by including a cumulative density function that will indicate the path to be followed inside the tree. Numerical results show the usefulness of this approach: using one single tree, we obtain better accuracies than classification trees and close to Random Forests, being much more flexible since class performance constraints can be easily included.

3 - MINLP to visualize dynamic proximities and frequencies

Speaker: Vanesa Guerrero, University Carlos III, ES, talk 759

Co-Authors: *Emilio Carrizosa*, *Dolores Romero Morales*,

The usefulness of Information Visualization lies with its power to improve interpretability of the unknown phenomena described by raw data to aid decision making. In particular, datasets involving time-varying frequency distributions and proximity relations are the ones studied in this work. In order to visualize this structured data, we develop a visualization framework which extends the standard Multidimensional Scaling and has a global optimization model at its heart. Difference of Convex functions and Nonconvex Quadratic Binary Optimization techniques are combined as a solution approach. Our methodology is illustrated using a dynamic linguistic real-world dataset.

Surrogate-based algorithms for constrained derivative-free problems

Continuous Optimization

DerFree - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 126

Chair: Phillipe Sampaio, Veolia, FR

1 - Optimal agricultural scheduling through MINLP surrogate-based optimization

Speaker: Manuel Ramos-Castillo, Veolia Research and Innovation, FR, talk 624

Co-Authors: *Gabriela Maschietto*, *Marie Orvain*, *Damien Chenu*, *Agathe Revallier*, *Maria Albuquerque*,

Agricultural interest in composting is reinforced by the will of reduction of the waste volume, search for good levels of organic matter in the soil and the need to rationalize the use of non-renewable resources, e.g. some synthetic fertilizers, among others.To valorize compost benefits in agriculture, the optimal agricultural scheduling which comprises compost spreading and doses to maximize the financial agricultural benefits is proposed.The optimization problem addressed aims to define the monthly application schedule of fertilizers and organic amendments, and the types and quantities of each product for several years to obtain the maximum profit for the whole time-horizon, subject to certain operational, regulatory and soil-dynamics constraints which leads to a complex optimization problem which has to be solved in relative short time for decision-making purposes. The problem is a grey-box (soil-simulation model, white-box and black-box constraints/objective function) mixed integer (scheduling) non-linear (dynamics of the soil model and operational constraints) model. In order to effectively solve it in a deterministic way, a novel surrogate-modeling approach with radial-basis functions (objective functions) and logistic regression (for the black-box constraints) is proposed. Another novelty comes by the implementation of a continuous-variable-reduction procedure for building effective surrogates. Results obtained on real case studies display short solution times to find a local optimal solution, and important gains when compared to expert-based application schedules.

2 - A global optimization algorithm for derivative-free constrained problems

Speaker: Phillipe Sampaio, Veolia, FR, talk 765

The surge of interest in derivative-free and simulation-based optimization methods in fields such as medicine, chemistry and engineering, has added to the demand for new efficient algorithms for finding the best possible solution. In this work, a global continuous optimization algorithm is proposed for constrained problems where the derivatives from both objective and constraint functions may not be available. It belongs to the class of trust-region sequential quadratic programming algorithms and employs a subspace minimization approach to handle bound constraints. Polynomial interpolation models are used as surrogates for the black-box functions and a multi-start strategy is applied for searching for the global optimum while global and local steps are taken during each run. Preliminary numerical results on a test problem set are shown.

3 - Derivative-Free Trust-Region Algorithms for L1, Min-

imax and Bi-Objective Optimiz
Speaker: Geovani Grapiglia, Universidade Federal do Paraná, BR, talk 1456
We consider a nonmonotone derivative-free trust-region method that aims the minimization of a function of the form $\Phi(x) = f(x) + h(c(x))$, where f and c are smooth, and h is convex but nonsmooth. Particular cases of this class of problems are L1 and Minimax optimization. We show that our general method takes at most $O(\epsilon^{-2})$ iterations to find an ϵ-approximate stationary point of the objective function. Particular implementations are described for L1, Minimax and Bi-Objective optimization. Numerical results are also reported.

Optimization Algorithms and Variational Inequalities II

Continuous Optimization
Variat - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 150
Organizer: Xiaoqi Yang, Hong Kong Polytechnic Uni., HK

1 - On Error Bound Moduli for Locally Lipschitz and Regular Functions
Speaker: Xiaoqi Yang, Hong Kong Polytechnic Uni., HK, talk 650
Co-Authors: *Minghua Li*, *Kaiwen Meng*,
In this paper we study local error bound moduli for a locally Lipschitz and regular function via its outer limiting subdifferential set. We show that the distance from 0 to the outer limiting subdifferential of the support function of the subdifferential set, which is essentially the distance from 0 to the end set of the subdifferential set, is an upper estimate of the local error bound modulus. This upper estimate becomes tight for a convex function under some regularity conditions. We show that the distance from 0 to the outer limiting subdifferential set of a lower C^1 function is equal to the local error bound modulus.

2 - Inexact primal-dual hybrid gradient methods for saddle-point problems
Speaker: Min Li, Nanjing University, CN, talk 604
Co-Authors: *Xiaoming Yuan*,
Saddle-point problems are core mathematical models in various areas; and how to numerically solve saddle-point problems has been receiving intensive attention in the literature. In this talk, we focus on the primal-dual hybrid gradient (PDHG) method that is being widely used to solve a broad spectrum of saddle-point problems arising from, e.g., variational image restoration problems with total variational regularization and many others. Despite of its wide applications in different areas, the study of inexact versions of PDHG that allows for inexact solutions of the splitted subproblems still seems to be in its infancy. In this talk, we investigate how to design implementable inexactness criteria for solving the PDHG's subproblems so that the convergence of an inexact PDHG can be guaranteed. We propose several specific inexactness criteria and accordingly some inexact PDHG methods for saddle-point problems. The convergence of these inexact PDHG methods is rigorously proved, and their convergence rates are estimated under different scenarios.

3 - On directional pseudo/quasi-normality and directional enhanced KKT conditions
Speaker: Kuang Bai, University of Victoria, CA, talk 195
Co-Authors: *Jane Ye*,
In this paper we mainly study the metric subregularity of a set-valued map which is the sum of a single-valued Lipschitz continuous mapping and a closed subset. First we derive a sufficient condition for metric subregularity called quasi-first order sufficient condition for metric subregularity (FOSCMS) that is weaker than the FOSCMS recently introduced by Gfrerer. Then we introduce a directional version of the pseudo-normality and quasi-normality which is weaker than the classical pseudo-normality and quasi-normality respectively. The directional quasi-normality are stronger than the quasi-FOSCMS but easier to verify. An example is used to illustrate that the directional pseduo-normality can be weaker than both the FOSCMS and the quasi-normality. For the class of set-valued maps where the Lipschitz mapping is linear and the closed set is the union of finitely many convex polyhedral sets, we show that the directional pseudo-normality holds automatically at each point of the graph. Finally we apply our results to non-smooth optimization problems. Under directional pseudo/quasi-normality, we show that any local minimizer must satisfy the directional enhanced KKT condition which is a stronger optimality condition than the classical enhanced KKT condition.

Knapsack Problems

Discrete Optimization & Integer Programming
IPpractice - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Invited Session 185
Organizer: Enrico Malaguti, DEI - University of Bologna, IT

1 - Algorithms for bilevel knapsack problem
Speaker: Ashwin Arulselvan, University of Strathclyde, GB, talk 1541
We have a bilevel knapsack problem in which at the outer level a leader decides on how much cost subsidy could be provided to the projects of his interest and at the inner level the follower solves a binary integer knapsack problem with some of the projects having a subsidised costs. Both players have their own budgets and profit functions. We analyse several special cases for which we provide efficient algorithms and provide an exact algorithm for the general case for which we show convergence. The problem finds applications in health economics where a donor is interested in allocating funds to developing countries for health related projects.

2 - Cutting Planes for the Multi-Modal Precedence Constrained Problem
Speaker: Orlando Rivera-Letelier, Universidad Adolfo Ibáñez, CL, talk 1250
Co-Authors: *Marcos Goycoolea*,
In this work we develop valid inequalities for the precedence constrained multi-modal knapsack problem. In this problem, a subset from a set of activities must be selected, satisfying precedence relationships in such a way that if an activity is

selected all its predecessors must be also selected. Each selected activity must be be assigned to one of its modes, where different modes can use different amounts of resources from the given resource capacity constraints, incurring in different profits. This problem has direct applications in project scheduling problems, and in particular in open pit mine planning problems. We develop a new class of cutting planes for this problem, that we call the Hourglass Cuts, based on the idea that if a job is selected, its predecessors must be sent at least in some amount to the modes using less resource capacity. We conduct a computational experiment to test the effectiveness of these cuts, using instances of the open pit strategic mine scheduling problem, with real mines data. We use heuristics to find integer feasible solutions, and study the improvement in the proved gap when compared to other types of well-known cuts for the problem. We find that we can compute near-optimal solutions with less than 1**3 - The Fractional Knapsack Problem with Penalties**

Speaker: Enrico Malaguti, DEI - University of Bologna, IT, talk 1513

Co-Authors: *Michele Monaci*, *Ulrich Pferschy*, *Paolo Paronuzzi*,

We consider integer optimization problems where variables can potentially take fractional values, but this occurrence is penalized in the objective function. This general situation has relevant examples in scheduling (preemption), routing (split delivery), cutting and telecommunications, just to mention a few. However, the general case in which variables integrality can be relaxed at cost of introducing a general penalty was not discussed before. As a case study, we consider the possibly simplest combinatorial optimization problem, namely the classical Knapsack Problem. We introduce the Fractional Knapsack Problem with Penalties (FKPP), a variant of the knapsack problem in which items can be split at the expense of a penalty depending on the fractional quantity. We analyze relevant properties of the problem, present alternative mathematical models, and analyze their performance from a theoretical viewpoint. In addition, we introduce a Fully Polynomial Time Approximation Scheme for the approximate solution of the general problem, and an improved dynamic programming approach that computes the optimal solution in one relevant case. We computationally test the proposed models and algorithms on a large set of instances derived from benchmarks from the literature.

Adaptivity in non-smooth optimization

Continuous Optimization

NonSmooth - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 187

Organizer: Volkan Cevher, EPFL, CH

1 - Adaptive Double Loop Smoothing Algorithms

Speaker: Olivier Fercoq, Télécom ParisTech, FR, talk 235

Co-Authors: *Quoc Tran-Dinh*, *Ahmet Alacaoglu*, *Volkan Cevher*,

Empirical evidence shows that restarting Nesterov's accelerated gradient-type algorithms achieves great performance. Various research has been conducted to investigate the convergence rates of restarting schemes. However, theoretical understanding of such an excellent technique is still missing in primal-dual methods. Inspired by the success of restarting strategies, in this paper, we develop a new adaptive double loop smoothing based primal-dual first-order algorithm, which can also be interpreted as a restarting method, to solve fully nonsmooth convex optimization problems and nonsmooth constrained convex optimization problems. Our algorithm extends recent technique called accelerated smoothed gap reduction (ASGARD) framework. The new algorithm can solve nonsmooth constrained convex optimization problems without requiring any structure assumption except strong duality, while achieving the best known O(1/k) rate convergence rate on the primal optimality and feasibility, where k is the iteration counter. Our algorithm only requires to initialize the parameters once, and automatically update them during the iteration process without tuning. We illustrate the advantages of our methods through several examples in comparison with state-of-the-art algorithms.

2 - Universal Acceleration through Learning Rate Adaptation

Speaker: Kfir Levy, ETH, CH, talk 233

Co-Authors: *Alp Yurtsever*, *Volkan Cevher*,

We present a novel method for convex unconstrained optimization that, without any modifications, ensures: (i) accelerated convergence rate for smooth objectives, (ii) standard convergence rate in the general (non-smooth) setting, and (iii) standard convergence rate in the stochastic optimization setting. To the best of our knowledge, this is the first method that simultaneously applies to all of the above settings. At the heart of our method is an adaptive learning rate rule that employs importance weights, in the spirit of (Duchi et al., 2011; Levy, 2017), combined with an update that linearly couples two sequences, in the spirit of (Allen-Zhu and Orecchia, 2017). An empirical examination of our method demonstrates its applicability to the above mentioned scenarios and corroborates our theoretical findings.

3 - ADMM vs gradient methods for ill-conditioned imaging problems

Speaker: Stephen Becker, University of Colorado Boulder, US, talk 251

Co-Authors: *James Folberth*,

Imaging problems can lead to very ill-conditioned optimization problems. We present results about the convergence of ADMM for these problems and discuss when it is advantageous over gradient-based methods. The implementation of ADMM must be modified to use iterative refinement in extra precision in order to converge. Both ADMM and gradient-based approaches can benefit from special types of preconditioning matrices.

Fast Converging Stochastic Optimization Algorithms

Continuous Optimization

RandomM - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 213

Organizer: Francis Bach, INRIA - ENS, FR

1 - Bridging the Gap between Constant Step Size SGD and Markov Chains
Speaker: Aymeric Dieuleveut, EPFL, CH, talk 1102
Co-Authors: *Alain Durmus*, *Francis Bach*,
We consider the minimization of an objective function given access to unbiased estimates of its gradient through stochastic gradient descent (SGD) with constant step-size. While the detailed analysis was only performed for quadratic functions, we provide an explicit asymptotic expansion of the moments of the averaged SGD iterates that outlines the dependence on initial conditions, the effect of noise and the step-size, as well as the lack of convergence in the general (non-quadratic) case. For this analysis, we bring tools from Markov chain theory into the analysis of stochastic gradient. We then show that Richardson-Romberg extrapolation may be used to get closer to the global optimum and we show empirical improvements of the new extrapolation scheme.

2 - Stochastic Optimization for Large Scale Optimal Transport
Speaker: Aude Genevay, ENS, FR, talk 888
Optimal transport (OT) defines a powerful framework to compare probability distributions in a geometrically faithful way. However, the practical impact of OT is still limited because of its computational burden. We propose a new class of stochastic optimization algorithms to cope with large-scale OT problems. These methods can handle arbitrary distributions as long as one is able to draw samples from them, which is the typical setup in highdimensional learning problems. This alleviates the need to discretize these densities, while giving access to provably convergent methods that output the correct distance without discretization error. These algorithms rely on two main ideas: (a) the dual OT problem can be re-cast as the maximization of an expectation; (b) the entropic regularization of the primal OT problem yields a smooth dual optimization which can be addressed with algorithms that have a provably faster convergence. We instantiate these ideas in three different setups: (i) when comparing a discrete distribution to another, we show that incremental stochastic optimization schemes can beat Sinkhorn's algorithm, the current state-of-the-art finite dimensional OT solver; (ii) when comparing a discrete distribution to a continuous density, a semidiscrete reformulation of the dual program is amenable to averaged stochastic gradient descent, leading to better performance than approximately solving the problem by discretization ; (iii) when dealing with two continuous densities, we propose a stochastic gradient descent over a reproducing kernel Hilbert space.

3 - Variance Reduced Methods via Sketching
Speaker: Robert Gower, Telecom Paristech, FR, talk 859
Co-Authors: *Peter Richtarik*, *Francis Bach*,
Using randomized sketching we develop a class of stochastic variance reduced methods for minimizing an average of functions. Our method can be seen as stochastic gradient descent applied to an equivalent stochastic reformulation of this average. After each iteration, we update our stochastic reformulation so that the resulting stochastic gradients have less variance. By choosing different randomized sketches we recover known methods such as the stochastc average gradient (SAGA) method with all of its mini-batch variants and even non-uniform sampling variants. We prove that this class of methods all converge linearly with a meaningful rate, as dictated by a single convergence theorem. When specialized to known methods, our convergence theorem recovers the best known convergence results, and furthermore, we obtain the first results that show a meaningful speed-up when using mini-batchs or non-uniform sampling variants of SAGA.

Reformulation-based solution methods for quadratic programming

Continuous Optimization
SDP - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle LC5 Building: L, Intermediate 1, Zone: 10
Invited Session 215
Organizer: Dominique Quadri, Université Paris Sud - LRI, FR

1 - Non-convex Quadratic Integer Programming : a piecewise linearization
Speaker: Eric Soutil, CEDRIC-Cnam, FR, talk 1299
Co-Authors: *Dominique Quadri*, *David Nizard*,
We address in this talk Non-convex Quadratic Integer Programming (NCQIP). More precisely we consider a problem in which the objective function is a quadratic non-convex one with pure general integer variables and linear constraints. The method proposed here generalizes a previous work addressing Convex QIP. We propose a general method to solve such problems that first transforms the problem into a mixed separable one, still non-convex. The quadratic part of the objective function becomes a weighted sum of squared variables, with no more products of two variables. This first transformation is done by diagonalizing the Hessian matrix of the initial objective function and requires new real variables and linear number of added constraints. Then we propose to use a parametric piecewise linearization of the equivalent problem. This linearization allows us to find the optimum of the initial problem when the number of line segments asymptotically grows. Experimentations are presented, in both convex and non-convex context, and extensions to quadratic constraints are discussed. Keywords: Quadratic Programming, Integer variables, Piecewise Linearization

2 - Solving Alternative Current Optimal Power Flow to global optimality
Speaker: Hadrien Godard, RTE, FR, talk 1117
Co-Authors: *Jean Maeght*, *Sourour Elloumi*, *Amélie Lambert*, *Manuel Ruiz*,
Alternative Current Optimal Power Flow (ACOPF) can be modelled as a non-convex quadratically constrained quadratic program with continuous variables. The SDP rank relaxation, computes efficient lower bounds on many classic ACOPF instances, but solving ACOPF to global optimality remains a challenge when this relaxation is not exact. We propose to use the Mixed-Integer Quadratic Convex Reformulation (MIQCR) method to solve ACOPF to global optimality. The MIQCR method uses a SDP relaxation to reformulate the initial problem into another quadratic program. This reformulation has some convexity properties and is solved to global optimality within a branch-and-bound framework, where bounding come from quadratic convex relaxations at each node. We adapt MIQCR to ACOPF using the rank relaxation as the SDP relaxation to reformulate the initial problem. It ensures that the root node lower bound is equal to the efficient rank relaxation lower bound. We present our specific branch-

and-bound with some results of our method on benchmark instances.

3 - Preprocessing and reformulation for the Quadratic Assignment Problem
Speaker: Sourour Elloumi, ENSTA-UMA and CNAM-CEDRIC, FR, talk 1522
Co-Authors: *Amélie Lambert*,
The Quadratic Assignment Problem (QAP) consists in assigning n nodes to n facilities and a quadratic cost occurs from the assignment of a pair of nodes to a pair of facilities. This NP-hard problem is known to be very difficult to solve to optimality. Many benchmark instances regrouped in QAPLIB are still very challenging. We review some preprocessing methods that work very well with many classes of instances and lead to drastic shrinking of the instance. We also present several linear or quadratic equivalent reformulations that allow the problem to be solved within a branch-and-bound framework. We show that combining preprocessing and equivalent reformulations may lead to efficient solutions. Some illustrations will be done on instances from QAPLIB.

Risk-Averse PDE-Constrained Optimization–Methods and Applications

Continuous Optimization
Control - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Invited Session 222
Organizer: Harbir Antil, George Mason University, US

1 - Stochastic Dominance in Elastic Shape Optimization
Speaker: Ruediger Schultz, Univ. of Duisburg - Essen, DE, talk 266
Co-Authors: *Sergio Conti*, *Martin Rumpf*,
This talk addresses shape optimization for elastic materials under stochastic loads. It transfers the paradigm of stochastic dominance, from finite-dimensional stochastic programming to shape optimization. Stochastic dominance constraints single out subsets of nonanticipative shapes which compare favorably to a chosen stochastic benchmark. A new class of stochastic shape optimization problems arises by optimizing over such feasible sets. The analytical description and the numerical implementation of dominance constraints are built on risk measures. Different numerical experiments demonstrate the potential of the proposed stochastic shape optimization model and in particular the impact of high variability of forces or probabilities in the different realizations.

2 - Weighted Sobolev Spaces with Application to Image Processing
Speaker: Harbir Antil, George Mason University, US, talk 1004
Co-Authors: *Carlos Rautenberg*,
We propose a new variational model in weighted Sobolev spaces with non-standard weights with applications in image processing. We show that one cannot use the classical analysis tools to analyze the problem. We identify the trace space for the weighted Sobolev space. We then propose a finite element scheme to solve the Euler-Lagrange equations, and for the image denoising application we propose an algorithm to identify the unknown weights. The approach is illustrated on several test problems and it yields superior results when compared to the existing techniques.

3 - Smoothing Techniques for Risk-Averse PDE-Constrained Optimization
Speaker: Drew Kouri, Sandia, US, talk 1394
Many science and engineering applications necessitate the optimal control or design of systems described by PDEs with uncertain inputs such as coefficients, boundary conditions and initial conditions. In this talk, I formulate such problems as risk-averse optimization problems in Banach space. For many popular risk measures such as coherent risk measures, the resulting risk-averse objective function is often nonsmooth and requires an enormous number of samples to accurately evaluate. To address these challenges, I present a general smoothing technique for risk measures based on the epigraphical calculus. I show that the resulting smoothed risk measures are differentiable and converge in a variational sense to the original nonsmooth risk measure. Moreover, under mild assumptions, I prove consistency of this smooth approximation for both minimizers and stationary points of the target optimization problem. I conclude with numerical examples confirming these results.

Progress in Conic and MIP Solvers

Specific Models, Algorithms, and Software
Algo - We 3:15pm-4:45pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 237
Organizer: Imre Polik, SAS Institute, US

1 - Artelys Knitro 11.0, a new conic solver and other novelties
Speaker: Jean-Hubert Hours, Artelys, FR, talk 556
Co-Authors: *Richard Waltz*, *Figen Oztoprak Topkaya*, *Michaël Gabay*, *Sylvain Mouret*,
In this talk, the latest 11.0 release of the nonlinear solver Artelys Knitro is presented. Knitro 11.0 introduces a novel solver for optimization problems with conic constraints. It encompasses second-order cone programs (SOCPs) as well as more general nonlinear non-convex models with conic constraints. Encouraging numerical results are presented on standard SOCP benchmarks. Knitro 11.0 also introduces a new C API, which allows users to build complex optimization models piece by piece and to provide a lot of structure in their problem formulation. Conic constraints are covered by the new API. Finally, several other numerical improvements on convex programs as well as ill-conditioned problems are presented.

2 - MOSEK version 9
Speaker: Erling Andersen, MOSEK, DK, talk 346
MOSEK is a software package for solving large scale sparse optimization problems. To be precise MOSEK is capable of solving linear, convex quadratic and conic optimization problems possibly having some integer constrained variables. In this presentation we will review what is new and improved in the upcoming version 9. In particular we will emphasize how version 9 able to deal with optimization problems having nonsymmetric conic constraints. We will also present computational results that documents upgrading to MOSEK version

9 is worthwhile.

3 - Recent enhancements in MATLAB Optimization Toolbox solvers for LP and MILP

Speaker: Franz Wesselmann, The MathWorks GmbH, DE, talk 737

The Optimization Toolbox provides solvers 'linprog' for linear and 'intlinprog' for mixed-integer linear programs. In this talk, we discuss some of the key features of these solvers and report on recent enhancements. We present computational results and detail the performance testing infrastructure used to benchmark these solvers.

Learning and Stochastic Programming

Optimization under Uncertainty

Stoch - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Invited Session 254

Organizer: Matthias Poloczek, University of Arizona, US

1 - Asymptotic Results For Two-stage Stochastic Quadratic Programming

Speaker: Junyi Liu, Univ. of Southern California, US, talk 642

Co-Authors: *Suvrajeet Sen*,

In this talk, we will present stochastic decomposition (SD) algorithms for a family of stochastic quadratic programming (STQP) problems. In these problems, the first stage is targeted to solve a quadratic program and the second stage is targeted to solve another quadratic/linear program. Based to their stochastic linear programming (SLP) predecessor, these iterative schemes in the SD algorithm approximate the objective function using affine/quadratic minorants and then apply a stochastic proximal mapping to obtain the next iterate. We show that under certain assumptions (e.g. convexity, and strict complementarity, etc.), the proximal mapping applied in SD obeys a contraction mapping property when the STQP problem has a positive definite matrix in the first stage. In addition, we demonstrate that SD provides an incumbent solution sequence which converges to an optimal solution in expectation with the convergence rate in order $O(N^{-1})$. This demonstrates the efficiency improvement of the SD algorithm compared to $O(N^{-1/2})$ convergence rate of Stochastic Approximation (SA) algorithm. We will also present an "in-sample" stopping rule to assess the optimality gap by constructing consistent bootstrap estimators in STQP problems.

2 - Optimizing Crashing Decisions in a Project Management Problem with Disruptions

Speaker: Haoxiang Yang, Northwestern University, US, talk 1064

Co-Authors: *David Morton*,

In this talk we first introduce a general type of sequential decision problem under uncertainty, where the uncertainty consists of a small number of disruptions and where both the magnitude and the timing of the disruption can be random. Then we consider a special case: a project crashing problem under a small number of disruptions. When a disruption occurs, the duration of an activity which has not started could change. The magnitude of the change of activity duration and the timing of the disruption can be random. We formulate a stochastic mixed integer programming (SMIP) model with problems of each stage a mixed integer program. This SMIP is a challenging problem to solve using conventional stochastic integer programming techniques. We propose a learning-based branch-and-bound algorithm to solve the SMIP and evaluate the computational performance of our approach.

3 - Bayesian Optimization of Combinatorial Structures

Speaker: Matthias Poloczek, University of Arizona, US, talk 639

Co-Authors: *Ricardo Baptista*,

The optimization of expensive-to-evaluate black-box functions over combinatorial structures is an ubiquitous task in machine learning, engineering and the natural sciences. The combinatorial explosion of the search space and costly evaluations pose challenges for current techniques in discrete optimization and machine learning, and critically require new algorithmic ideas (NIPS BayesOpt 2017). In this talk we present Bayesian optimization of combinatorial structures (BOCS), that takes a novel approach to overcome these challenges. It is based on an adaptive scalable statistical model that is able to identify useful combinatorial structures even when data is scarce. BOCS' acquisition function pioneers the use of semidefinite programming to achieve efficiency and scalability. We will also discuss a comprehensive experimental evaluation that demonstrate that BOCS consistently outperforms other methods from combinatorial and Bayesian optimization.

Variants of the Assignment problem

Discrete Optimization & Integer Programming

COMB - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 41 Building: C, 3rd floor, Zone: 1

Invited Session 266

Organizer: Kavitha Telikepalli, TIFR Mumbai, IN

1 - Approximating Airports and Railways

Speaker: Tobias Mömke, University of Bremen, DE, talk 186

Co-Authors: *Anna Adamaszek*, *Amit Kumar*, *Antonios Antoniadis*,

We consider the airport and railway problem (AR), which combines capacitated facility location with network design, both in the general metric and the two-dimensional Euclidean space. An instance of the airport and railway problem consists of a set of points in the corresponding metric, together with a non-negative weight for each point, and a parameter k. The points represent cities, the weights denote costs of opening an airport in the corresponding city, and the parameter k is a maximum capacity of an airport. The goal is to construct a minimum cost network of airports and railways connecting all the cities, where railways correspond to edges connecting pairs of points, and the cost of a railway is equal to the distance between the points. The network is partitioned into components, where each component contains an open airport, and spans at most k cities. We obtain the first bicriteria approximation algorithm for AR for the general metric case, which yields a 4-approximate solution with a resource augmentation of the airport capacity k by a factor of 2. More generally, for any parameter 0 < p <= 1 where p k is an integer, we develop a (4/3)(2+1/p)-approximation algorithm for metric AR with a resource augmentation by a factor of 1+p. Furthermore, we obtain the first constant factor approximation algorithm that does not resort to resource augmentation for AR in the Euclidean plane. For the Euclidean setting we provide a QPTAS for the same problem with a resource augmentation by a factor of 1+mu on the airport capacity, for any fixed mu > 0.

2 - A (2+eps)-Approximation for Maximum Weight Matching in the Semi-Streaming Model

Speaker: Ami Paz, IRIF - CNRS and U. Paris Diderot, FR, talk 655

Co-Authors: *Ami Paz*,

I will present our new (2+eps)-approximation algorithm for the maximum weight matching problem in the semi-streaming model, that was presented in SODA 2017. We will start by discussing the local-ratio technique, a simple, sequential approximation paradigm we use in our algorithm. Then, we will consider the variations needed in order to adjust this technique to the semi-streaming model.

3 - Popularity, Mixed Matchings, and Self-duality

Speaker: Kavitha Telikepalli, TIFR Mumbai, IN, talk 511

Co-Authors: *Chien-Chung Huang*,

We consider a matching problem in bipartite graphs where every vertex has a strict preference list ranking its neighbors. There is also an edge weight function and we consider the problem of matching vertices in a popular and weight-optimal manner. A matching M is popular if at least half the vertices weakly prefer M to any matching. A popular fractional matching could have a much higher weight than any popular matching. We show that there is always a max-weight popular fractional matching that is half-integral. The linear program that gives rise to the formulation of the popular fractional matching polytope is self-dual and this plays a crucial role in our proof of half-integrality of this polytope.

Nonconvex and Complex Problems in Multiobjective Optimization

Optimization under Uncertainty

Game - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 268

Chair: Gabriele Eichfelder, Technische Universität Ilmenau, DE

1 - A Trust Region Method for Heterogeneous Multiobjective Optimization

Speaker: Gabriele Eichfelder, Technische Universität Ilmenau, DE, talk 114

Co-Authors: *Jana Thomann*,

In multiobjective heterogeneous optimization one considers optimization problems with multiple objective functions, where it is assumed that one of the functions is an expensive black-box function while the other objective functions are analytically given. Such problems occur in applications for instance in the context of Lorentz force velocimetry, when the task is to find an optimal design of a magnet which minimizes the weight of the magnet and maximizes the induced Lorentz force. The latter might be computable only by a time-consuming simulation. The proposed method uses the basic trust region approach by restricting the computations in every iteration to a local area and replacing the objective functions by suitable models. The next iteration point is computed by using the ideal point and the Pascoletti Serafini scalarization. Convergence results as well as numerical experiments are presented and the proposed procedure is compared to other algorithms.

2 - Multiobjective programming via bundle methods

Speaker: Elizabeth Karas, UFPR, BR, talk 994

Co-Authors: *Claudia Sagastizabal*, *Hasnaa Zidani*,

We present a method solving multiobjective optimization problems that combines achievement and improvement functions. The algorithm exploits the specific structure of the achievement function from a nonsmooth optimization perspective based on bundle methods that it is specially tailored for efficiently building the Pareto front. This is done by parsing attainable points for the objective functions, in a manner that allows for warm starts of the succesive nonsmooth problems solved by the bundle algorithm. The methodology is illustrated with several examples that show the interest of the approach.

3 - Sparse multiobjective optimization via concave approximations

Speaker: Tommaso Levato, Università di Firenze, IT, talk 836

Co-Authors: *Guido Cocchi*, *Giampaolo Liuzzi*, *Marco Sciandrone*,

In this work, we propose a concave approximation approach to compute the Pareto front of sparse multiobjective problems, where the only non-smooth objective is the zero-norm. This latter objective is replaced by a sum of concave functions, which allows us to optimize the obtained smooth reformulation by means of a multiobjective descent algorithm. Typical applications include portfolio optimization and feature selection in machine learning. We state equivalence properties with respect to the original problem, and test our framework on a set of suitable sparse multiobjective problems. The numerical comparison with existing approaches shows the effectiveness of our approach in terms of the obtained Pareto front.

Structure Detection in Integer Programming

Specific Models, Algorithms, and Software

Algo - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 22 Building: G, 2nd floor, Zone: 6

Invited Session 272

Organizer: Taghi Khaniyev, University of Waterloo, CA

1 - Automatic structure detection in mixed integer programs

Speaker: Taghi Khaniyev, University of Waterloo, CA, talk 478

Co-Authors: *Matthew Galati*, *Samir Elhedhli*,

Certain classes of mixed-integer programs are known to be efficiently solvable by exploiting special structures embedded in their constraint matrices. One such structure is the bordered block diagonal (BBD) structure that lends itself to Dantzig-Wolfe reformulation (DWR) and branch-and-price. Given a BBD structure for the constraint matrix of a general MIP, several platforms (such as COIN/DIP, SCIP/GCG and SAS/ DECOMP) exist that can perform automatic DWR of the problem and solve the MIP using branch-and-price. The challenge of using branch-and-price as a general-purpose solver, however, lies in the requirement of the knowledge of a structure a priori. We propose a new algorithm to automatically detect BBD structures inherent in a matrix. We start by introducing a new measure of goodness to capture desired features in BBD structures such as minimal border size, block cohesion and granularity of the structure. The main building block of the proposed approach is the modularity-based community detection in lieu of traditional graph/hypergraph partitioning methods to alleviate one major drawback of the existing approaches in the literature: predefining the number of blocks. When tested on MIPLIB (and customer) instances using the SAS/DECOMP framework, the proposed algorithm was found to identify structures that, on average, lead to significant improvements both in computation time and optimality gap compared to those detected by the state-of-the-art BBD detection techniques in the literature.

2 - Modular Detection of Model Structure in Integer Programming

Speaker: Michael Bastubbe, RWTH Aachen University, DE, talk 686

Co-Authors: *Marco Lübbecke*,

Dantzig-Wolfe reformulation applied to specially structured mixed integer programming models is well-known to provide strong dual bounds, though one of many requirements for implementing this method is structural problem knowledge. This is typically a reordering of the coefficient matrix to singly bordered block diagonal form. While searching such forms we pursue two goals: (a) try to retrieve what the modeler had in mind when building the model, and (b) find a vast variety of promising decompositions to facilitate studies on decomposition quality measures. In this talk we present a new modular, iterative algorithm to detect model structures in general mixed integer programming models aiming for these goals. After a predetection step, where constraints and variables are classified in various ways, we iteratively build a tree of successively more completed (refined) decompositions where each leaf is a complete decomposition. We demonstrate several refinement procedures, based on the predetected classfications, (hyper-)graph partitioning algorithms, and user given meta data. Finally we present computational results on classical problem instances and instances from MIPLIB2010 of our implementation integrated in the generic branch-and-price solver GCG and present a study of decomposition quality measures.

3 - A Computational Investigation on Generic Cutting Planes in Branch-Price-and-Cut

Speaker: Jonas Witt, RWTH Aachen University, DE, talk 955

Co-Authors: *Matthias Walter*, *Marco Lübbecke*,

In Dantzig-Wolfe reformulation for mixed-integer programs, an original problem is reformulated yielding a potentially stronger formulation, the so-called master problem. The linear programming relaxation of the master problem is solved with column generation and can be further strenghened with cutting planes, formulated with either original or master problem variables. We want to investigate the strength of generic cutting planes formulated with original problem variables. We use the generic branch-price-and-cut solver GCG in order to evaluate the strength of these cutting planes on a wide range of problem classes. Our experiments show that these cutting planes only slightly improve the dual bound on problems where Dantzig-Wolfe reformulation classically applies well, whereas they have a larger impact on other problem classes. This suggests that in these classical applications whole classes of valid inequalities for the original problem are already satisfied when applying Dantzig-Wolfe reformulation. We provide some theoretical results underlining this statement and discuss how stronger cutting planes could be obtained.

Emerging Energy Markets

Specific Models, Algorithms, and Software

Energy - We 3:15pm-4:15pm, Format: 2x30 min

Room: Salle 24 Building: G, 3rd floor, Zone: 6

Invited Session 291

Organizer: Dennice Gayme, Johns Hopkins University, US

1 - Designing coalition-proof mechanisms - the case of electricity markets

Speaker: Maryam Kamgarpour, ETH Zurich, CH, talk 651

Co-Authors: *Orcun Karaca*, *Neil Walton*, *Pier Giusepp Sessa*,

Various electricity markets, real-time, intraday, control reserves for instance, work together to ensure a stable power system. As we move towards liberalised electricity markets, we face a plethora of new problems in market design to ensure a safe and efficient power system. It is known that current mechanisms such as pay-as-bid or LMP (locational marginal pricing) may allow strategic manipulation by market participants. To remedy this shortcoming, we show the applicability of the Vickrey-Clarke-Groves (VCG) to general electricity markets. In particular, we show that desired properties of incentive compatibility, individual rationality and efficiency proven for auctions over multiple items carry naturally to auctions over continuous bids and with complex objectives and constraints. To ensure participants cannot benefit from collusion or shill-bidding under the VCG mechanism we derive conditions on the bid and constraint functions of electricity markets. If such conditions cannot be met due to system stability constraints, using recent advances in weak-submodular optimization we drive upper bounds on any strategic manipulation under VCG. Furthermore, we define alternative mechanisms that ensure strategic-proofness while maximizing incentive compatibility and efficiency of the markets. Our results are demonstrated with examples from the LMP markets using IEEE test cases and with the Swiss ancillary service markets.

2 - Irrational Agents and the Power Grid

Speaker: Sean Meyn, University of Florida, US, talk 1370

For decades power systems academics have proclaimed the need for real time prices to create a more efficient grid. The rationale is economics 101: proper price signals will lead to an efficient outcome. In this talk we argue that competitive equilibrium theory does support the real-time price paradigm, provided we impose a particular model of rationality. However this standard model of consumer utility does not match reality: the products of interest to the various "agents" are complex functions of time. The product of interest to a typical consumer is only loosely related to electric power – the quantity associated with price signals. There is good news: an efficient outcome is easy to describe, and we have the control technology to achieve it. We need supporting market designs that respect dynamics and the enormous fixed costs that are inherent in power systems engineering, recognizing that we need incentives on many time-scales. Most likely the needed economic theory will be based on an emerging theory of efficient and robust contract design.

Air Transportation and Air Traffic Management

Specific Models, Algorithms, and Software Sciences - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 315
Organizer: Sonia Cafieri, ENAC, FR

1 - A two-stage stochastic model for scheduling aircraft arrivals under uncertainty
Speaker: Ahmed Khassiba, ENAC Université de Montréal, FR, talk 755
Co-Authors: *Fabian Bastin*, *Sonia Cafieri*, *Bernard Gendron*, *Marcel Mongeau*,
Efficient sequencing and scheduling aircraft arrivals is crucial to improve air traffic performance in view of the air traffic growth. Extending the sequencing and scheduling horizon up to a few hours before landing is foreseen to be a key measure towards limiting delays and enhancing eco-efficiency near airports. This yields greater uncertainty on predicted arrival times to be dealt with. To address this problem, we propose a two-stage stochastic optimization model enriched by chance constraints. In the first stage, aircraft are sequenced and scheduled at the entry of the terminal area under uncertain entry times. Chance constraints mitigate the risk of separation violation between aircraft, once uncertainty is revealed. In the second stage, assuming uncertainty on entry times to the terminal area is revealed, aircraft are scheduled for landing. Our solution method relies on Sample Average Approximation and Benders decomposition. Encouraging results are obtained on realistic instances of arrivals at Paris Charles-De-Gaulle airport.

2 - Aircraft conflict resolution and heading recovery with mixed-integer programming
Speaker: Fernando Dias, University of New South Wales, AU, talk 787
Co-Authors: *David Rey*,
We address the aircraft conflict resolution problem in air traffic control using a novel approach for collision avoidance and parallel trajectory recovery. As air traffic volume is steadily increasing, it has become crucial to improve traffic control algorithms to deal with greater demand and to improve airspace capacity. Yet, most mathematical optimization approaches for conflict resolution solely focus on collision avoidance thus overlooking the cost of recovering aircraft initial trajectories. To address this gap, we propose an iterative two-stage algorithm based on mixed-integer non-linear programming for i) avoiding potential conflicts using heading control and ii) recovering aircraft's initial heading. We minimize the total deviation to aircraft's initial trajectories subject to separation constraints and heading control bounds. The proposed algorithm attempts to anticipate the cost of recovery during the first stage to guide the search towards optimal solutions. This conflict resolution algorithm enables aircraft to safely avoid collisions and recover their initial heading on a parallel trajectory.

3 - MINLP for aircraft conflict avoidance via speed and heading angle deviations
Speaker: Sonia Cafieri, ENAC, FR, talk 1098
Co-Authors: *Andrew Conn*, *Marcel Mongeau*,
The distance between any pair of aircraft throughout their flight trajectory has to be above a threshold value at all times. Any loss of separation is defined as an aircraft conflict, and represents a critical issue for air traffic controllers. We propose an efficient mixed-integer nonlinear program to address the conflict avoidance problem by adjusting both aircraft speeds and aircraft heading angles simultaneously. A reformulation is able to remove the infinite-dimensional feature (that is, over all time) of the separation constraints, and a linearization of the nonlinear angle-related terms is proposed, along with some essential valid linear inequalities. We include numerical results that validate the proposed approach.

Network Design and Routing

Discrete Optimization & Integer Programming
APPROX - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Contributed Session 346
Chair: Yuko Kuroki, University of Tokyo, JP

1 - A 4-approximation algorithm for k-prize collecting Steiner tree problems
Speaker: Yusa Matsuda, Univ. Electro-Communications, JP, talk 533
Co-Authors: *Satoshi Takahashi*,
It is very important problem in discrete optimization to find a minimum cost tree on a graph under some constraints such as Steiner tree problems. k-Minimum spanning tree problems(k-MST) and prize collecting Steiner tree problems(PCST), which are actively studied on approximation algorithms, are also examples. In 2017, Han et al. presented a k-prize collecting Steiner tree problem(k-PCST) which is a common generalization of k-MST and PCST and proposed a 5-approximation algorithm for k-PCST. Since both the best approximation ratio of k-MST and PCST are less than or equal to 2, it can be expected that there is a better approximation algorithm of k-PCST. In this study, we present a 4-approximation algorithm for k-PCST that can be obtained by combining two 2-approximation algorithms for k-MST and PCST. By using the same method, we also propose a 4-approximation algorithm for the k-prize collecting traveling salesman problem when the graph is metric.

2 - Approximation algorithm for star-star hub-and-spoke network design problems
Speaker: Yuko Kuroki, University of Tokyo, JP, talk 1246
Co-Authors: *Tomomi Matsui*,
Transportation networks frequently employ hub-and-spoke network architectures to route flows between many origin and destination pairs. Hub facilities work as switching points for flows in large networks. In this study, we deal with a problem, called the single allocation hub-and-spoke network design problem. In the problem, the goal is to allocate each non-hub

node to exactly one of given hub nodes so as to minimize the total transportation cost. The problem is essentially equivalent to another combinatorial optimization problem, called the metric labeling problem. The metric labeling problem was first introduced by Kleinberg and Tardos in 2002, motivated by application to segmentation problems in computer vision and related areas. In this study, we deal with the case where the set of hubs forms a star, which arises especially in telecommunication networks. We propose a polynomial-time randomized approximation algorithm for the problem, whose approximation ratio is less than 5.281. Our algorithms solve a linear relaxation problem and apply dependent rounding procedures.

3 - Time-dependent shortest path with discounted waiting
Speaker: Jeremy Omer, IRMAR-INSA, FR, talk 588
Co-Authors: *Michael Poss*,
We study a variant of the shortest path problem in a congested environment. In this setting, the travel time is represented by a piece-wise continuous affine function. Besides, the driver is allowed to wait at vertices to avoid wasting time in traffic. While waiting, the driver is able to perform useful tasks for her job or herself, so the objective is to minimize only the driving time. We prove that the problem is NP-complete under a mild assumption. We then provide a fully pseudo-polynomial time approximation scheme based on discretizing the waiting time. We also study special cases for which we provide polynomial algorithms and FPTAS.

Nash equilibrium and games 1

Continuous Optimization
Variat - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8
Invited Session 365
Organizer: Lorenzo Lampariello, Roma Tre University, IT

1 - Solving Multi-Leader-Follower Games
Speaker: Anna Thünen, RWTH Aachen University, DE, talk 843
Co-Authors: *Sonja Steffensen*, *Michael Herty*,
The multi-leader-follower game is a particular subset of classical game theory. These models serve as an analytical tool to study the strategic behavior of individuals in a noncooperative manner. In particular, the individuals (players) are divided into two groups, namely the leaders and the followers, according to their position in the game. Mathematically, this leads optimization problems with optimization problems as constraints. The challenge in leader-follower problems arise due to possible nonsmoothness in the constraints. We use an all KKT approach where the nonsmooth part is regularized using a suitable smooth regularizer. We discuss existence of Nash equilibria of the smoothed problems and deduce a numerical algorithm based on the smooth formulation. We further present an update of the smoothness parameter for efficient computation. Finally, we present numerical results to illustrate our approach and give an outlook to future research.

2 - Nash equilibrium: uniqueness and approximation via continuous optimization
Speaker: Jacqueline Morgan, Univ. of Naples Federico II, IT, talk 1056
Co-Authors: *Francesco Caruso*, *Maria Ceparano*,
Firstly, we address the issue of uniqueness of Nash equilibrium of a two-player non-cooperative game when the strategy spaces are (not necessarily finite dimensional) Hilbert spaces. As well-known, a unique Nash equilibrium exists if the best replies correspondences are single-valued and one of the two possible compositions of the best reply functions is a contraction. In this presentation sufficient conditions are given on the data of the game for the existence of one and only one Nash equilibrium when no one of the two possible compositions of the best reply functions is a contraction. Note that for weighted potential games these conditions do not necessarily require neither the strict concavity of the potential function nor the existence of a maximum point for such a function. Then, in the above mentioned setting, we propose and investigate an iterative method based on continuous optimization which converges to the unique Nash equilibrium of the game.

3 - Fixed point and extragradient algorithms for quasi-equilibria
Speaker: Mauro Passacantando, University of Pisa, IT, talk 963
Co-Authors: *Giancarlo Bigi*,
The abstract equilibrium problem (EP) subsumes multiobjective optimization, variational inequalities, fixed point and complementarity problems, Nash equilibria in noncooperative games and inverse optimization in a unique mathematical model. The quasi-equilibrium problem (QEP) is the natural generalization of EP where the constraints are given through a set-valued map that describes how the feasible region changes together with the considered point. Special cases of QEPs are quasi-variational inequalities (QVIs) and generalized Nash equilibrium problems (GNEPs). Unlike QVI and GNEP, algorithms for the QEP format did not receive much attention in the literature. The goal of this talk is to extend two classical algorithmic approaches from EP to QEP, i.e., fixed point and extragradient methods. The main difficulties arise from having a feasible region that changes: the iterates belong to different sets and any solution of QEP has to be a fixed point of the constraining set-valued map. A range of convexity, monotonicity and Lipschitz continuity assumptions will be combined suitably in order to guarantee the convergence of the above algorithms to a solution and to provide estimates of their rate.

Dynamic programming applications

Optimization under Uncertainty
Markov - We 3:15pm-4:15pm, Format: 2x30 min
Room: Salle 31 Building: B, Ground Floor, Zone: 5
Contributed Session 379
Chair: Susanne Hoffmeister, University of Bayreuth, DE

1 - Markov Decision Processes for Sport Strategy Optimization
Speaker: Susanne Hoffmeister, University of Bayreuth, DE, talk 1528
Co-Authors: *Jörg Rambau*,
We introduce a framework of Markov Decision Processes suitable for sports games. The objective of these so-called Sport-Strategy Optimization Markov Decision Processes (SSOMDPs) is to maximize the probability of winning a

match. We investigate properties of SSOMDPs that help to determine an optimal strategy. The introduced SSOMDPs are used to answer a sport strategic question. We formalize what we consider a sport strategic question and show how the optimal strategy may depend on the involved opponent team and the environmental circumstances of the specified match. The talk includes examples of beachvolleyball-SSOMDPs that model the same strategic question on different levels of detail. We show the advantages and disadvantages of each modeling decision from a sport-related perspective. Finally, we introduce a framework that combines the advantages of a rough model with a very detailed model. We call this framework a two-scale approach.

2 - A Model to evaluate the cost-effectiveness trade-off for urologic treatments

Speaker: Paolo Serafini, CISM, IT, talk 619

Co-Authors: *Simone Crivellaro*, *Laurel Sofer*,

Treatments for benign prostatic hyperplasia (BPH) are associated with improving outcomes but at an added cost. This study aims to simulate a capitated health care system and to identify the most cost-effective treatment option for different severities of BPH. A set of health states were identified for BPH and utilities of each state were obtained from the published literature. These states were used to build a Markov chain. The transition probabilities between states for a given intervention were determined using data from the available literature as well as expert opinion. For each state, a disutility value was associated. A cost was associated to each intervention in a particular state. Linear programming was used to compute the average cost at a given disutility threshold in the Markov decision model. Base-case analyses and sensitivity testing were performed. Cost analysis was performed using outcomes and adverse event data from the literature for each of the interventions and hospital costs from hospital administration. A cost-effectiveness curve was created by varying the maximum allowed disutility values and determining the average cost. In this way, a decision for each health state at a maximum disutility was determined. This model provides a useful tool for urologists to determine the most cost-effective treatment option for patients with different severities of BPH. This model can be applied to other disease states within urology. Further studies are needed to validate the model for real-life application.

Logistics

Invited Talks

INTERFACE - We 3:15pm-4:45pm, Format: 3x30 min

Room: SIGALAS Building: C, 2nd floor, Zone: 2

Contributed Session 388

Chair: Frieder Smolny, Technical University Berlin, DE

1 - Using OpenStreetMap data for route optimization: extraction and reduction

Speaker: Kaj Holmberg, Linkoping University, SE, talk 842

Data from OpenStreetMap can give valuable input to many kinds of route optimization problems. We discuss how to extract network data and transform it into forms that are useful for off-line optimization when all data must be present at solution time. Sets of real life test problems are presented and extracted. We investigate the effect of different reductions when importing the networks. Computational tests for doing the network extraction and reduction are reported. We show the effect of the reductions by solving some standard optimization problems in the resulting networks (minimal spanning tree, Chinese postman problem). Disadvantages of the reductions are discussed for the map matching problem when GPS observations shall be associated with streets on the digital map, as the curvature of the streets then is important. Computational tests show that the reductions have a dramatic effect on the network size and the time needed for solving the optimization problems. Often the reductions are necessary in order to be able to solve the optimization problem in reasonable time.

2 - Modeling the Periodic Vehicle Routing Problem in an industrial context

Speaker: Gwénaël Rault, Mapotempo, FR, talk 1625

Co-Authors: *Adeline Fonseca*, *Frédéric Rodrigo*,

Salesmen must visit their customers once every contractual period, which differs in accordance with the income, the product consumption or storage capacity. In order to improve the customer satisfaction, visits must have a regular spacing over the considered time horizon. Moreover it has the consequence to maximize the quantities ordered by customer at each passage. This kind of route is often manually built. Solutions are constructed starting sequentially by the retail outlets where demand is the most frequent. Our company, Mapotempo, was initially providing solutions for daily delivery with short term route optimization. Some of our customers asked us to enlarge the time horizon on which they can get decision support in order to assist their workforce. The aim of our solution procedure is to provide these features complementary to any problem constraint we already manage. Thus we have chosen to define the previously introduced PVRP as an extension of our current model for the Heterogeneous Vehicle Routing Problem. This allows us to keep all constraints we manage so far, as the heterogeneous fleet, multiple time windows, lateness, capacities, skills or orders. Different approaches have been investigated, such as static periods or time lags between visits. We will provide an overview of the Constraint Programming approach of our model. Furthermore we will present some instances which illustrates the results we currently get using the CP solver ORtools through our API.

3 - Multiscale optimization of logistics networks

Speaker: Frieder Smolny, Technical University Berlin, DE, talk 1268

Co-Authors: *Karl Däubel*, *Martin Skutella*, *Torsten Mütze*, *Guillaume Sagnol*,

The optimization of logistics networks includes solving hard multicommodity flow problems with complex transport costs. Networks arising in practice have grown rapidly in size and in the number of demands. The research project LogiScale addresses these challenges using a multiscale approach. Specifically, we develop techniques to aggregate network data, tariffs and demands in logistics networks while preserving connections to the original data in order to recover feasible solutions of good quality. We present a generic optimization procedure that repeatedly solves subproblems of increasingly finer granularity. Operating on a dynamic data structure the algorithm works on different levels of detail of a given network, dynamically adapting the granularity where it seems most promising. Each solution of the considered subproblems corresponds to a solution to the original instance of at most the same cost. We present the algorithms and data structures implemented within this project, as well as first computational results on real-world data provided by our industry partner 4flow.

Polyhedral aspects of combinatorial optimization problems

Discrete Optimization & Integer Programming
COMB - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Contributed Session 404
Chair: Guillerme Duvillié, Université libre de Bruxelles, BE

1 - A polyhedral insight into covering a 2/3 supermodular function by a graph

Speaker: Shungo Koichi, Nanzan University, JP, talk 1216
Berczi and Frank introduced a positively 2/3 supermodular function on bi-sets of a finite set to show a min-max theorem on smallest simultaneous coverings of two fully supermodular bi-set functions, and their proof is totally combinatorial. We give a polyhedral insight into the proof by introducing a polyhedron associated with a positively 2/3 supermodular function. We show that, for a uniform weight, the minimization problem on the polyhedron attains its minimum at an integral point, from which the min-max theorem follows. Furthermore, the integral point corresponds to a degree sequence of an undirected graph which covers the positively 2/3 supermodular function. This approach is similar to the one taken by Frank to giving an edge augmentation of minimum node-cost with a help of polymatroids. If the same argument as his is applicable, our insight may lead to solving the minimum node-induced cost problem on covering a positively 2/3 supermodular function by a graph.

2 - Alternating contractions and their combinatorial applications

Speaker: Sergei Chubanov, University of Siegen, DE, talk 1386
In this talk we will consider an algorithm which generalizes the method of alternating projections. This algorithm runs parallel copies of so-called alternating conditional contractions onto some target sets associated with the problem in question. A conditional contraction is a mapping which does not increase the distance from a given point to the target set. After some number of steps, if a certain solution derived from the current states of the mentioned copies of alternating contractions is still not feasible, the algorithm decides that one of the target sets is empty. If the target sets are defined in an appropriate way, this allows to eliminate a variable without affecting the optimal value. We will see that the algorithm is powerful enough to solve a class of combinatorial problems in polynomial time, including the maximum matchings in non-bipartite graphs. At the same time, this algorithm is a polynomial algorithm for linear programming.

3 - Comparison of some symmetry breaking techniques for graph coloring problem

Speaker: Guillerme Duvillié, Université libre de Bruxelles, BE, talk 1167
Co-Authors: *Bernard Fortz*,
The graph coloring problem, due to its wide range of applications, has been broadly studied in many areas of computer science. Integer Linear Programming is not an exception and several formulations have been provided to tackle it. Unfortunately, inherent symmetry of the problem usually led these formulations to be inefficient in practice. Campelo et al. made a breakthrough with the asymmetric representatives formulation. Instead of assigning colors to vertices, the formulation determines for each vertex, a representative. All the node that have the same representatives will share the same color, and a single representative per color class is chosen. The symmetry can then be handled by, given a well chosen order on the vertices, ensuring that the representative of an IS is the smallest vertex according to the order. Orbitopes, introduced by Kaibel et al., are another way of handling symmetry. The classical formulation contains binary variables $x_{i,k}$ indicating if node i is colored with color k. A feasible solution can thus be seen as a partitionning matrix (i.e. matrix containing exactly one 1 per row), and symmetric solutions are matrices obtained by applying permutation on the columns of the latter. Breaking symmetry comes down to considering a single matrix for each orbit. The partitionning polytope is the convex hull of such representatives and a complete linear description has been provided. An extended formulation has also been described by Faenza et al.. We propose a comparison of these techniques, which to our knowledge has never been done before.

Quadratic Optimization

Continuous Optimization
NLP - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 9 Building: N, 4th floor, Zone: 12

Contributed Session 417
Chair: Anders Forsgren, KTH Royal Inst. of Technology, SE

1 - On limited-memory quasi-Newton methods for minimizing a quadratic function

Speaker: David Ek, KTH, Royal Institute of Tech., SE, talk 884
Co-Authors: *Anders Forsgren*,
In nonlinear optimization, a fundamental subproblem is to solve a linear system corresponding to an unconstrained quadratic problem where the Hessian is symmetric positive definite. We give a multi-parameter quasi-Newton update scheme together with a corresponding limited-memory scheme that on unconstrained quadratic optimization problems with exact linesearch generate search directions parallel to those of the method of preconditioned conjugate gradients. Hence showing that the methods have finite termination on quadratic optimization problems. We also discuss how it is possible to extend these classes and show their behavior on randomly generated quadratic optimization problems. The analysis is based on an alternative compact representation of quasi-Newton update matrices of the Hessian approximation that uses only explicit matrices, and gradients as vector components. We also give the corresponding alternative compact representation from of the full Broyden class for the general unconstrained optimization problem.

2 - On degeneracy in active-set methods for linear and convex quadratic programming

Speaker: Anders Forsgren, KTH Royal Inst. of Technology, SE, talk 645

Co-Authors: *Philip Gill*, *Elizabeth Wong*,
We discuss the treatment of degeneracy in active-set methods for linear and convex quadratic programming. In particular, we show that the use of dual regularization in a primal active-set method gives a nondegenerate primal problem. Conversely, the use of primal regularization in a dual active-set method gives a nondegenerate dual problem. The overall cost of using regularization for a convex quadratic program is insignificant. However, for a linear program, the straightforward use of regularization gives a non-simplex method that requires the solution of a sequence of linear least-squares problems. This would potentially increase the computational cost per iteration. We discuss how the linear algebraic issues that arise in such a regularized method for linear programming may be addressed.

3 - An algorithm for projecting a point onto a level set of a quadratic function
Speaker: Fernanda Raupp, LNCC, BR, talk 1532
Co-Authors: *Wilfredo Sosa*,
We propose an iterative algorithm to project a point onto a level set of a quadratic function, based on the spectral decomposition of the Hessian, which is performed in a unique iteration. The proposed algorithm was tested on instances with distinct Hessian matrices and shows great potential in applications, such as in computer graphics.

Cursing the Dimensionality: Two-Stage and Multi-Stage Robust Optimization

Optimization under Uncertainty
Robust - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 37 Building: B, Intermediate, Zone: 4

Invited Session 443
Organizer: Angelos Tsoukalas, American University of Beirut, LB

1 - Efficient Algorithms for Robust MDPs with State Rectangularity
Speaker: Chin Pang Ho, Imperial College London, GB, talk 1054
Co-Authors: *Marek Petrik*, *Wolfram Wiesemann*,
Robust Markov decision processes (MDPs) seek for optimal policies in view of the worst transition kernel from within an ambiguity set that specifies the knowledge about the unknown true Markov process. Although robust MDPs have emerged as powerful modeling tools, robust MDPs have typically been considered to be intractable, except for special cases where the ambiguity sets are rectangular in both the states and the actions. In this talk, we develop tractable solution techniques for robust MDPs whose ambiguity sets are only required to be rectangular in the states.

2 - Dual approach for two-stage robust nonlinear optimization models
Speaker: Frans de Ruiter, CQM, NL, talk 1337
Co-Authors: *Jianzhe Zhen*, *Dick den Hertog*,
Adjustable robust optimization models in which the adjustable variables appear in a nonlinear way are difficult to solve. For example, if we substitute linear decision rules, then the model becomes convex in the uncertain parameters, whereas for computational tractability we need concavity in the uncertain parameters. In this talk we explain how to reformulate the original adjustable robust nonlinear problem into an equivalent adjustable robust linear problem, for which well-known approaches, such as (non)linear decision rules, can be used. We also describes how to effectively obtain lower bounds on the optimal objective value by linking the realizations in the new dualized uncertainty set to realizations in the original uncertainty set. We show the effectiveness and applicability of the new approach via numerical examples.

3 - Robust Dual Dynamic Programming
Speaker: Angelos Tsoukalas, American University of Beirut, LB, talk 1233
Co-Authors: *Angelos Georghiou*, *Wolfram Wiesemann*,
We propose a robust dual dynamic programming (RDDP) scheme for multi-stage robust optimization problems. The RDDP scheme takes advantage of the decomposable nature of these problems by bounding the costs arising in the future stages through inner and outer approximations. In contrast to Stochastic Dual Dynamic Programming, we refine the approximations deterministically, using our inner approximations as a devise to determine the points of refinement. RDDP converges deterministically in finite time. Numerical results illustrate the good practical performance of the algorithm.

Rail and Maritime Transportation

Specific Models, Algorithms, and Software
Logistics - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 16 Building: I, 2nd floor, Zone: 7

Contributed Session 454
Chair: Kazuhiro Kobayashi, Tokyo University of Science, JP

1 - Accelerated column generation for a ship routing problem with speed optimization
Speaker: Kazuhiro Kobayashi, Tokyo University of Science, JP, talk 802
Co-Authors: *Mirai Tanaka*,
Ship routing and scheduling with speed optimization is an important operational level planning problem in maritime logistics. The objective of this problem is to determine schedules of the ships in the fleet which minimize the fuel consumption to transport the cargoes. The fuel consumption depends on the shipping speed. Thus, we also optimize the shipping speed of each ship in its voyage. For this problem, we propose a column generation approach, in which the subproblem is a mixed-integer nonlinear optimization problem. We also propose an efficient algorithm to obtain a near-optimal solution for this problem in a reasonable computational time. In order to speed up the column generation process, we utilize the solutions of the relaxed subproblem. Although this may lead to the addition of the redundant columns, considerable speed up may be obtained.

2 - Column Generation in Railway Optimization
Speaker: Stanley Schade, Zuse Institute Berlin, DE, talk 1367
Co-Authors: *Markus Reuther*, *Ralf Borndörfer*, *Boris Grimm*, *Thomas Schlechte*,
We present a coarse-to-fine method, i.e., a special column generation technique based on aggregation. It is applied to solve the LP relaxation of a rolling stock rotation problem for

the German intercity express network. Unlike other methods, the coarse-to-fine method does not solve an aggregated problem, which would lead to a decreased solution space. Instead during the column generation process the reduced cost and the pricing problem are aggregated. This reduces the computational load without removing the optimal solution from the solution space. In the talk we discuss why the coarse-to-fine method is so well suited for the rolling stock rotation problem and present the results of computational experiments in order to support this claim.

3 - Optimizing Train Stopping Patterns for Congestion Management
Speaker: Tatsuki Yamauchi, Chuo University, JP, talk 226
Co-Authors: *Mizuyo Takamatsu*, *Shinji Imahori*,
We optimize train stopping patterns during morning rush hour in Japan. When trains are very crowded, congestion rates of trains strongly influence passengers' behavior. Thus, we need to determine stopping patterns based not only on travel time but also on congestion rates of trains. We exploit a Wardrop equilibrium model to compute passenger flows subject to congestion phenomena and present a local search algorithm to optimize stopping patterns which iteratively computes a Wardrop equilibrium. In order to devise an efficient algorithm, we introduce a train type network, which represents routes of trains of each type and transfer behavior of passengers. Our algorithm is also applicable to the problem of optimizing the frequency of services for each train type with a slight modification. We apply our algorithms to railway lines in Tokyo including Keio Line with six types of trains and demonstrate that we succeed in relaxing congestion.

Second order methods for training ML models

Specific Models, Algorithms, and Software
Learning - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Contributed Session 474
Chair: Julien Mairal, Inria, FR

1 - Newton method with an adjusted generalized Hessian matrix for SVMs
Speaker: Amir Abdessamad, University of Mostaganem, DZ, talk 248
Co-Authors: *Yassine Adnan*,
The linear formulation of the classical optimization model of soft margin support vector machines (SVM) for pattern classification, can be converted to an unconstrained optimization problem, where the objective function is a strongly convex piecewise quadratic, which is not twice differentiable and prevents the use of a classical Newton method. However, one can use a Newton method with Armijo stepsize with the generalized Hessian matrix. The calculation of the generalized Hessian matrix depends on the subgradient of plus function which is a step function, that takes values in [0,1] for null elements. In general, authors take a fixed value in [0,1] to minimize computation time. In this work, we show that one can get a better value that can gives a solution of high quality. We approached the problem with three strategies. In the first, we tolerate this value to be a vector and we compute a direction that gives the best decrease for the objectif function. In the second approach and in order to reduce the computational time, we restricted this value to be a constant computed using a one-dimensional algorithm. In the third approach, we considered this value as a tuning parameter, several SVMs were trained using a leave-one-out correctness to select the best parameter that give high accuracy. The problem of nonlinearly separable data has also been addressed, using nonlinear kernel classifiers.

2 - A Variable Metric Inexact Proximal Point Algorithm for Quasi-Newton Acceleration
Speaker: Julien Mairal, Inria, FR, talk 1607
Co-Authors: *Hongzhou Lin*, *Zaid Harchaoui*,
We propose a variable-metric inexact proximal point algorithm to accelerate gradient-based optimization algorithms with quasi-Newton principles. The proposed scheme, called QNing, can be applied to incremental first-order methods such as stochastic variance-reduced gradient (SVRG). It is also compatible with composite objectives, meaning that it has the ability to provide exactly sparse solutions when the objective involves a sparsity-inducing regularization. QNing relies on limited-memory BFGS rules, making it appropriate for solving high-dimensional optimization problems. Besides, it enjoys a worst-case linear convergence rate for strongly convex problems. We present experimental results where QNing gives significant improvements over competing methods for solving large-scale high-dimensional machine learning problems.

3 - An Adaptive Sample Size Trust-Region Method for Empirical Risk Minimization
Speaker: Robert Mohr, KIT, DE, talk 668
Co-Authors: *Oliver Stein*,
We propose a new method for the minimization of a nonconvex function F that is an average of n smooth functions f_i. As it is common in large scale machine learning problems, the method operates on averages of samples of the functions f_i. During the optimization process the size of the samples is adaptively increased (or decreased) depending on the progress made on the objective function F. Moreover, instead of using a preset stepsize strategy, techniques from trust-region methods are used to update the stepsize according to information gathered during the optimization process. We prove that after a finite number iterations the sample size reaches n and the method becomes a full-batch trust-region method. Numerical experiments support our claim that our algorithm has significant advantages compared to current state-of-the-art methods.

Convex optimization, distances and constraints

Specific Models, Algorithms, and Software
Learning - We 3:15pm-4:45pm, Format: 3x30 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Contributed Session 476
Chair: Pablo Parrilo, MIT, US

1 - Computational Optimal Transport: Accelerated Gradient Descent vs Sinkhorn
Speaker: Pavel Dvurechensky, WIAS, DE, talk 626

Co-Authors: *Alexander Gasnikov*, *Alexey Kroshnin*,
Optimal transport (OT) distances between probability measures or histograms play an increasing role in Machine Learning, e.g., in image and text analysis, and statistics. These distances are defined as a solution to a convex OT optimization problem. In this work, we analyze algorithms for this optimization problem and provide two algorithms for approximating the general OT distance between two discrete distributions of size n, up to accuracy ε. For the first algorithm, which is based on the celebrated Sinkhorn's algorithm, we prove the complexity bound $\widetilde{O}\left(\frac{n^2}{\varepsilon^2}\right)$ arithmetic operations, where $\widetilde{O}$ hides polylogarithmic factors. For the second algorithm, which is based on our novel Adaptive Primal-Dual Accelerated Gradient Descent algorithm, we prove the complexity bound $\widetilde{O}\left(\min\left\{\frac{n^{9/4}}{\varepsilon}, \frac{n^2}{\varepsilon^2}\right\}\right)$ arithmetic operations. Both bounds have better dependence on ε than the state-of-the-art result given by $\widetilde{O}\left(\frac{n^2}{\varepsilon^3}\right)$. Our second algorithm not only has better dependence on ε in the complexity bound, but also is not specific to entropic regularization and can solve the OT problem with different regularizers. See https://arxiv.org/abs/1802.04367 for the details.

2 - Geodesic distance maximization
Speaker: Pablo Parrilo, MIT, US, talk 1406
Co-Authors: *De Meng*, *Stephen Boyd*, *Maryam Fazel*,
Given a graph with fixed edge weights, finding the shortest path, also known as the geodesic, between two nodes is a well-studied network flow problem. We introduce the Geodesic Distance Maximization Problem (GDMP), i.e., the problem of finding the edge weights that maximize the length of the geodesic, subject to convex constraints on the weights. We show that GDMP is a convex optimization problem for a wide class of flow costs, and provide a physical interpretation using the dual. GDMP can be generalized from graphs to continuous fields, where the Eikonal equation (a fundamental partial differential equation governing flow propagation) naturally arises in the dual problem. We present applications in various domains, including network interdiction, optical lens design, and control of forest fires. Based on joint work with De Meng, Maryam Fazel and Stephen Boyd.

3 - A Splitting Algorithm for Minimization under Stochastic Linear Constraints
Speaker: Adil Salim, Telecom ParisTech, FR, talk 1404
Co-Authors: *Pascal Bianchi*, *Walid Hachem*,
Many applications in machine learning, statistics or signal processing require the solution of the following optimization problem :

$$\min_{(x,z)\in X\times Z} F(x) + G(z), \quad \text{s.t} \quad Ax + Bz = c$$

where X, Z are Euclidean spaces, F, G are convex functions, A, B are matrices and c is a vector. In order to solve this problem, primal-dual methods typically generate a sequence of primal estimates $(x_n, z_n)_n$ and a sequence of dual estimates $(\lambda_n)_n$ jointly converging to a saddle point of the Lagrangian function. We consider the case where *all* the quantities used to define the minimization problem are likely to be unavailable : F, G, A, B, c are define as expectations. These expectations are unknown but revealed across time through i.i.d realizations of a random variable. Among the instances of this problem are the Markowitz portfolio optimization and large scale minimization problems. We provide a new stochastic primal-dual algorithm and establish its a.s convergence. It generalizes the stochastic proximal gradient algorithm.

Decomposition I

Discrete Optimization & Integer Programming
IPpractice - We 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4
Contributed Session 486
Chair: Dieter Weninger, FAU Erlangen-Nürnberg, DE

1 - Benders Decomposition and Column-and-Row Generation for LPs w/Column-Dependent Rows
Speaker: Kerem Bulbul, Sabanci University, TR, talk 1445
Co-Authors: *Ibrahim Muter*, *Ilker Birbil*,
We study a general class of LPs – known as problems with column-dependent-rows (CDR-problems). These LPs feature two sets of constraints with mutually exclusive groups of variables in addition to a set of structural linking constraints, in which variables from both groups appear together. The number of linking constraints grows very quickly with the number of variables, which motivates generating both columns and their associated linking constraints simultaneously on-the-fly. In this paper, we expose the decomposable structure of CDR-problems via Benders decomposition. However, this approach brings on its own theoretical challenges. One group of variables is generated in the Benders master problem, while the generation of the linking constraints is relegated to the Benders subproblem along with the second group of variables. A fallout of this separation is that only a partial description of the dual of the Benders subproblem is available over the course of the algorithm. We demonstrate how the pricing subproblem for the column generation applied to the Benders master problem does also update the dual polyhedron and the existing Benders cuts in the master problem to ensure convergence. Ultimately, a novel integration of Benders cut generation and the simultaneous generation of columns and constraints yields a brand-new algorithm for solving large-scale CDR-problems. We illustrate the application of the proposed method on a time-constrained routing problem. Our numerical experiments confirm the outstanding performance of the new decomposition method.

2 - Improved Cut Selection for Benders Decomposition
Speaker: Paul Stursberg, Technische Universität München, DE, talk 1087
Benders Decomposition is a widely-used technique to deal with large-scale optimization problems that expose certain structural properties. These properties allow the problem to be decomposed into smaller subproblems that can each be solved more easily, while the algorithm ensures that a globally optimal solution is obtained. Examples for typical applications include Mixed-Integer Programming and Stochastic Optimization. Mathematically, Benders Decomposition can be viewed as a classical cutting plane algorithm. Therefore, an important aspect of the design of Benders type algorithms is the selection of cuts, the so-called separation problem. A number of different criteria and techniques have been proposed in the literature for solving the separation problem in the context of Benders Decomposition. We put these criteria into context with classical cutting plane algorithms and derive some interesting properties and relations. We then use these to improve existing schemes for the selection of Benders cuts to-

wards faster convergence. Furthermore, we expose new ways in which prior knowledge and assumptions about the optimal solution can be leveraged without compromising optimality guarantees. To illustrate our results, we apply our algorithm to a typical problem from the domain of infrastructure planning for electricity systems. Here, long time horizons have to be modelled with high temporal resolution, yet decisions for different points in time are mostly independent of each other which makes the problem very suitable for a decomposition approach.

3 - A Penalty Alternating Direction Decomposition Framework for MIPs

Speaker: Dieter Weninger, FAU Erlangen-Nürnberg, DE, talk 1065

Co-Authors: *Lars Schewe*, *Martin Schmidt*,

Feasibility pumps are an highly efficient class of primal heuristics for mixed-integer linear and nonlinear optimization. At its core, they can be seen as an alternating direction method applied to a special reformulation of the original problem. Building on this insight, we propose a novel decomposition framework that combines hypergraph partitioning with a penalty alternating direction method for computing primal solutions of mixed-integer linear problems. The practical application of the proposed method is demonstrated by computational results on general-purpose MIPLIB instances and on real-world supply chain instances.

Scheduling in Networks

Specific Models, Algorithms, and Software

Scheduling - We 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 532

Chair: Hamish Waterer, University of Newcastle, AU

1 - Global optimization for the pump scheduling problem in drinking water networks

Speaker: Gratien Bonvin, MINES ParisTech, FR, talk 1321

Co-Authors: *Andrea Lodi*, *Sophie Demassey*,

This article offers a novel approach for computing globally optimal solutions to the pump scheduling problem in drinking water networks, an optimization task belonging to the class of nonconvex MINLPs. A convex relaxation (P') of the original problem (P) is devised and embedded in a branch-and-bound procedure. Integer feasible nodes of (P') are then investigated using NLP in order to prune the infeasible solutions or to compute the actual optimal cost of the feasible solutions. We address the integration of variable speed pumps into the global optimization scheme and discuss the classification of the water networks depending on whether the NLP subproblem at leaf nodes can be treated as a feasibility problem or not. Our approach is numerically assessed on five case studies and compared with alternative methods that exist in the literature.

2 - Addressing a scheduling problem for planned disruptions on urban road networks

Speaker: Amadeu Coco, UTT, FR, talk 1360

Co-Authors: *Christophe Duhamel*, *Andrea Santos*,

Scheduling planned disruptions (e.g. maintenance, sporting events, etc.) on urban road network is a complex task for several reasons: the impact on the traffic, the resources limitation, and the network strong connectivity constraint (i.e. there is a path between all pairs of nodes in the network). Several kinds of disruptions may happen (partial or complete blockages). For each case, different solutions can be deployed such as the traffic flow may be left unchanged, alternating lights may be set, or even some street orientations may be changed. Here, complete blockages are considered and street orientations are allowed to be reversed. The urban network is modeled as a connected digraph, where nodes are points of the urban networks and arcs represent the streets circulation directions. Each disruption is associated with a street, a duration and a resource consumption per time period. We model the problem of assigning the planned disruptions such that, for each period of time, the total consumption for the operations does not exceed the resource limit and the network remains strongly connected. For unidirectional connected digraphs, removing an arc may break the strong connectivity. Thus, arc reversals are allowed to ensure this property. Two optimization criteria are initially considered: (i) minimizing the number of reversed arcs and (ii) minimizing the sum of the completion time for each disruption. A compact mathematical formulation and algorithms are proposed.

3 - Scheduling of maintenance windows in a mining supply chain railway network

Speaker: Hamish Waterer, University of Newcastle, AU, talk 1476

Co-Authors: *Thomas Kalinowski*, *Jason Matthews*,

Rail infrastructure forms a critical part of the mining supply chain in Australia, and the planning of maintenance and renewal work is crucial to ensure that the infrastructure assets are kept in a condition which provides safe, efficient, and reliable transport. Such work requires track access which temporarily reduces the throughput capacity of the network and thus revenue generation. Balancing this inherent trade-off between reliability, cost, and revenue is of great importance. An emerging annual planning approach is to schedule geographically localised maintenance windows that are free of trains, into which specific maintenance tasks can be scheduled closer to the day of operation. We report on a MILP model that schedules maintenance windows subject to forecast maintenance requirements and the availability of maintenance resources. For large practical instances of the problem where solving the MILP directly is not tractable, we report on a MILP local search heuristic that alternately decomposes the problem by resource type and by week.

Noncommutative polynomial optimization: semidefinite relaxations, free convexity and applications to quantum information I

Continuous Optimization

SDP - We 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 20 Building: G, 1st floor, Zone: 6

Invited Session 20

Organizer: Monique Laurent, CWI and Tilburg University, NL

1 - Inclusion of spectrahedra, free spectrahedra and coin tossing

Speaker: Markus Schweighofer, Universität Konstanz, DE,

talk 453
Co-Authors: *Bill Helton*, *Igor Klep*, *Scott McCullough*,
Spectrahedra are generalizations of (convex) polyhedra sharing many of the good algorithmic features with polyhedra but allowing for roundness in their shapes. Given two spectrahedra in form of a linear matrix inequality, it is in general hard to decide whether one contains the other. To the linear matrix inequalities one can however associate not only scalar solutions but also matrix solutions. This gives rise to so called free spectrahedra. Inclusion of free spectrahedra is in many cases easy to decide, e.g., by using a generalization of the Gram matrix method and a linear Positivstellensatz for symmetric linear matrix polynomials due to Helton, Klep and McCullough. The natural question arises how the inclusion of two free spectrahedra relates to the inclusion of the corresponding classical spectrahedra. Surprisingly, this question is related to very subtle non-trivial properties of Binomial and Beta distributions some of which are known and some of which are new.

2 - Matrix convex sets and matrix extreme points
Speaker: Tom-Lukas Kriel, Univeristy of Konstanz, DE, talk 74
We will introduce matrix convex sets and consider different notions of extreme points for those sets. The aim will be to prove analogues of the Krein-Milman theorem from classical convexity.

3 - Extracting optimisers by non-commutative GNS construction is robust
Speaker: Janez Povh, University of Ljubljana, SI, talk 53
Co-Authors: *Jurij Volcic*, *Igor Klep*,
Extracting eigenvalue optimisers in optimization of noncommutative polynomials can be done efficiently by Gelfand-Naimark-Segal (GNS) construction if the dual (moment) problem has flat optimum solution. However, in numerical computations the flatness is always subject to rounding threshold, i.e., often we can find only approximately flat dual solutions. In this talk we present how to apply GNS construction to approximately flat data and present sensitivity analysis results. We show that if the optimum of the dual problem is close to a flat solution then it yields a solution on the primal side that is close to an optimum solution. The distance to the optimum solution on the primal side can be expressed by the distance to a flat solution on the dual side. Similarly we can express for constraint optimization how close is the solution given by GNS construction to primal feasible and/or optimum solution in terms of the distance of the dual optimum to flatness. With extensive numerical evaluations we show that the established relations are usually very tight when we deal with random non-commutative polynomials. The focus will be on the (constrained) eigenvalue optimization for noncommutative polynomials, but we will also explain how the main results pertain to commutative and tracial optimization.

Approximation Algorithms for Geometric Packing Problems

Discrete Optimization & Integer Programming
APPROX - We 5:00pm-6:30pm, Format: 3x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1
Invited Session 28
Organizer: Fabrizio Grandoni, IDSIA, CH

1 - Approximating Geometric Knapsack via L-Packings
Speaker: Fabrizio Grandoni, IDSIA, CH, talk 371
Co-Authors: *Waldo Galvez*, *Sandy Heydrich*, *Salvatore Ingala*, *Arindam Khan*, *Andreas Wiese*,
We study the two-dimensional geometric knapsack problem (2DK) in which we are given a set of n axis-aligned rectangular items, each one with an associated profit, and an axis-aligned square knapsack. The goal is to find a (non-overlapping) packing of a maximum profit subset of items inside the knapsack (without rotating items). The best-known polynomial-time approximation factor for this problem (even just in the cardinality case) is $2 + \epsilon$ [Jansen and Zhang, SODA 2004]. In this paper we break the 2 approximation barrier, achieving a polynomial-time $\frac{17}{9} + \epsilon < 1.89$ approximation. Essentially all prior work on 2DK approximation packs items inside a constant number of rectangular containers, where items inside each container are packed using a simple greedy strategy. Our main structural contribution is to show that there exists a large profit solution where items are packed inside a constant number of containers plus one L-shaped region at the boundary of the knapsack which contains items that are high and narrow and items that are wide and thin. Our main algorithmic contribution is a PTAS for packing skewed items in the L-shaped region. We also present improved results for the cardinality case of the problem and for its variant where we are allowed to rotate items by 90 degrees.

2 - Parameterized (1+eps)-approximation algorithms for packing problems
Speaker: Andreas Wiese, Universidad de Chile, CL, talk 354
Co-Authors: *Fabrizio Grandoni*, *Stefan Kratsch*,
Approximation algorithms and parameterized algorithms are two well-established ways to deal with NP-hard problems. In the first case, the goal is to compute in polynomial time a solution of cost close to the optimum. In the second case, the goal is to compute an optimal solution in (FPT) time f(k)n power O(1), where k is some parameter of the input. The recent area of parameterized approximation seeks to combine the two approaches by, e.g., aiming for (1+eps)-approximations in f(k,eps)n power g(eps) time. We present such algorithms for three important packing problems: for the Maximum Independent Set of Rectangles problem, for the Unsplittable Flow on a Path problem, and for the Two-Dimensional Knapsack problem with rotations. All three problems are W[1]-hard and hence we do not expect to find an FPT algorithm for them. Also, it seems very difficult to construct a PTAS for them which motivates studying parameterized (1+eps)-approximations for them.

3 - Closing the gap for pseudo-polynomial strip packing
Speaker: Klaus Jansen, University of Kiel, DE, talk 265
Co-Authors: *Malin Rau*,
Given a set of rectangular axis parallel items and a strip with bounded width and infinite height, the objective is to find a packing of the items into the strip which minimizes the packing height. We speak of pseudo-polynomial Strip Packing if we consider algorithms with pseudo-polynomial running time with respect to the width of the strip. It is known that there is no pseudo-polynomial algorithm for Strip Packing with a ratio better than 5/4 unless P=NP. The best algorithm so far has a ratio of close to 4/3. In this talk, we close this gap: We present an algorithm with approximation ratio arbitrarily close to 5/4. This algorithm uses a structural result which is the main accomplishment of this paper. This structural result

applies to other problem settings as well, which enabled us to present algorithms with approximation ratio close to 5/4 for Strip Packing with rotations (90 degrees) and Contiguous Moldable Task Scheduling.,

Non-Convex and Second-order Methods in Machine Learning

Continuous Optimization
RandomM - We 5:00pm-6:30pm, Format: 4x20 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 33
Organizer: Martin Takac, Lehigh University, US

1 - Escaping Saddles with Stochastic Algorithms
Speaker: Aurelien Lucchi, ETH Zurich, CH, talk 531
The optimization of non-convex functions has recently attracted a lot of interest, especially in the field of machine learning where deep neural networks are now achieving impressive results. Non-convex functions are hard to optimize due to the presence of saddle points and local minima which are not global optima. In this talk we will review the current state of research related to the escape from saddle points. While second-order methods can escape saddle-points by exploiting curvature information, it has also recently been shown that a perturbed version of gradient descent as well as stochastic gradient descent can both escape saddle points efficiently. We will also discuss conditions under which the rate of escape is independent of the dimension of the problem. This can be a very significant practical advantage when optimizing deep neural networks that contain millions of trainable parameters.

2 - Convergence Rate of Expectation-Maximization
Speaker: Reza Babanezhad, UBC, CA, talk 1135
Co-Authors: *Raunak Kumar*, *Mark Schmidt*,
Expectation-maximization (EM) is an iterative algorithm for finding the maximum likelihood or maximum a posteriori estimate of the parameters of a statistical model with latent variables or when we have missing data. In this talk, we view EM in a generalized surrogate optimization framework and analyze its convergence rate under commonly-used assumptions. We show a lower bound on the decrease in the objective function value on each iteration, and use it to provide the first convergence rate for non-convex functions in the generalized surrogate optimization framework and, consequently, for the EM algorithm. We also discuss how to improve EM by using ideas from optimization.

3 - Parameter-free nonsmooth convex stochastic optimization through coin betting
Speaker: Francesco Orabona, Stony Brook University, US, talk 1108
Stochastic subgradient descent has become the method of choice for large-scale optimization of nonsmooth convex functions. However, in order to achieve the best theoretical and practical performance, it requires to tune its parameters: the stepsizes. These stepsizes are particularly critical in the unconstrained setting, where the distance between the initial point and the optimal solution can be arbitrary large. In this talk, I will show that stochastic optimization with Lipschitz convex losses can be reduced to a game of betting on a non-stochastic coin. Betting on a non-stochastic coin is a well-known problem that can be solved using tools from information theory. Moreover, optimal parameter-free coin betting algorithms are known, giving rise to novel parameter-free stochastic optimization algorithms. This approach is very general, i.e. it works for any norm, and it gives optimal rates in a number of settings, i.e. stochastic optimization in reproducing kernel Hilbert spaces, without any parameter/stepsize to tune. Empirical results will be shown as well.

4 - SGD and Hogwild! Convergence Without the Bounded Gradients Assumption
Speaker: Martin Takac, Lehigh University, US, talk 1342
Co-Authors: *Lam Nguyen*, *Phuong Nguyen*, *Marten van Dijk*, *Peter Richtarik*, *Katya Scheinberg*,
Stochastic gradient descent (SGD) is the optimization algorithm of choice in many machine learning applications such as regularized empirical risk minimization and training deep neural networks. The classical analysis of convergence of SGD is carried out under the assumption that the norm of the stochastic gradient is uniformly bounded. While this might hold for some loss functions, it is always violated for cases where the objective function is strongly convex. In (Bottou et al.,2016) a new analysis of convergence of SGD is performed under the assumption that stochastic gradients are bounded with respect to the true gradient norm. Here we show that for stochastic problems arising in machine learning such bound always holds. Moreover, we propose an alternative convergence analysis of SGD with diminishing learning rate regime, which is results in more relaxed conditions that those in (Bottou et al.,2016). We then move on the asynchronous parallel setting, and prove convergence of the Hogwild! algorithm in the same regime, obtaining the first convergence results for this method in the case of diminished learning rate.

Online Optimization

Discrete Optimization & Integer Programming
APPROX - We 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4

Invited Session 35
Organizer: Kevin Schewior, École Normale Supérieure, FR

1 - How large is your graph?
Speaker: Victor Verdugo, Universidad de Chile, CL, talk 437
Co-Authors: *Varun Kanade*, *Frederik Mallmann-Trenn*,
We consider the problem of estimating the graph size, where one is given only local access to the graph. We formally define a query model in which one starts with a *seed* node and is allowed to make queries about neighbours of nodes that have already been seen. In the case of undirected graphs, an estimator of Katzir et al. (2014) based on a sample from the stationary distribution π uses $O\left(\frac{1}{\|\pi\|_2} + d_{\text{avg}}\right)$ queries, we prove that this is tight. In addition, we establish this as a lower bound even when the algorithm is allowed to crawl the graph arbitrarily, the results of Katzir et al. give an upper bound that is worse by a multiplicative factor $t_{\text{mix}} \log(n)$. The picture becomes significantly different in the case of directed graphs. We show that without strong assumptions on the graph structure, the number of nodes cannot be predicted to within a constant multiplicative factor without using a number of queries that are at least linear in the number of nodes,

in particular, rapid mixing and small diameter, properties that most real-world networks exhibit, do not suffice. The question of interest is whether any algorithm can beat breadth-first search. We introduce a new parameter, generalising the well-studied conductance, such that if a suitable bound on it exists and is known to the algorithm, the number of queries required is sublinear in the number of edges, we show that this is tight.

2 - Submodular Secretary Problems: Cardinality, Matching, and Linear Constraints

Speaker: Andreas Tönnis, University of Bonn, DE, talk 360

Co-Authors: *Thomas Kesselheim*,

We study various generalizations of the secretary problem with submodular objective functions. Generally, a set of requests is revealed step-by-step to an algorithm in random order. For each request, one option has to be selected so as to maximize a monotone submodular function while ensuring feasibility. For our results, we assume that we are given an offline algorithm computing an α-approximation for the respective problem. This way, we separate computational limitations from the ones due to the online nature. When only focusing on the online aspect, we can assume $\alpha = 1$. In the submodular secretary problem, feasibility constraints are cardinality constraints, or equivalently, sets are feasible if and only if they are independent sets of a k-uniform matroid. That is, out of a randomly ordered stream of entities, one has to select a subset size k. For this problem, we present a 0.31α-competitive algorithm for all k, which asymptotically reaches competitive ratio $\frac{\alpha}{e}$ for large k. In addition, we give an $\frac{\alpha}{4}$-competitive algorithm for submodular secretary matching. This also covers the problem, in which sets of entities are feasible if and only if they are independent with respect to a transversal matroid. And we give an $O(\alpha d^{-\frac{2}{B-1}})$-competitive algorithm for submodular function maximization subject to linear packing constraints. Here, d is the column sparsity, that is the maximal number of non-zero entries in a column of the constraint matrix, and B is the minimal capacity of the constraints.

3 - Tight Competitive Analysis for Online TSP on the Line

Speaker: Kevin Schewior, École Normale Supérieure, FR, talk 321

We consider the online traveling salesperson problem (TSP), where requests appear online over time on the real line and need to be visited by a server initially located at the origin. We distinguish between closed and open online TSP, depending on whether the server eventually needs to return to the origin or not. While online TSP on the line is a very natural online problem that was introduced more than two decades ago, no tight competitive analysis was known to date. We settle this problem by providing tight bounds on the competitive ratios for both the closed and the open variant of the problem. In particular, for closed online TSP, we provide an approximately 1.64-competitive algorithm, thus matching a known lower bound. For open online TSP, we give a new upper bound as well as a matching lower bound that establish the remarkable competitive ratio of approximately 2.04. Additionally, we consider the online Dial-a-Ride problem on the line, where each request needs to be transported to a specified destination. We provide an improved non-preemptive lower bound of 1.75 for this setting, as well as an improved preemptive algorithm with competitive ratio 2.41, which even works in arbitrary metrical spaces. Finally, we generalize known and give new complexity results for the underlying offline problems. This is joint work with Antje Bjelde, Yann Disser, Jan Hackfeld, Christoph Hansknecht, Maarten Lipmann, Julie Meißner, Miriam Schlöter, and Leen Stougie.

Progress in methods and theory of derivative-free optimization

Continuous Optimization

DerFree - We 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 42

Chair: Serge Gratton, ENSEEIHT, FR

1 - Mesh-based Nelder-Mead algorithm for inequality constrained optimization

Speaker: Charles Audet, Polytechnique Montréal, CA, talk 191

Co-Authors: *Christop Tribes*,

Despite the lack of theoretical and practical convergence support, the Nelder-Mead (NM) algorithm is widely used to solve unconstrained optimization problems. It is a derivative-free algorithm, that attempts iteratively to replace the worst point of a simplex by a better one. The present paper proposes a search step of the Mesh Adaptive Direct Search (MADS) algorithm for inequality constrained optimization, inspired by the NM algorithm. The proposed algorithm does not suffer from the NM lack of convergence, but instead inherits from the totality of the MADS convergence analysis. Numerical experiments show an important improvement in the quality of the solutions produced using this search step.

2 - Manifold Sampling for Nonconvex Optimization of Piecewise Linear Compositions

Speaker: Jeffrey Larson, Argonne National Laboratory, US, talk 466

Co-Authors: *Stefan Wild*, *Kamil Khan*,

We develop a manifold sampling algorithm for the unconstrained minimization of a nonsmooth composite function $f \triangleq \psi + h \circ F$ when ψ is smooth with known derivatives, h is a nonsmooth, piecewise linear function, and F is smooth but expensive to evaluate. The trust-region algorithm classifies points in the domain of h as belonging to different manifolds and uses this knowledge when computing search directions. Since h is known, classifying objective manifolds using only the values of F is simple. We prove that all cluster points of the sequence of the manifold sampling algorithm iterates are Clarke stationary; this holds although points evaluated by the algorithm are not assumed to be differentiable and when only approximate derivatives of F are available. Numerical results show that manifold sampling using zero-order information is competitive with gradient sampling algorithms that are given exact gradient values.

3 - Competitive derivative-free optimization with optimal complexity

Speaker: Morteza Kimiaei, Vienna University, AT, talk 467

Co-Authors: *Arnold Neumaier*,

This paper presents an algorithm with an optimal complexity result for bound-constrained black box optimization in the smooth nonconvex, smooth convex and smooth strictly convex case. Such an algorithm tries to reduce the number of function evaluations as much as possible, while still guaranteeing a fast decrease of the objective function by a stochastic or deterministic test. A comparison of our algorithm with some solvers from the literature for bound-constrained black box optimization problems will be presented.

MINLP (III)

Discrete Optimization & Integer Programming
MINLP - We 5:00pm-6:30pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 67
Organizer: Daniel Bienstock, Columbia University, US

1 - Cardinality-constrained linear regression with sparse matrices
Speaker: Alberto Del Pia, UW-Madison, US, talk 167
Co-Authors: *Robert Weismantel*, *Santanu Dey*,
In cardinality-constrained linear regression we search for the best linear predictor that involves a small subset of variables. Due to the vast applicability of this model, many approaches have been proposed by different communities, including enumeration, greedy algorithms, branch and bound, and convex relaxations. Our point of departure is to understand the problem from a computational complexity viewpoint. Using mainly tools from discrete geometry, we show that the problem can be solved in polynomial time if the associated data matrix is obtained by adding a fixed number of columns to a block diagonal matrix. This is joint work with Santanu S. Dey and Robert Weismantel.

2 - Computational evaluation of new dual bounding techniques for sparse PCA
Speaker: Guanyi Wang, Georgia Tech, US, talk 935
Co-Authors: *Santanu Dey*, *Rahul Mazumder*,
Principal component analysis (PCA) is a widely used dimensionality reduction method in statistics. Most components of the PCA direction are nonzero - this impedes interpretability. The sparse PCA (SPCA) is a framework that enhances the interpretability. Given $Q \in \mathcal{S}^n_+$, the SPCA is: $\lambda^k(Q) \triangleq \max\{x^\top Qx : \|x\|_2 \leq 1, \|x\|_0 \leq k\}$ where $\|x\|_0 \leq k$ allows at most k nonzero components. Note the SPCA problem is NP-hard. Many heuristic algorithms have been proposed. However, these heuristic algorithms require strong assumptions. Their performances are not clear in general. It is thus desirable to create a framework that gives good solutions to SPCA with associated certificates of optimality, via dual bounds without restrictive assumptions. We give, exact and approximate methods to obtain dual bounds of the SPCA problem: 1. Convex IP-relaxation: We relax ℓ_1-relaxation of SPCA problem by SOS-2 constraint and obtain a upper bound via solving a convex integer programming. 2. Linear IP: Ben-Tal and Nemirovski show that $\|x\|_2 \leq 1$ ball can be outer approximated well by a polyhedral P. Then we show $\max\{x^\top Qx : x \in P, \|x\|_0 \leq k\}$ can be solved via a linear integer program exactly. 3. Boolean quadratic problem: We show the inequality $\lambda^k(Q) \leq \max\{\sqrt{z^\top Q \odot Qz} : z \in \{0,1\}, \|z\|_0 \leq k\} \leq \sqrt{k}\lambda^k(Q)$ holds, and the optimization problem can be solved using a linear MIP. Then we compare the numerical results of above methods with SDP relaxation.

3 - Cutting Planes for Linear Programs with Complementarity Constraints
Speaker: Jeff Linderoth, Univ. of Wisconsin-Madison, US, talk 1327
Co-Authors: *Alberto Del Pia*, *Haoran Zhu*,
Our focus is on finding the globally optimal solution to a linear program with additional complementarity restrictions on certain pairs of its variables. We study an extended formulation of the problem arising from a special form of the Reformulation-Linearization-Technique proposed by Nguyen, Richard, and Tawarmalani. We prove structural properties about this extended formulation and then augment the formulation with cutting planes derived from the Boolean Quadric Polytope in order to improve computational performance of branch-and-bound based methods.

Optimization and modeling of integrated energy systems

Specific Models, Algorithms, and Software
Energy - We 5:00pm-6:30pm, Format: 4x20 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 71
Organizer: Jalal Kazempour, DTU, DK

1 - Market-based valuation of natural gas network flexibility
Speaker: Stefanos Delikaraoglou, ETH Zurich, CH, talk 718
Co-Authors: *Gabriela Hug*,
The operation of natural gas networks involves large time constants, compared to electricity grids, and therefore the gas system is typically never in steady state. In addition, gas networks have an inherent storage capability known as linepack that allows for instantaneous imbalances between gas injections and withdrawals. This transient nature and the linepack characteristic provide high spatial and temporal flexibility during the short-term operation of the gas network, which has significant economic value for both the shippers and the system operator. Under existing market rules, the linepack flexibility service is commonly priced according to the end-of-day imbalance, whereas the cost of cumulative intra-day imbalances is socialized through network tariffs. In this work, we propose a market-based mechanism for the valuation of natural gas network flexibility that accounts for the peak cumulative imbalance during operation. The resulting linepack prices reflect the actual balancing costs incurred by the system operator and account for the substitutional relationship between linepack flexibility and transport services.

2 - Unintended consequences: The snowball effect of energy communities
Speaker: Ibrahim Abada, ENGIE SA, FR, talk 300
Co-Authors: *Xavier Lambin*, *Andreas Ehrenmann*,
Following the development of decentralized generation and smart appliances, energy communities have become a phenomenon of increased interest. While the benefits of such communities have been discussed, there is increasing concern that inadequate grid tariffs may lead to the excess adoption of such business models. Furthermore, snowball effects may be observed following the effects these communities have on grid tariffs. We show that restraining the study to a simple cost-benefit analysis is far from satisfactory. Therefore, we

use the framework of cooperative game theory to take account of the ability of communities to share gains between members. The interaction between energy communities and the DSO then results in a non-cooperative equilibrium. We provide mathematical formulations and intuitions of such effects, and carry out realistic numerical applications where communities can invest jointly in solar panels and batteries. We show that such a snowball effect may be observed, but its magnitude and its welfare effects will depend on the grid tariff structure that is implemented, leading to possible PV over-investments.

3 - Coordination of Heat and Electricity Systems via Market-Based Mechanisms

Speaker: Lesia Mitridati, DTU, DK, talk 728

Co-Authors: *Jalal Kazempour*, *Pierre Pinson*,

In systems with a high share of combined heat and power plants and heat pumps, new markets mechanisms exploiting synergies between heat and electricity systems are needed. In this talk we compare various heat and electricity markets frameworks, including traditional sequential markets and an ideal combined economic dispatch. And, to improve the coordination between heat and electricity markets while respecting their sequential nature, we introduce a novel hierarchical heat dispatch, constrained by electricity market equilibrium. In this model the heat market operator minimizes the expected heat cost, while endogenously modeling scenarios of electricity market clearing in the lower-level problems. This stochastic hierarchical optimization problem is first recast as a Mathematical Problem with Equilibrium Constraints (MPEC) and a Mixed Integer Linear Problem (MILP). Finally, a novel Benders decomposition algorithm is introduced to decompose this optimization problem per scenario. Each sub-problem is recast as a bilinear problem, using a primal-dual formulation, and solved sequentially as two Linear Problems (LPs).

4 - Virtual bidders and self-schedulers in electricity and natural gas markets

Speaker: Anna Schwele, DTU, DK, talk 725

Co-Authors: *Christos Ordoudis*, *Jalal Kazempour*, *Pierre Pinson*,

Current energy market designs are based on a sequential clearing of day-ahead and real-time trading floors with deterministic description of uncertain power supply, while the electricity and natural gas markets are cleared separately under limited coordination. We propose the introduction of virtual bidders and self-schedulers in the current market structure to approximate the ideal solution obtained by a stochastic market-clearing of the fully coupled electricity and natural gas system. We formulate a two-settlement equilibrium model including the deterministic market clearing by the electricity and natural gas operators in the day-ahead and real-time stages as well as the independent dispatch by virtual bidders and self-schedulers maximizing their expected profits. A case study solving the resulting stochastic mixed complementarity problem demonstrates the increase of market efficiency.

Methods and Analysis for Nonsmooth Optimization

Continuous Optimization

NonSmooth - We 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 86

Organizer: Michael Overton, New York University, US

1 - Partial Smoothness of the Numerical Radius

Speaker: Michael Overton, New York University, US, talk 789

Co-Authors: *Adrian Lewis*,

The field of values (numerical range) of a matrix A is defined as $W(A) = \{v^*Av : ||v||_2 = 1\}$; it is a convex, compact set in the complex plane. The numerical radius is $\{\max |z| : z \in W(A)\}$. Solutions to optimization problems involving the numerical radius often belong to a special class: the set of matrices A for which $W(A)$ is a disk centered at the origin. We illuminate this phenomenon by studying matrices around which this set is a manifold M with respect to which the numerical radius is "partly smooth". At such matrices, the numerical radius varies smoothly w.r.t. changes to the matrix contained in or tangent to M, and nonsmoothly w.r.t changes normal to M. Examples include Jordan blocks and the Crabb matrix related to a well-known conjecture of Crouzeix.

2 - Partial smoothness and active sets: a fresh approach

Speaker: Adrian Lewis, Cornell ORIE, US, talk 862

Co-Authors: *Jingwei Liang*,

Underlying active set identification in minimization algorithms is the idea of "partial smoothness", which combines several variational properties of an objective and its subdifferential A narrower focus on the subdifferential alone reveals this property in a simpler differential-geometric light, suggesting extensions to certain popular splitting algorithms.

3 - Subgradient methods for sharp weakly convex problems

Speaker: Dmitriy Drusvyatskiy, University of Washington, US, talk 885

Co-Authors: *Damek Davis*, *Kellie MacPhee*, *Courtney Paquette*,

Subgradient methods converge linearly on a convex function that grows sharply away from its solution set. In this talk, I will explain that the same is true locally for sharp functions that are only weakly convex – meaning those that can be written as a difference of a convex function and a quadratic. A variety of statistical and signal processing tasks come equipped with good initialization, and provably lead to formulations that are both weakly convex and sharp, with high probability. Therefore, in such settings, subgradient methods can serve as cheap local search procedures. I will illustrate the techniques on robust phase retrieval and covariance estimation problems.

Aspects of Multiobjective Combinatorial Optimization

Optimization under Uncertainty

Game - We 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 30 Building: B, Ground Floor, Zone: 5

Invited Session 87

Organizer: Matthias Ehrgott, Lancaster University, GB

1 - Generating Representative Sets for Multiobjective Discrete Optimization Problems

Speaker: Serpil Sayin, Koç University, TR, talk 329

Co-Authors: *Gokhan Kirlik*,

We present an algorithm to generate representations with a quality guarantee on coverage error for a multiobjective discrete optimization problem with any number of objectives. The algorithm relies on partitioning and searching the p-dimensional outcome space by means of rectangles. For each rectangle, two-stage mathematical programs are solved where the first stage is the well-known epsilon-constraint scalarization so that nondominated solutions can be identified. The algorithm aspires to eliminate a rectangle from the search whenever the coverage error requirement is already satisfied for that particular rectangle, although its solution might lead to discovery of new nondominated solutions. Computing the coverage error for a rectangle requires solution of a bilevel optimization problem and is computationally expensive. Therefore an approximation that can be computed in polynomial time is presented. Tests are conducted on multiobjective knapsack, assignment and traveling salesman problem instances. The algorithm offers varying level of savings in comparison to obtaining the entire nondominated set.

2 - A multi-objective approach to sensitivity analysis of MILP

Speaker: Kim Andersen, Aarhus University, DK, talk 986
Co-Authors: *Lars Nielsen*, *Trine Boomsma*,

We present a multi-objective optimization approach to sensitivity analysis of the objective function coefficients in mixed-integer linear programming. We determine the maximal region of the coefficients for which the solution remains optimal. The region is maximal in the sense that for variations beyond this, the optimal solution is no longer the same. For changes in a single objective function coefficient, we show how to achieve this by bi-objective mixed-integer linear programming. In particular, we prove that it suffices to determine the two extreme non-dominated points that are neighbors to the optimal solution of the MILP. Furthermore, we show how to extend the methodology for simultaneous changes in two or more coefficients by use of multi-objective analysis.

3 - Approximating the Multiobjective Shortest Path Problem in Practice

Speaker: Fritz Bökler, Osnabrück University, DE, talk 1422

In this talk, we study approximation algorithms for the multiobjective shortest path (MOSP) problem. The theoretical approximation algorithms in the literature have two common problems: Their running times do not scale well with the number of objectives in general and, to the best of our knowledge, there are no practical implementations available. Hence, we develop a novel scheme of approximation algorithms for the MOSP problem which makes use of the exact labeling approaches which are well tested in practice. In an extensive computational study, we show that our implementation of this scheme performs well even on instances with a larger number of objectives. We compare our implementation of the new method to novel implementations of the other existing approximation algorithms and show its capabilities.

Robust Adaptive Control and Learning

Optimization under Uncertainty
Robust - We 5:00pm-6:00pm, Format: 2x30 min
Room: Salle 37 Building: B, Intermediate, Zone: 4

Invited Session 97

Organizer: Siqian Shen, University of Michigan, US

1 - Distributionally Robust Adaptive Control under Nonstationary Uncertainty

Speaker: Siqian Shen, University of Michigan, US, talk 415
Co-Authors: *Hideaki Nakao*, *Ruiwei Jiang*,

We formulate a distributionally robust counterpart for a partially observable Markov decision process (POMDP), where the probability of state transition and the observation is ambiguous. We show that the value function is piecewise linear convex under the moment based ambiguity set, and construct an approximation algorithm for distributionally robust POMDP (DRPOMDP) based on point-based value iteration. We conduct case studies by applying DRPOMDP to adaptive inventory control problems, where the demand is dependent on an unobservable trend following a Markov chain.

2 - Leveraging stochastic programming to design robust policies for Markov decision

Speaker: Lauren Steimle, University of Michigan, US, talk 159
Co-Authors: *Brian Denton*,

Markov decision processes (MDPs) are commonly used to derive optimal sequential decision-making policies. However, these policies can underperform if the true model parameters differ from the estimates used in the optimization process. To address this issue, the Multi-model MDP has been proposed as a way to find a policy that performs well with respect to multiple models of the MDP parameters, and thus is robust to deviations in these parameters. Finding a policy that maximizes a weighted value function across the models can be viewed as a two-stage stochastic integer program in which the policy corresponds to the first-stage decisions and each model of the MDP parameters corresponds to a possible scenario. Leveraging this connection, we characterize the complexity of the Multi-model MDP models, describe properties of the optimal policies, and present exact and approximate solution methods. Finally, we illustrate the effectiveness of this approach using a case study in the context of medical decision making.

Robust Approaches for Challenging Uncertain Optimization Problems

Discrete Optimization & Integer Programming
MINLP - We 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 124

Organizer: Frauke Liers, Friedrich-Alexander University, DE

1 - A New Approach for Extending Cover Inequalities for the Robust Knapsack Polytope

Speaker: Timo Gersing, RWTH Aachen University, DE, talk 876
Co-Authors: *Christina Büsing*, *Arie Koster*,

The binary knapsack problem is one of the most frequently occurring substructures in integer linear programs. Thus, we are particularly interested in studying its polytope and finding valid inequalities in order to solve complex problems containing knapsack constraints more efficiently within a branch-and-cut framework. Such frameworks are also widely used in robust optimization. Therefore, polytopal insights into robust counterparts of the knapsack problem become more and more relevant in practice. In this talk, we study the robust knapsack with uncertain weights for which we consider the budget uncertainty set of Bertsimas and Sim. In literature, robust cover inequalities have been proposed alongside with two different extensions. We propose a novel class of extended cover inequalities, exploiting the structure of the uncertainty set by combining information of different scenarios. The new extensions are particularly suited for instances where the lengths of the uncertainty intervals around the nominal weights are not proportional to the nominal weights themselves. A preliminary computational study confirms the added value of the new approach, compared to the earlier versions of extended cover inequalities.

2 - An Interdiction Approach for the Design of High-Rise Water Supply Systems

Speaker: Andreas Schmitt, TU Darmstadt, DE, talk 448
Co-Authors: *Marc Pfetsch*,

In this talk, we present a bilevel model and a solving method to optimize the investment cost and energy consumption of a high-rise water supply system which tolerates the failure of a given number of pumps. The first level of the problem models the placement of pipes, pumps and their control whereas the second level is used to determine the most vital pumps to fail in the first level. Our model features realistic approximations of pump characteristics via quadratic and cubic polynomials as well as the interconnection of pumps. We analyze properties of the pumps, which allow us to simplify the search for the most critical one. By further exploiting the underlying networks tree structure we form efficient relaxations. This yields a robust solving method via an iterative approach that dynamically generates variables for new failure scenarios and corresponding rows that couple the components.

3 - Robust optimization with selected scenarios

Speaker: Sebastian Tschuppik, Universität Erlangen-Nürnberg, DE, talk 547
Co-Authors: *Andreas Bärmann*, *Frauke Liers*, *Alexander Martin*, *Oskar Schneider*,

We propose a new methodology based on online convex optimization for selecting representative scenarios from historical data in the context of recoverable robust optimization. In particular, we use a variant of the weighted majority algorithm to learn a priorization of a large-scale scenario set. Classical results for the expert setting are then transferred to our algorithm. We evaluate our approach on two problems, namely the robust matching problem where edges can fail and the recoverable robust multiple knapsack problem with limited repacking actions. Finally, we give some remarks on the application of the bandit method to recoverable robustness.

Software for Nonlinear Optimization

Continuous Optimization
NLP - We 5:00pm-6:30pm, Format: 3x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

Invited Session 133
Organizer: Sven Leyffer, Argonne National Laboratory, US

1 - Argonot: An Open-Source Software Framework for Nonlinear Optimization

Speaker: Charlie Vanaret, Argonne National Laboratory, US, talk 1086
Co-Authors: *Sven Leyffer*,

Iterative methods for nonlinear optimization usually share common ingredients, such as strategies to compute a descent direction or mechanisms that promote global convergence. Our new open-source framework for nonlinearly constrained optimization, Argonot, offers a selection of off-the-shelf strategies that can be assembled at will. Argonot thus implements a variety of methods (e.g. trust-region filter SQP, line-search penalty Sl_1QP, ...) and interfaces with specialized solvers (BQPD, CLP) with no programming effort from the user. Argonot also provides an interface to the algebraic modeling language AMPL. We present extensive results on a subset of problems from the CUTEr collection, and compare Argonot against state-of-the-art solvers CONOPT, IPOPT, KNITRO, LANCELOT, LOQO, MINOS and SNOPT.

2 - A Primal-Dual Shifted Barrier Method for Nonlinear Optimization

Speaker: Philip Gill, UC San Diego, US, talk 942
Co-Authors: *Vyacheslav Kungurtsev*, *Daniel Robinson*,

Interior methods provide an effective approach for the treatment of inequality constraints in nonlinearly constrained optimization. A new primal-dual interior method is proposed based on minimizing a sequence of shifted primal-dual penalty-barrier functions. Under suitable assumptions, the method is equivalent to the conventional path-following interior method in the neighborhood of a solution. A feature of the method is the ability to handle infeasible shifts when the barrier parameter is reduced.

3 - L-RH-B: Software for Large-Scale Bound-Constrained Optimization

Speaker: Elizabeth Wong, UC San Diego, US, talk 1112
Co-Authors: *Philip Gill*, *Michael Ferry*,

Reduced-Hessian (RH) methods for unconstrained optimization are based on approximating the Hessian on an expanding sequence of subspaces spanned by the gradient vectors. In a limited-memory reduced-Hessian (L-RH) method the reduced Hessian is restricted in dimension by using a gradient space spanned by a subset of the preceding search directions. A projected-search method is proposed that extends the limited-memory variant of the reduced-Hessian method to problems with upper and lower bounds on the variables. The method uses a modified Wolfe line search that extends the conventional Wolfe line search to piecewise continuous functions. Numerical results are presented for the software package L-RH-B, which implements a limited-memory reduced-Hessian method based on the BFGS approximate Hessian. This is joint work with Michael Ferry and Philip E. Gill.

Advances in MINLP

Discrete Optimization & Integer Programming
MINLP - We 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4

Invited Session 165
Organizer: Laura Palagi, Sapienza University of Rome, IT

1 - An Active Set Algorithm for Robust Combinatorial Optimization

Speaker: Marianna De Santis, Sapienza University of Rome, IT, talk 336
Co-Authors: *Christoph Buchheim*,
We address combinatorial optimization problems with uncertain coefficients varying over ellipsoidal uncertainty sets. The robust counterpart of such a problem can be rewritten as a second-oder cone program (SOCP) with integrality constraints. We propose a branch-and-bound algorithm where dual bounds are computed by means of an active set algorithm. The latter is applied to the Lagrangian dual of the continuous relaxation, where the feasible set of the combinatorial problem is supposed to be given by a separation oracle. The method benefits from the closed form solution of the active set subproblems and from a smart update of pseudo-inverse matrices. We present numerical experiments on randomly generated instances and on instances from different combinatorial problems, including the shortest path and the traveling salesman problem, showing that our new algorithm consistently outperforms the state-of-the art mixed-integer SOCP solver of Gurobi.

2 - Membrane System Design Optimization
Speaker: Veronica Piccialli, University of Rome Tor Vergata, IT, talk 872
Co-Authors: *Bernardetta Addis*, *Marjan Bozorg*, *Alvaro Ramirez Santos*, *Christoph Castel*, *Eric Favre*,
Membrane gas separation by means of synthetic polymeric membranes is a well-established technology for several industrial applications. One of the most relevant is CO2 capture from power plants and industrial emissions. Because of the inherent limitations of the solution-diffusion separation mechanism in polymeric membranes, several separation stages are often necessary when applications demand high levels of recovery and purity of one or several components, or when the feed is poor in the component(s) to be recovered, or both. Optimizing the design translates into an hard non convex MINLP problem, that remains non convex even when considering a fixed design. We apply global optimization with respect to the continuous variables, and treat some of the design choices by means of continuous optimization, whereas we apply smart enumeration for the remaining purely combinatorial choices, obtaining very good results on real world case studies.

3 - Dantzig Wolfe Decomposition for Binary Quadratic Programming
Speaker: Emiliano Traversi, University of Paris XIII, FR, talk 1348
Co-Authors: *Alberto Ceselli*, *Lucas Letocart*,
In this work we investigate the behavior of Dantzig Wolfe Decomposition when applied to Binary Quadratic Programming. Several decomposition are compared from a theoretical and experimental point of view. As test case we use the 0-1 k-item Quadratic Knapsack Problem. We show that with a proper reformulation we are able to close in the majority of the cases the whole integrality gap in a reasonable amount of time, solving to proven optimality more instances than a generic solver can do.

Complementarity Problems

Continuous Optimization
Variat - We 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 173
Organizer: Samir Neogy, Indian Statistical Institute, IN

1 - Weakly homogeneous variational inequalities
Speaker: Muddappa Gowda, UMBC, US, talk 193
Co-Authors: *David Sossa*,
Given a closed convex cone C in a finite dimensional real Hilbert space H, a weakly homogeneous map $f : C \to H$ is a sum of two continuous maps h and g, where h is positively homogeneous of degree γ (> 0) on C and $g(x) = o(\|x\|^\gamma)$ as $\|x\| \to \infty$ in C. We denote h by f^∞ and call it the 'recession part' of f. Examples include polynomial maps over R^n_+ and Riccati maps $f(X) := XAX + BX + XB^*$ over the cone of (real/complex) Hermitian positive semidefinite matrices. Given a weakly homogeneous map f, a nonempty closed convex subset K of C, and a $q \in H$, we consider the variational inequality problem, $\mathrm{VI}(f, K, q)$, of finding an $x^* \in K$ such that $\langle f(x^*) + q, x - x^*\rangle \geq 0$ for all $x \in K$. When K is a cone, this becomes a complementarity problem. In this talk, we describe some results connecting the variational inequality problem $\mathrm{VI}(f, K, q)$ and the cone complementarity problem $\mathrm{VI}(f^\infty, K^\infty, 0)$, where f^∞ is the recession part of f and K^∞ is the recession cone of K. Specializing, we extend a result of Karamardian formulated for homogeneous maps on proper cones to variational inequalities. As an application, we discuss the solvability of nonlinear equations corresponding to weakly homogeneous maps over closed convex cones.

2 - On testing matrices with nonnegative principal minors
Speaker: Samir Neogy, Indian Statistical Institute, IN, talk 1314
Co-Authors: *Dipti Dubey*,
In this paper, we revisit various methods proposed in the literature on testing matrices with nonnegative principal Minors and discuss various characterizations useful for testing $P(P_0)$-matrices using linear complementarity theory. We also identify few subclasses of P_0-matrix for which we propose a polynomial time algorithm for testing P_0 -matrices. We also discuss the problem of testing P(P0)-matrices as a Nonlinear Programming Problem.

3 - Total Dual Integrality and Integral Solutions of Linear Complementarity Problem
Speaker: Dipti Dubey, Indian Statistical Institute, IN, talk 1235
Co-Authors: *Samir Neogy*,
This paper deals with the problem of finding an integer solution to a linear complementarity problem (LCP). Chandrasekaran et al. (1998) introduced the class I of integral matrices for which the corresponding LCP has an integer solution for every integral vector q, for which it has a solution and proved that for some well known matrix classes principal unimodularity forms a necessary and sufficient condition for inclusion in class I. In this paper, we identify some more well-known matrix classes for which principal unimodularity forms a necessary and sufficient condition for inclusion in class I. The concept of total dual integrality is utilized to obtain a necessary and sufficient condition for existence of an integer solution to LCP with a hidden K-matrix. We interconnect the concept of Hilbert basis with principal unimodularity of a matrix and the corresponding complementary cones. A necessary and sufficient condition is given for the existence of an integer solution of a linear fractional programming problem by using its LCP formulation.

Advances in optimization methods for time dependent problems II

Continuous Optimization
Control - We 5:00pm-6:30pm, Format: 4x20 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Invited Session 225
Organizer: Denis Ridzal, Sandia National Labs, US

1 - Preconditioners for unsteady PDE-constrained optimization and parallel variants
Speaker: Stefan Ulbrich, TU Darmstadt, DE, talk 887
We consider optimization problems governed by time-dependent parabolic PDEs and discuss the construction of preconditioners for the solution of the optimality system for the case without and with control constraints. The preconditioner decouples into a forward and backward PDE solve and forms a convenient basis for the application of time-domain decomposition techniques. We prove bounds for the condition number of the preconditioned system which show no or only a weak dependence on the size of regularization parameters for the control. We propose to use the parareal time domain decomposition method for the forward and backward PDE solves within the PDE preconditioner to construct an efficient parallel preconditioner. Numerical results are presented.

2 - Parallel-in-time PDE-constrained optimization using PFASST
Speaker: Sebastian Goetschel, Zuse Institute Berlin, DE, talk 573
Co-Authors: *Michael Minion*,
Gradient evaluation for optimal control problems governed by parabolic PDEs requires one solve of the state equation and one backward-in-time solve of the adjoint equation, making the iterative optimization process computationally demanding. Time-to-solution can be decreased by utilizing the increasing number of CPU cores available in current computers. In addition to more common spatial parallelization, time-parallel methods are receiving increasing interest. There, iterative multilevel schemes such as PFASST (Parallel Full Approximation Scheme in Space and Time) are currently state of the art and achieve significant parallel efficiency of more than 50*percent*. We investigate approaches to use PFASST for the solution of parabolic optimal control problems. Besides enabling time parallelism, the iterative nature of the temporal integrators within PFASST provides additional flexibility for reducing the cost of solving nonlinear equations, re-using previous solutions in the optimization loop, and adapting the accuracy of state and adjoint solves to the optimization progress. We discuss benefits and difficulties, and present numerical examples.

3 - Direct Multiple Shooting for parabolic PDE constrained optimization
Speaker: Andreas Potschka, IWR, Heidelberg University, DE, talk 966
We present Newton-Picard preconditioners that can be used in a Direct Multiple Shooting method for parabolic PDE constrained optimization problems. We first discuss convergence of a preconditioned fixed-point iteration for the example of a quadratic tracking problem subject to the periodic heat equation. The analysis is based on semigroup and spectral theory in a single shooting approach. Then we present numerical results for a two-grid Newton-Picard preconditioner. In the last part, we extend the approach to a multiple shooting framework for nonlinear problems with inequality constraints. We present a modified structure-exploiting condensing technique and conclude with numerical examples.

4 - Multigrid-in-time methods for optimization with nonlinear PDE/DAE constraints
Speaker: Denis Ridzal, Sandia National Labs, US, talk 602
Co-Authors: *Eric Cyr*,
We propose new parallel solvers for optimization problems explicitly constrained by time-dependent partial differential equations (PDEs) and/or differential algebraic equations (DAEs). Our methods are based on a time-domain decomposition approach for the augmented optimality systems involving the bidirectional-in-time coupling of PDE/DAE Jacobians and their adjoints. A relaxation of the coupling through a fixed-point iteration enables the parallel solution of smaller optimality systems in the subdomains. The time coupling is recovered gradually at each optimization iteration through a Krylov scheme preconditioned with a bidirectional-in-time multigrid method, where the fixed-point iterations are used as smoothers. To handle nonlinearity and nonconvexity we use a matrix-free trust-region sequential quadratic programming (SQP) approach that enables a very coarse solution of the augmented optimality systems. We conclude the talk with parallel scaling studies for optimal control problems constrained by large-scale PDE and DAE systems.

Progress in MIP Solvers II

Specific Models, Algorithms, and Software
Algo - We 5:00pm-6:30pm, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 234
Organizer: Hans Mittelmann, Arizona State University, US

1 - Benders Decomposition in IBM CPLEX
Speaker: Andrea Tramontani, IBM, IT, talk 895
Benders decomposition is a well known algorithmic technique that has been shown to be extremely effective on some classes of convex optimization problems that exhibit a decomposable structure like, for instance, network design problems, facility location problems, or deterministic equivalent of stochastic problems. In this talk we present the Benders decomposition branch-and-cut that was implemented in CPLEX for Mixed Integer Linear Programming (MILP). We illustrate the main algorithmic blocks behind our implementation and we present an extensive computational analysis on some classes of decomposable MILP problems, to assess the performance of the newly developed Benders branch-and-cut in comparison with the default branch-and-cut of CPLEX. Interestingly, the results show that some models that are out of reach for a "standard" branch-and-cut can instead be solved by Benders decomposition. Finally, we discuss the latest improvements in our Benders decomposition algorithm that are currently work in progress.

2 - Gurobi 8.0 - What's new
Speaker: Michael Winkler, Gurobi, DE, talk 1393
We will give an overview on new features and improvements in the current Gurobi release. In particular, we focus on the

new Cloud and Compute Server enhancements and present our newest performance improvements.

3 - Recent Progress in the Xpress Solvers
Speaker: Michael Perregaard, FICO, GB, talk 658
FICO Xpress has solvers for linear, quadratic, second-order cones and general nonlinear problems, including mixed integer versions of these. We will present some of the recent advances in these solvers.

Stochastic Programming and Distributionally Robust Optimization Models with Endogenous Uncertainty

Optimization under Uncertainty
Stoch - We 5:00pm-6:30pm, Format: 3x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 248
Organizer: Miguel Lejeune, George Washington University, US

1 - Distributionally Robust Optimization with Decision-Dependent Ambiguity Set
Speaker: Nilay Noyan, Sabanci University, TR, talk 1440
Co-Authors: *Miguel Lejeune*, *Gabor Rudolf*,
We introduce a new class of distributionally robust optimization problems under decision-dependent ambiguity sets. In particular, as our ambiguity sets we consider balls centered on a decision-dependent probability distribution. The balls are based on a class of Earth Mover's Distances that includes both the Total Variation Distance and the Wasserstein-1 metric. We also consider a special class of problems where decisions are binary and the inherent randomness is characterized by a set of binary vectors, and develop mixed-integer linear programming reformulations.

2 - Optimization Under Decision-dependent Uncertainty
Speaker: Kartikey Sharma, Northwestern University, US, talk 897
Co-Authors: *Omid Nohadani*,
The efficacy of robust optimization spans a variety of settings with uncertainties bounded in predetermined sets. In many applications, uncertainties are affected by decisions and cannot be modeled with current frameworks. This paper takes a step towards generalizing robust optimization to problems with decision-dependent uncertainties. In general settings, we show these problems to be NP-complete. To alleviate the computational inefficiencies, we introduce a class of uncertainty sets whose size depends on decisions. We propose reformulations that improve upon alternative standard linearization techniques. To illustrate the advantages of this framework, a shortest path problem is discussed, where the uncertain arc lengths are affected by decisions. Beyond the modeling and performance advantages, the proposed proactive uncertainty control also mitigates over conservatism of current robust optimization approaches.

3 - Chance-Constrained Optimization Models with Endogenous and Exogenous Uncertainty
Speaker: Miguel Lejeune, George Washington University, US, talk 105
Co-Authors: *Francois Margot*, *Alan Del de Oliveira*,
We present chance-constrained stochastic programming models under combined endogenous and exogenous sources of uncertainty. We propose a solution method featuring conic bounding and reformulation techniques and a spatial branch-and-bound algorithm. The model is motivated by the problem of urgently evacuating severe casualties. Computational results will be presented.

Robust combinatorial optimization III

Optimization under Uncertainty
Robust - We 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 33 Building: B, Ground Floor, Zone: 5

Invited Session 255
Organizer: Moritz Mühlenthaler, TU Dortmund University, DE

1 - Robust Matching Augmentation
Speaker: Moritz Mühlenthaler, TU Dortmund University, DE, talk 1236
Co-Authors: *Felix Hommelsheim*, *Oliver Schaudt*, *Viktor Bindewald*,
We call a perfect matching of a bipartite graph 1-robust, if the graph admits a perfect matching after the removal of any single matching edge. We consider the problem of augmenting a minimum-cost edge set to a bipartite graph in order to make a given perfect matching of the graph 1-robust. By exploiting a close but non-trivial relation to the Strong Connectivity Augmentation problem and the Set Cover problem, we give a simple, deterministic $\log n$-factor approximation algorithm for the unit-cost problem. This algorithm is essentially best possible under the standard assumption that $P \neq NP$. Furthermore, we show that the problem is tractable on chordal bipartite graphs. Finally, we provide a complexity classification for the weighted problem.

2 - Solving Bulk-Robust Assignment Problems to Optimality
Speaker: Viktor Bindewald, KIT, DE, talk 1148
Co-Authors: *David Adjiashvili*, *Matthias Walter*, *Dennis Michaels*,
Given a biparite graph, edge costs, a list of failure edge sets and an integer k, the bulk-robust assignment problem asks for a minimum-cost edge set with the following property: after the deletion of any failure set from the list the remaining edges contain a matching of size at least k. A recent result is an approximation algorithm for the case where each failure set consists of a single edge and the goal is to obtain robust solution containing perfect matchings. The straight-forward integer programming model is rather large and not suitable for computations. In this talk we present an improved ILP model and discuss strong cutting planes as well as the associated separation problem. Preliminary computational results indicate effectiveness of the new model.

3 - Assignment Problems with few Failure Resources
Speaker: Felix Hommelsheim, TU Dortmund University, DE, talk 1344
Co-Authors: *David Adjiashvili*, *Viktor Bindewald*,
Many real-life planning problems require making a priori decisions before all parameters of the problem have been revealed. Uncertainty may arise in the availability of the

resources (structural-robustness) or in the cost functions of the problem (cost-robustness). The task is to compute solutions, which are cost-minimal and feasible in any scenario (structural-robustness) or cost-minimal in the worst case (cost-robustness). In this talk, we deal with four different structural-robust versions of the famous assignment problem. The focus is on the special case with only two scenarios, each consisting of one failure resource. It turns out that two of them are NP-hard, while the remaining two problems are solvable in polynomial time. Furthermore, we discuss the complexity of the cost-robust counterpart of assignment problems when only a constant number of resources are subject to uncertainty

4 - Distributionally Robust Chance-Constrained Binary Knapsack Problem
Speaker: Jaehyeon Ryu, KAIST, KR, talk 1215
Co-Authors: *Sungsoo Park*,
We consider the distributionally robust chance-constrained binary knapsack problem with the first- and second-order moments. Item weights of the problem are not certain, but assumed to be arbitrary independent random variables with a mean vector and a diagonal covariance matrix. The problem can be formulated as a zero-one integer second-order cone programming (SOCP) problem with one SOC constraint. The SOC constraint is equivalent to a robust constraint with an ellipsoidal uncertainty set. Both inner and outer approximations of the uncertainty set are derived from piecewise-linear approximations of a quadratic loss function, which measures the deviation of each uncertain item weight from its mean. An optimal solution of the problem with each approximate uncertainty set can be obtained by solving binary knapsack problems at most nm times, where n is the number of items and m is the number of linear segments of the piecewise-linear approximation. Computational results are presented to show efficiency and probability guarantees of our approach.

Exact Approaches for Vehicle Routing and Variants

Discrete Optimization & Integer Programming
IPpractice - We 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Invited Session 288
Organizer: Ricardo Fukasawa, Ricardo, CA

1 - The Capacitated Vehicle Routing Problem with Stochastic Demands
Speaker: Ricardo Fukasawa, Ricardo, CA, talk 1365
Co-Authors: *Jim Luedtke*, *Fernando Santos*,
The capacitated vehicle routing problem deals with finding the least cost way to serve customers using a fleet of vehicles with a certain capacity. In the version with stochastic demands, demands are random variables for which the value is only known after routes are planned (previous information like expectation and standard deviation are assumed to be known). The chance-constrained version of the problem (CCVRP) imposes that the set of feasible routes are those that the probability that a certain vehicle has its capacity exceeded is small. Recently, Dinh, Fukasawa and Luedtke proposed branch-and-cut and branch-and-cut-and-price approaches to solve the CCVRP that is able to deal with several important cases of distributions of the demands, like joint normal and scenario models. In this talk we will present recent developments that improves on those approaches.

2 - Efficient metaheuristic pricing in vehicle routing
Speaker: Claudio Contardo, ESG UQAM, CA, talk 925
Co-Authors: *Thibaut Vidal*, *Rafael Martinelli*,
We consider the pricing subproblem arising from branch-cut-and-price algorithms for vehicle routing. We provide an efficient implementation of local search operators that allows for a fast evaluation of local search neighborhoods. We show that, in addition to the regular features commonly found in vehicle routing problems such as capacities and time windows, pricing-specific features such as ng-routes or limited-memory subset-row inequalities can be also preprocessed in quadratic time and thus evaluated in constant time. Preliminary results will be provided to assess the quality of the operators.

3 - Exact Solution of a Class of Vehicle Scheduling Problems
Speaker: Rafael Martinelli, PUC-Rio, BR, talk 1459
Co-Authors: *Luciano Costa*, *Anand Subramanian*,
The Vehicle Scheduling Problem (VSP) consists of scheduling a fleet of vehicles to perform a set of activities. The objective of the problem may be to minimize fixed and/or variable costs, the number of vehicles used, the total completion time or a combination of them. Several different attributes can be considered based on real-life constraints, namely: multiple depots, heterogeneous fleet, time windows, vehicle's availability times, and maximum duration of routes, among others. The problem is directly related to many real-world applications that arise in the real-life, such as: urban bus scheduling, maintenance technicians, nurse scheduling, drillship scheduling in oil operations, etc. Due to its structure, the VSP is commonly modeled as a set partitioning/covering problem and later solved by means of Column Generation and Branch-and-Price algorithms. In this work, we propose a tailored Branch-and-Price approach to solve a class of VSP variants. When solving each problem, our pricing algorithm exploits the underlying structure of the graph over which each problem is defined. We present extensive computational experiments to assess the efficiency of the proposed methodology.

Problems in the intersection of machine learning and optimization

Specific Models, Algorithms, and Software
Learning - We 5:00pm-6:30pm, Format: 3x30 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Contributed Session 328
Chair: Ross Anderson, Google, US

1 - OptNet: End-to-End Differentiable Constrained Optimization
Speaker: Brandon Amos, Carnegie Mellon University, US, talk 50
Co-Authors: *J. Zico Kolter*,
Deep learning and end-to-end architectures provide a general and powerful way of implementing most modern machine learning tasks with a relatively small set of differentiable operations. These operations are usually simple affine operations composed with pointwise nonlinearities like the ReLU

or sigmoid function. While general and successful, the drawbacks of these operations are plentiful, as the resulting learned modules can be uninterpretable and difficult to inject domain-specific knowledge into. This talk presents OptNet, a new paradigm for deep learning that integrates the solution of optimization problems "into the loop." OptNet allows domain knowledge in the form of learnable constrained optimization problems to be integrated into larger end-to-end architectures. We will first discuss the new OptNet primitive operations in the form of learning the parameters of a constrained convex quadratic program from data. Then we will show applications of applying these primitive operations in non-convex stochastic optimization and control.

2 - Solving argmax for a neural network with MIP, and related optimization problems

Speaker: Ross Anderson, Google, US, talk 1381
Co-Authors: *Ondrej Sykora*,

A typical approach to optimize over variables with an unknown relationship observable only through data is to fit a model, e.g. linear regression, and then optimize over it. We show that if the fitted model is a neural network, the resulting optimization problem can be solved via MIP. We explore the relationship between network architecture, MIP formulation (including extended formulations) and computational tractability. We demonstrate the practicality of the method on problems from genomics, image processing, and ADP.

3 - Learning Fast Optimizers for Contextual Stochastic Integer Programs

Speaker: Vinod Nair, DeepMind, GB, talk 1262
Co-Authors: *Dvijotham Krishnamurthy*, *Iain Dunning*, *Oriol Vinyals*,

We present a novel reinforcement learning (RL) approach to learning a fast and highly scalable solver for a two-stage stochastic integer program in the large-scale data setting. Mixed integer programming solvers do not scale to large datasets for this problem class. Additionally, they solve each instance independently, without any knowledge transfer across instances. We address these limitations with a learnable local search solver that jointly learns two policies, one to generate an initial solution and another to iteratively improve it with local moves. The policies use contextual features for a problem instance as input, which enables learning across instances and generalization to new ones. We also propose learning a policy to compute a bound on the objective using dual decomposition. Benchmark results show that on test instances our approach rapidly achieves approximately 30 percent to 2000 percent better objective value, which a state of the art integer programming solver (SCIP) requires more than an order of magnitude more running time to match.

Conjugate Gradient Methods

Continuous Optimization
NLP - We 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

Contributed Session 362
Chair: Giovanni Fasano, University Ca' Foscari, Venice, IT

1 - A New Diagonalizable Conjugate Gradient Method for Unconstrained Optimization

Speaker: Mehiddin Al-Baali, Sultan Qaboos University, OM, talk 653
Co-Authors: *Giovanni Fasano*, *Massimo Roma*, *Andrea Caliciott*,

The recent class of diagonalizable conjugate gradient (CG) methods for large-scale unconstrained optimization will be considered. A particular feature of this class will be used to obtain the global convergence property of the methods. Numerical results for a selection of the well-known CG methods with their modifications will be described. It will be shown that the proposed technique improves the performance of several CG algorithms substantially.

2 - Conjugate Direction Methods and Polarity for Quadratic Hypersurfaces

Speaker: Giovanni Fasano, University Ca' Foscari, Venice, IT, talk 1254
Co-Authors: *Raffaele Pesenti*,

We use results from polarity theory to recast several geometric properties of a family of optimization methods. Specifically, we consider the geometric properties of the Conjugate Gradient-based methods used for the solution of symmetric linear systems. We show that this approach allows to pursue different theoretical objectives. We provide a novel geometric perspective on the generation of conjugate directions. Initially we consider the case of positive definite systems, then we generalize our considerations to indefinite linear systems. In this latter context, we show how the geometric insight suggested by polarity theory can be exploited to study the possible degeneracy (pivot breakdown) of Conjugate Gradient-based methods. In particular, we use polarity to prove that the degeneracy of the standard Conjugate Gradient on nonsingular indefinite linear systems can occur only once during the execution of the method itself. Finally, we extend the perspective to study and to recast the class of Krylov-subspace methods known as Planar-CG methods.

3 - Non-linear conjugate gradient for vector optimization on Riemannian manifolds

Speaker: Luis Lucambio Perez, Univ. Federal Goiás, BR, talk 1278
Co-Authors: *Leandro Prudente*,

In this work, we propose non-linear conjugate gradient methods for finding critical points of vector-valued functions on Riemannian manifolds with respect to the partial order induced by a closed, convex and pointed cone with non-empty interior. No convexity assumption is made on the objectives. The concepts of Wolfe and Zoutendjik conditions are extended for this setting. In particular, we show that there exist intervals of stepsizes satisfying the Wolfe-type conditions. The convergence analysis covers the extensions of the Fletcher-Reeves, Conjugate Descent, Dai-Yuan, Polak-Ribi'ere-Polyak, and Hestenes-Stiefel parameters that retrieve the classical ones in the scalar minimization case. Under inexact line searches and without regular restarts, we prove that the sequences generated by the proposed methods find points that satisfy the first-order necessary condition for Pareto-optimality. Numerical experiments illustrating the practical behavior of the methods are presented.

Solvers and softwares

Invited Talks
INTERFACE - We 5:00pm-6:30pm, Format: 4x20 min

Room: SIGALAS Building: C, 2nd floor, Zone: 2

Contributed Session 390
Chair: François Clautiaux, Université de Bordeaux, FR

1 - Solving packing, routing and scheduling problems using LocalSolver
Speaker: Julien Darlay, LocalSolver, FR, talk 578
LocalSolver is a mathematical programming solver based on heuristics technics. Having modeled your optimization problem using common mathematical operators, LocalSolver provides you with high-quality solutions in short running times. Collection decisions have been introduced to LocalSolver formalism to simplify the modeling of some combinatorial problems. A Set in an unordered subset of integers from 0 to n-1 and can be used to model packing problems. A List is the ordered version of the Set and is useful to formulate routing problems. Constraints and objectives can be defined on collections by applying functions expressed with LocalSolver operators. The main advantage of these collections is to keep the number of variables linear in the input size instead of quadratic with the classical Boolean formulation. This presentation will show how this new kind of variables allows building very simple and effective models for several optimization problems, including routing and scheduling problems. Benchmarks on classical vehicle routing problem will be presented.

2 - Applied mixed integer programming: The why and how
Speaker: Pawel Lichocki, Google, PL, talk 1443
Mixed integer programming (MIP) is NP-hard, yet it has been successfully used to solve a plethora of combinatorial optimization problems in industry. Our goal is to shed light on this phenomenon of the 'unreasonable effectiveness of MIP' from a practitioner's perspective. We draw on several years of experience of applying MIP at Google and we share the lessons learnt. In particular, we focus on two questions. First, we explain why MIP is considered a worthy tool from an engineering standpoint. We show how the clarity and expressivity of a MIP model facilitates rapid development and eases the maintenance of the code. To this end, we present multiple examples inspired by real-life applications of MIP at Google, focusing mainly on packing and assignment like problems. Second, we discuss the main challenges of using MIP in practice, and we show the ways to address them. It turns out that the NP-hardness of proving the optimality is rarely an actual concern, in contrast to: input data quality, careful design of an optimization model, and its integration with the engineered system. Along the way, we discuss the art of crafting large-scale MIP models by sharing several useful tricks that work well in practice, such as greedy model's decomposition and symmetry breaking by means of variable grouping. Overall, we hope to present compelling evidence that the time is ripe to consider MIP as an indispensable tool of a today's software developer.

3 - Solving MIPs with Gurobi Instant Cloud
Speaker: Robert Luce, Gurobi, DE, talk 714
Co-Authors: *Michel Jaczynski*, *Edward Rothberg*,
Gurobi Instant Cloud is an easy to use cloud service to solve mixed integer optimization problems. Except for setting a few parameters, using Gurobi Instant Cloud is transparent from a user application point of view, and all of Gurobi's APIs support cloud access. In this talk we walk through the most important concepts and usage patterns. A central design challenge is the dynamic allocation of computing resources to submitted jobs. We discuss our concept of "pools", differentiated by specific needs (large/small problems, development/deployment etc.), to which user applications submit jobs over HTTPS. In our scheme each pool has associated with it a set of machines which execute the submitted jobs. Pools can be instantly scaled up or down through a web application, by dynamically adding or removing machines in the pool. The application further supports monitoring and controlling the job queue, accessing job history, and gaining detailed job information through a dashboard. We also show how to manage jobs, pools and machines through a RESTful API, which allows you to create custom, automatic cloud environment control.

4 - Creating an optimization web app with FICO Xpress
Speaker: Johannes Müller, FICO Xpress Optimization, DE, talk 977
Co-Authors: *Susanne Heipcke*, *Yves Colombani*,
FICO Xpress Mosel is an algebraic modeling and programming language for solving optimization problems, such as mixed-integer, non-linear, and constraint programming problems. It has recently been made freely available (Xpress Community License) and it is now also possible to use third party solvers from the language in addition to the Xpress Solvers. The Mosel language has interfaces to analytic tools and languages such as R and Python, it supports parallel and distributed computing, and comes with a host of data connectors. Mosel applications find increasing use in large-scale cloud projects, including from non-optimization users. A prominent example is the recently released FICO Decision Optimizer 7 that has been fully re-implemented with Mosel. In this talk, we give a brief overview of the Xpress Optimization stack and show how you can turn your optimization model into a multi-user web application without any need for being an expert in web development. Creating such a web application merely requires some annotation markup in the Mosel model and configuration via additional XML files.

Resource-constrained assignment and scheduling

Specific Models, Algorithms, and Software Sciences - We 5:00pm-6:30pm, Format: 3x30 min
Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 398
Organizer: Fabian Bastin, Université de Montréal, CA

1 - A novel formulation for job-shop scheduling in traffic management
Speaker: Giorgio Sartor, SINTEF, NO, talk 213
Co-Authors: *Carlo Mannino*,
A central problem in traffic management is that of scheduling the movements of vehicles so as to minimize the cost of the schedule. This problem can be modeled as a job-shop scheduling problem. We present a new MILP formulation which is alternative to classical approaches such as big-M and time-indexed formulations. It does not make use of artificially large coefficients and its constraints correspond to basic graph structures, namely paths, cycles and trees. The

new formulation can be obtained by strengthening and lifting the constraints of a classical Benders' reformulation. We successfully tested our approach on real-life instances of two relevant traffic management problems: the Hotspot Problem, which consists of rescheduling flight trajectories to prevent congested airborne sectors while minimizing overall delay; and train dispatching, which consists of rescheduling the movements of rolling stocks in railway lines, typically due to delays or disruptions.

2 - Improving local search for distributed resource allocation and equilibrium.

Speaker: Vipin Vijayalakshmi, RWTH Aachen University, DE, talk 1044

Co-Authors: *Alexander Skopalik*,

Congestion games constitute an important class of games to model resource allocation by different users such as in traffic networks. We study the approximation ratio of local optima in these games. However, we allow for that the cost functions used during the local search procedure may be different from the overall objective function. Our analysis exhibits an interesting method to choose these cost functions to obtain the following results: 1. As computing an exact or even approximate pure Nash equilibrium is in general PLS-complete, Caragiannis et al. [FOCS 2011] presented a polynomial-time algorithm that computes $(2+\epsilon)$-approximate pure Nash equilibria for games with linear cost functions and further results for polynomial cost functions. We show that this factor can be improved to $1.67+\epsilon$ by a seemingly simple modification of their algorithm using our technique. 2. Bilo and Vinci [EC 2016] presented an algorithm to compute load dependent taxes that improve the price of anarchy e.g. for linear game from 2.5 to 2. Our methods yield slightly weaker results, e.g., 2.1 for linear games. However, our tax functions are locally computable and independent of the actually instance of the game.

3 - A learning-based approach for multi-skill staffing optimization in call centers

Speaker: Fabian Bastin, Université de Montréal, CA, talk 1204

Co-Authors: *Tien Mai*, *Thuy Anh Ta*, *Pierre L'Ecuyer*,

We study a staffing problem in multi-skill call centers. The objective is to minimize the total cost of agents early optimal under some probability constraints defined over the randomness of the service level in a given time period. We formulate and solve a sample average approximation (SAA) version of the problem, where the probability functions in the constraints are expressed as functions of the staffing for a fixed sequence of random numbers driving the simulation. There are several challenges lying in solving this problem, namely, the non-linearity of the constraints, the noisiness of simulation, and the complication of large instances. We propose a nonlinear regression approach to approximate the probability functions, and design a learning-based algorithm to efficiently find staffing solutions. Our algorithm performs three steps in an iterative manner, namely, a simulation step to generate probability values given each candidate staffing solution , a learning step to learn the shape of the probability functions, and the third step concerns solving an integer linear program to obtain new staffing solutions. We test our algorithm with data sets collected from real-life call centers, and we show that our approach returns better solutions in shorter computational times, compared to existing approaches in the literature.

Linear Optimization II

Continuous Optimization

NLP - We 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 9 Building: N, 4th floor, Zone: 12

Contributed Session 416

Chair: Julian Hall, University of Edinburgh, GB

1 - Starting the dual revised simplex method from an advanced basis

Speaker: Julian Hall, University of Edinburgh, GB, talk 1478

Co-Authors: *Ivet Galabova*,

When the dual revised simplex method for linear programming (LP) problems is started from a basis of slack variables, it is typically accelerated by the use of steepest edge weights on the primal infeasibilities. Crash techniques for the simplex method attempt to find a non-slack basis so that the overall time required to solve the LP problem is reduced, and are popular when using the primal revised simplex method. In the context of the high performance linear optimization solver HiGHS, this talk will discuss several crash procedures for the dual revised simplex method, their consequences for steepest edge strategies, and the overall effect on solution time. When solving MIP problems using branch-and-bound, the dual simplex method is started from the optimal basis of an LP relaxation. Techniques for computing (approximate) steepest edge weights in this case will be explored.

2 - On the number of simplex iterations of the steepest-edge for a nondegenerate LP

Speaker: Masaya Tano, Tokyo Univ. of Agri. and Tech., JP, talk 975

Co-Authors: *Ryuhei Miyashiro*, *Tomonari Kitahara*,

In this talk, we propose a p-norm rule as a pivoting rule for the simplex method and analyze the number of simplex iterations with the p-norm rule. The p-norm rule is generalization of the steepest-edge rule and coincides with the steepest-edge rule when $p = 2$. For a nondegenerate linear programming problem, we show two upper bounds for the number of iterations of the simplex method with the p-norm rule. One of the upper bounds is expressed as $(n-m)\left\lceil m^{(p+1)/p} \cdot \frac{\gamma^2}{\delta^2} \log\left(\frac{m\gamma}{\delta}\right)\right\rceil$, where m is the number of constraints in a given nondegenerate LP, n is that of variables, and γ and δ are the maximum and minimum positive elements in all basic feasible solutions of the LP, respectively.

3 - New Results on the Simplex Method for Minimum Cost Flows in Infinite Networks

Speaker: Marina Epelman, University of Michigan, US, talk 1429

Co-Authors: *Chris Ryan*, *Robert Smith*,

We provide a simplex algorithm for a class of uncapacitated countably infinite network flow problems. Previous efforts to develop simplex algorithms for countably infinite network flow problems required explicit capacities on arcs with uniformity properties to facilitate duality arguments. In contrast, our method takes a "primal approach" by devising a simplex method that produces iterates that converge in optimal value without relying on duality arguments and facilitates the removal of explicit capacity bounds. Instead, our approach leverages a compactness assumption on the set of simplex iterates. This assumption holds in a variety of applications that do not admit a model with explicit capacity constraints, including infinite-horizon production planning, nonstationary infinite-horizon dynamic programming, and all-to-infinity shortest path problems. We also discuss implementation details of the algorithm, with the goal of obtaining convergent sequences of simplex iterates and finitely-implementable pivot operations — thus making the algorithm practical in applied settings.

Connectivity problems and Steiner trees

Discrete Optimization & Integer Programming
COMB - We 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 41 Building: C, 3rd floor, Zone: 1

Contributed Session 421
Chair: Andreas Feldmann, Charles University, CZ

1 - Computing minimum 2-connected Steiner networks in the Euclidean plane

Speaker: Marcus Brazil, University of Melbourne, AU, talk 806
Co-Authors: *Martin Zachariasen*, *Marcus Volz*,
The 2-connected Steiner network problem asks us to find a network N of minimum possible length that is 2-connected, and spans a given finite set of points (known as terminals) with specified locations in the Euclidean plane. The network N may contain additional nodes other than the terminals in order to minimise the network length. The term '2-connected' here is short for 2-edge-connected, meaning that there are at least two edge-disjoint paths in N between every pair of nodes. Here we present a new exact algorithm for solving the 2-connected Steiner network problem in the Euclidean plane. The algorithm uses the GeoSteiner framework for computing minimum Steiner trees in the plane, which is based on generating candidate optimal sub-networks, known as full Steiner trees (FSTs), and then finding a minimum-length 2-connected union of these FSTs that spans the terminals. Several new geometric and topological properties of minimum 2-connected Steiner networks are developed and incorporated into the new algorithm. The previous leading existing exact algorithm is only able to solve instances with up to about 25 terminals. Our computational results show that for random problem instances with 25 terminals, the new algorithm provides an average reduction of 93 percent in the number of FSTs generated and an average reduction of 77 percent to the CPU time, compared to the previous algorithm. The new algorithm can reliably compute exact solutions to instances with up to 50 terminals — doubling the range of existing exact algorithms.

2 - Enumerating All Spanning Subgraphs with Edge-Connectivity at Least k

Speaker: Yasuko Matsui, Tokai University, JP, talk 1009
Co-Authors: *Katsuhisa Yamanaka*, *Shin-ichi Nakano*,
In this talk, we consider the problem of enumerating spanning subgraphs with high edge-connectivity of an input graph. Such subgraphs ensure multiple routes between two vertices. We first present an algorithm that enumerates all the 2-edge-connected spanning subgraphs of a given plane graph with n vertices. The algorithm generates each 2-edge-connected spanning subgraph of the input graph in O(n) time by using reverse search method by Avis and Fukuda. We next present an algorithm that enumerates all the k-edge-connected spanning subgraphs of a given general graph with m edges. The algorithm generates each k-edge-connected spanning subgraph of the input graph in O(mT) time, where T is the running time to check the k-edge-connectivity of a graph. From the result by Nagamochi and Ibaraki, it can be observed that T = $O(m + \min\{kn^2, nm + n^2 \log n\})$ holds.

3 - The variable-cost node-weighted Steiner tree problem in the Euclidean plane.

Speaker: Mark Turner, Zuse Institute Berlin, DE, talk 498
Co-Authors: *Charl Ras*,
In this talk we present a natural extension of the Euclidean Steiner tree problem, the variable-cost node-weighted Steiner tree problem. We establish and prove structural properties of the proposed variant. Furthermore, we define a generalisable neighbourhood structure that can be readily applied to local search techniques. We explore the benefits of the Delaunay triangulation when considered in the context of Steiner tree applications. Greedy local search and Tabu search metaheuristics are proposed that utilise the defined neighbourhood structure and Delaunay triangulation. Finally, we perform extensive computational experiments on both meta-heuristics with randomly generated instances.

4 - Parameterized Approximation Algorithms for Bidirected Steiner Network Problems

Speaker: Andreas Feldmann, Charles University, CZ, talk 420
Co-Authors: *Rajesh Chtinis*, *Pasin Manurangsi*,
The Directed Steiner Network (DSN) problem takes as input a directed edge-weighted graph $G = (V, E)$ and a set $D \subseteq V \times V$ of k demand pairs. The aim is to compute the cheapest network $N \subseteq G$ for which there is an $s \to t$ path for each $(s, t) \in D$. It is known that this problem is notoriously hard as there is no $k^{1/4-o(1)}$-approximation algorithm under Gap-ETH, even when parametrizing the runtime by k [Dinur and Manurangsi, ITCS 2018]. In light of this, we systematically study several special cases of DSN and determine their parameterized approximability for the parameter k. For the bi-DSN-Planar problem, the aim is to compute a planar optimum solution $N \subseteq G$ in a bidirected graph G, i.e., for every edge uv of G the reverse edge vu exists and has the same weight. This problem is a generalization of several well-studied special cases. Our main result is that this problem admits a parameterized approximation scheme (PAS) for k. We also prove that our result is tight in the sense that (a) the runtime of our PAS cannot be significantly improved, and (b) it is unlikely that a PAS exists for any generalization of bi-DSN-Planar, unless FPT=W[1]. Additionally we study several generalizations of bi-DSN-Planar and obtain upper and lower bounds on obtainable runtimes parameterized by k.

Shortest paths and cutting stock

Discrete Optimization & Integer Programming
COMB - We 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Contributed Session 426
Chair: Arnaud Vandaele, University of Mons, BE

1 - Cost Projection Methods for the Shortest Path Prob-

lem with Crossing Costs
Speaker: Pedro de las Casas, ZIB, DE, talk 1310
Co-Authors: *Ralf Borndörfer*, *Marco Blanco*, *Nam Dung Hoang*,
Real world routing problems, e.g., in the airline industry or in public and rail transit, can feature complex non-linear cost functions. An important case are costs for crossing regions, such as countries or fare zones. We introduce the Shortest Path Problem with Crossing Costs (SPPCC) to address such situations; it generalizes the classical Shortest Path Problem and variants such as the Resource Constrained Shortest Path Problem and the Minimum Label Path Problem. Motivated by an application in flight trajectory optimization with overflight costs, we focus on the case in which the crossing costs of a region depend only on the nodes used to enter or exit it. We propose an exact Two-Layer-Dijkstra Algorithm as well as a novel cost-projection linearization technique that approximates crossing costs by shadow costs on individual arcs, thus reducing the SPPCC to a standard Shortest Path Problem. We evaluate all algorithms' performance on real-world flight trajectory optimization instances, obtaining very good a posteriori error bounds.

2 - Solving the Time-Dependent Shortest Path Problem using Super-Optimal Wind
Speaker: Adam Schienle, Zuse Institute Berlin, DE, talk 1277
Co-Authors: *Ralf Borndörfer*, *Marco Blanco*, *Nam Dung Hoang*,
In the Horizontal Flight Trajectory Optimisation Problem (HFTOP), one has to find a cost-minimal aircraft trajectory between to airports on the Airway Network, a directed graph. We distinguish three cases: a static one without wind, and two cases where we regard wind as a function of time. This allows us to model HFTOP as a Shortest Path Problem in the first case and a Time-Dependent Shortest Path Problem in the latter cases. In the static case, we show that A* guided by a great-circle-distance potential yields speedups competitive to those of Contraction Hierarchies. In the time-dependent version, we study two different modelling approaches. Firstly, we compute the exact costs for the time on the arcs. In a second version, we use piecewise linear functions as the travel time. For both versions, we design problem-specific potential functions for the A* algorithm. As the exact costs are non-linear, we introduce the notion of Super-Optimal Wind to underestimate the travel time on the arcs, and show that Super-Optimal Wind yields a good underestimation in theory and an excellent approximation in practice. Moreover, we compare the runtimes of the time dependent versions of Dijkstra's Algorithm, A* and Time-dependent Contraction Hierarchies (TCHs) in the PWL case, showing that A* outperforms Dijkstra's Algorithm by a factor of 25 and TCHs by a factor of more than 16. For the exact case, we compare Dijkstra's Algorithm to A* and show that using Super-Optimal Wind to guide the search leads to an average speedup of 20.

3 - Earliest Arrival Transshipments in Networks With Multiple Sinks
Speaker: Miriam Schlöter, TU Berlin, DE, talk 678
We study a classical flow over time problem that captures the essence of evacuation planning: Given a network with capacities and transit times on the arcs and sources/sinks with supplies/demands, an earliest arrival transshipment (EAT) sends the supplies from the sources to the sinks such that the amount of flow which has reached the sinks is maximized for every point in time simultaneously. So far, a lot of effort has been put into the development of algorithms for computing EATs in networks with only a single sink, as in such networks EATs do always exist. Regarding EATs in networks with multiple sinks not much is known aside from the fact that in such networks EATs do in general not exist. In particular, no PSPACE algorithm for computing EATs in case of existence is known and also the complexity of deciding whether an EAT solving a given transshipment problem in a multiple sink network does exist is still unknown. This talk concentrates on our latest results regarding EATs in networks with multiple sinks: In particular, we formulate the first PSPACE algorithm that decides whether a given tight earliest arrival transshipment problem in a general network has solution and computes the EAT in case of existence. We show that in case of existence an earliest arrival transshipment can be determined as a convex combination of special flows over time while minimizing a suitably defined submodular function. Additionally, we settle the complexity question by showing that in multiple sink networks it is NP-hard to decide whether an EAT solving a given problem does exist.

4 - One-dimensional cutting stock instances for which few patterns are needed
Speaker: Arnaud Vandaele, University of Mons, BE, talk 1242
The Cutting Stock Problem (CSP) is one of the most famous combinatorial optimization problem. An instance of the 1-dimensional CSP consists of d items with different number of copies to cut from large master rolls. The goal is then to produce the required demands with the minimum possible number of master rolls. Each possible combination of items on a master roll is called a pattern. In general, there is an upper bound, exponential in d, for the number of different patterns needed in an optimal solution of a 1-d CSP instance. In this work, we study specific instances for which at most d patterns are needed at the optimum. For example, we study the special case where it is assumed that any k items fit into a pattern but no $k+1$ do. This particular case is easy to solve, but we show in this talk that there is an optimal solution using at most d different patterns.

Interior Point Methods in LP and NLP

Continuous Optimization
NLP - We 5:00pm-6:30pm, Format: 3x30 min
Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Contributed Session 430
Chair: Andre Tits, Univ of Maryland College Park, US

1 - Constraint-Reduced MPC for CQP, with a Modified Active Set Identification Scheme
Speaker: Andre Tits, Univ of Maryland College Park, US, talk 33
Co-Authors: *Paul Laiu*,
A constraint-reduced Mehrotra–Predictor–Corrector (MPC) algorithm for convex quadratic programming is proposed. (At each iteration, constraint-reduced algorithms use only a subset of the inequality constraints in constructing the search direction, resulting in CPU savings.) This algorithm makes use of a regularization scheme to cater to cases where the

reduced constraint matrix no longer has full rank. Global and local convergence properties are established under arbitrary working-set selection rules subject to satisfaction of a general condition. A modified active-set identification scheme that fulfills this condition is also introduced. Numerical tests show great promise for the proposed algorithm, in particular for its active-set identification scheme.

2 - An IPM approach for a time dependent large-scale assortment allocation problem

Speaker: Thiane Coliboro, State University of Campinas, BR, talk 1366

Co-Authors: *Aurelio Oliveira*, *Felipe Silva*, *Márcio Oshiro*,

In this work, an assortment allocation problem from a Brazilian e-commerce company is introduced. The aim of this model is to assign appropriately the products in different storage centers while minimizing the cost and determine the amount of merchandise that must moved among centers. The main features of the model are the large number of products to be stored, the many possible destination for sales with their different demand, and the requirement to solve the problem simultaneously for different periods of time. It is a large-scale problem with millions of variables, even in simplified instances. In essence, it is a mixed integer linear programming problem. However, due to the difficulty to solve such large-scale problems, a linear programming model is taken as a suitable approach. The theoretical features of the model and the changes performed to improve it are shown. An approach based on iterative methods and hybrid preconditioning is presented. Two classes of preconditioners are discussed, indicating how they can be combined effectively to solve the linear systems that arises at each iteration of the Interior Point Method (IPM). The contributions of this work is the application in a real problem of a method which have shown to be well suited for classes of large-scale test problems. Concerning the company, the gain comes through minimization costs. Numerical experiments are performed and preliminary results are presented, comparing the number of iterations, quality of the solution and running time.

3 - Local analysis of a primal-dual method for NLP without constraint qualification

Speaker: Ngoc Nguyen Tran, University of Limoges, FR, talk 569

Co-Authors: *Paul Armand*,

In nonlinear optimization, the lack of the Mangasarian-Fromovits constraint qualification (MFCQ) may lead to numerical difficulties and in particular to slow down the convergence of an optimization algorithm. In this talk we analyse the local behavior of an algorithm based on a mixed logarithmic barrier-augmented Lagrangian method for solving a nonlinear optimization problem. This work has been motivated by the good efficiency and robustness of this algorithm, even in the degenerate case in which MFCQ does not hold. Furthermore, we detail different updating rules of the parameters of the algorithm to obtain a rapid (superlinear or quadratic) rate of convergence of the sequence of iterates. The local convergence analysis is done by using a stability theorem of Hager and Gowda, as well as a property of uniform boundedness of the inverse of the regularized Jacobian matrix used in the primal-dual method. Numerical results on degenerate problems are also presented.

Location and Routing

Specific Models, Algorithms, and Software

Logistics - We 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 24 Building: G, 3rd floor, Zone: 6

Contributed Session 451

Chair: Mustapha Oudani, UIR, MA

1 - Stochastic Two-echelon Location-Routing

Speaker: Imen Ben Mohamed, IMB, FR, talk 1603

Co-Authors: *Francois Vanderbeck*, *Walid Klibi*,

In the two-echelon location-routing problem, one has to decide on the number and the location of primary warehouses as well as intermediate distribution platforms; while fixing the capacity of the links between them. The system must be dimensioned to enable an efficient distribution of goods to customers under a stochastic and multi-period demand over a planning horizon. I.e., in the second echelon, the planning prescribes vehicle routes that visit ship-to-points from selected distribution platforms, minimizing the total expected transportation cost. For this two-stage stochastic program with recourse, we developed a Primal-Dual approach. We combine a Benders decomposition where the first stage are the location and capacity decisions, with a Branch-and-Price algorithm to tackle the second stage routing problem. Our preliminary computational study illustrates the tight optimality gaps that can be obtained on realistic instances.

2 - Benders decomposition for a hierarchical facility location problem

Speaker: Rasul Esmaeilbeigi, The University of Newcastle, AU, talk 1000

Co-Authors: *Richard Middleton*, *Rodolfo Garcia-Flores*,

We consider a special case of the hierarchical facility location problem in which demand must be satisfied through two levels of facilities. This research is motivated by a whey recovery network design problem. Whey is a by-product of cheese production that should be processed due to economical and/or competitive advantages. We assume that demand (the amount of raw whey) for each location is a random variable. We formulate the problem as a two-stage stochastic program, where location-allocation decisions are made at two sequential stages. We consider the sample average approximation method to approximate the expected value function. To solve the problem efficiently, we propose an accelerated Benders decomposition approach. Computational results on a set of randomly generated instances will also be reported.

3 - Benders Decomposition for Uncertain Hub Location with Variable Allocation

Speaker: Nicolas Kämmerling, TU Dortmund University, DE, talk 1224

Co-Authors: *Borzou Rostami*,

The design of hub-and-spoke transport networks is a strategic planning problem as the choice of hub locations has to remain unchanged for long time periods. However, the future transport volumes and transport costs are not known in advance and can only be estimated by a stochastic distribution during the planning process whereas classical models for hub location problems assume fixed input data. Moreover, carriers observe significant fluctuation in demand and costs over time. Therefore, it is important to include uncertainty in hub locations problems. In this talk we develop a two-stage stochastic optimization formulation for single allocation hub location problems where the allocations to the hubs are viewed as variable over time. This allows to modify the routing in the hub-and-spoke transport network according to the current scenario, but also blows up the number of variables in the model and, thus, makes the problem much harder to solve. In order to solve large-scale instances to proven optimality, the problem is decomposed into scenario-specific subproblem which are interlinked by generalized Benders cuts for a common choice of hub locations. The decomposition also allows us to dissolve the inherent quadratic structure of the classical formulation of single allocation hub location problems. Embedded into a modern mixed-integer solver our decomposition approach is able to solve large instances under uncertainty in the input data.

4 - The Incomplete Hub Location and Routing Problem
Speaker: Mustapha Oudani, UIR, MA, talk 1143
Co-Authors: *Kenza Oufaska*,
Hub Location Problems are well-studied problems. They have many important applications especially in air transportation, telecommunications and postal networks. In this study, we introduce the Incomplete Hub Location and Routing Problem (IHLRP). The problem contains three interdependent decisions: the first one concerns hubs location, the second related to how to allocate non-hubs (spokes) nodes to hubs and the third concerns which vehicles to use to satisfy customers requests. Unlike the classical hub location problems where the inter-hubs graph must be complete, the studied problem has the particularity to allow the induced graph by the located hubs to be incomplete. Furthermore, the supplementary routing decision makes the problem more realistic but more constrained and therefore more difficult to solve. The problem is modeled as a linear integer program. Small and medium instances are solved to optimality using CPLEX solver. We used heuristics methods to solve larger real-size instances of the problem due its NP-hardiness.

Production-Routing

Specific Models, Algorithms, and Software
Logistics - We 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 16 Building: I, 2nd floor, Zone: 7

Contributed Session 456
Chair: Feng Gao, Nanjing University of F and E, CN

1 - Models and Algorithms for Robust Production Routing Under Demand Uncertainty
Speaker: Feng Gao, Nanjing University of F and E, CN, talk 978
Co-Authors: *Panos Pardalos*,
This paper introduces a robust production routing problem (PRP) where a supplier produces and distributes a single product to multiple customers facing dynamic uncertain demands over a finite discrete time horizon. The probability distribution of the uncertain demand at each customer is unknown. The only available information is that these uncertain demands are independent and can take some value from their support interval. The supplier is responsible for production lot-sizing, and distributes the product using a capacitated vehicle to replenish the customers. Backlogging of the demand at customers is not allowed. The problem is to determine the production and delivery quantities as well as the times and routes to the customers, while ensuring feasibility regardless of the realized demands, and minimizing the total cost composed of production, transportation, inventory holding, and shortage costs. Using a robust optimization approach, we propose robust mixed integer programming formulations for the problem, based on a MIP formulation for the deterministic (nominal) case of the problem. We implement a branch-and-cut algorithm and report results on a set of instances adapted from the literature. The results show that robust production routing problem can produce very competitive solutions to those obtained by stochastic PRP with demand uncertainty in two-stage and multistage decision processes.

2 - Meta-Heuristics for Multi-Period Sales Districting Problem
Speaker: Saranthorn Phusingha, University of Edinburgh, GB, talk 1088
Co-Authors: *Joerg Kalcsics*,
In the sales districting problem, we are given a set of customers and a set of salesmen in some area. The customers are given as points distributed across the area and the salesmen have to provide services at the customers' locations to satisfy their requirements. The task is to allocate each customer to one salesman. This partitions the set of customers into subsets, called districts. Each district is expected to have approximately equal workload and travelling time for each salesman to promote fairness among them, and the overall travelling distance should be minimal for economic reasons. We now extend this problem to be more realistic by considering that each customer requires recurring services with different visiting frequencies like every week or two weeks during the planning horizon. This problem is called the 'Multi-Period Sales Districting Problem'. In addition to determining the sales districts, we also want to get the weekly visiting schedule for the salesmen such that the weekly travelling distances are minimal and the workload and travelling time are balanced each week. Although the problem is very practical, it has been studied just recently. In this talk, we focus on the scheduling problem for one sales representative in a specific district, which is already an NP-hard problem. We start by presenting a mixed integer linear programming formulation for the problem. As only small data sets can be solved optimally, we are currently developing a meta-heuristics to solve larger instances. We will present numerical experiments comparing both approaches.

3 - Models and Algorithms for Stochastic and Robust Production Routing with Time Win
Speaker: Yuzhuo Qiu, Nanjing University of F and E, CN, talk 979
Co-Authors: *Panos Pardalos*,
We consider the production routing problem with time windows under travel time uncertainty in the contexts of stochastic and robust optimization. The problem is defined on a directed graph where a supplier produces and distributes a single product to multiple customers with time windows requirement. In the stochastic production routing problem with time windows (SPRP-TW), the probability distribution of the travel times is known, and the objective of the problem is to minimize the sum of probability of time windows violations. In the robust production routing problem with time windows (RPRP-TW), however, the exact probability distribution is unknown but belongs to a certain family of distributions. The RPRP-TW is solved to optimize a performance measure,

which represents the risk of violating the time windows. The size of the problem that can be solved is usually relatively small. We develop an algorithm based on a branch-and-cut framework to solve the problems. The experiments show that the algorithm provides computational efficiency when solving practical problems. Finally, we computationally evaluate the solution quality of the SPRP-TW and the RPRP-TW. The results show that the RPRP-TW can produce very competitive solutions to those obtained by the SPRP-TW with many scenarios, whereas much less sensitive to the distributional uncertainty.

Completely Positive Cones and Applications

CONTINUOUS OPTIMIZATION
SDP - We 5:00pm-6:30pm, Format: 4x20 min
Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

CONTRIBUTED SESSION 464
Chair: Patrick Groetzner, University of Trier, DE

1 - Approximation Hierarchies for Copositive and Completely Positive Tensor Cones
Speaker: Muhammad Iqbal, Faisal, PK, talk 1418
Co-Authors: *Faizan Ahmed*,
In this article, we consider different approximation hierarchies for the Copositive and Completely Positive tensor cones. Since the Copositive cone and its dual are not tractable, we propose different inner and outer approximation hierarchies based on couple of approaches, such as; discretization methods and sum-of-squares conditions. The inclusion relations among the inner and outer approximation hierarchies are discussed. Moreover, it has been established that, both the sequences of inner and outer approximations are exact in the limiting case.

2 - Inner approximating the completely positive cone via the cone of SDD matrices
Speaker: Mina Saee Bostanabad, University of Coimbra, PT, talk 756
Co-Authors: *João Gouveia*, *Ting Kei Pong*,
Motivated by the expressive power of completely positive programming and its dual, copositive programming, to encode hard optimization problems, many approximation schemes for the completely positive and copositive cones have been proposed and successfully used. For the completely positive cone, the most common approach is to build outer approximations, with the only inner approximations available being an LP method proposed by Bundfuss and Dur, and an SDP method proposed by Lasserre. We propose the use of the cone of nonnegative scaled diagonally dominant (SDD) matrices as a natural inner approximation to the completely positive cone. Using projections of this cone we derive new graph-based second order cone approximation schemes for completely positive and copositive programming, leading to both uniform and problem dependent hierarchies. This offers a compromise between the expressive power of semidefinite programming and the speed of LP approaches. Furthermore, the approach is versatile and liable to be adapted in other contexts and schemes.

3 - Solving nonlinear conic programming problems with a new DC approach
Speaker: Ellen Fukuda, Kyoto University, JP, talk 1060
Co-Authors: *Ichiro Isonishi*, *Nobuo Yamashita*,
Nonlinear conic optimization (NCP) problems generalize some well-known problems: nonlinear programming, nonlinear second-order cone programming and nonlinear semidefinite programming. In this work, we consider a difference of convex (DC) approach to solve NCP problems with convex objective functions. Each iteration of the method consists in solving a subproblem, with constraints written as a difference of two convex functions. We linearize the second term, making the constraints to be convex. We also add a regularization term into the objective function. This technique is similar to the one proposed by Dihn et al. (2012), for semidefinite optimization, in particular, with bilinear matrix inequality constraints. The difference, besides the extension of the optimization model, is that the DC decomposition and the regularization parameter can be changed at each iteration. Here, we show the global convergence of this new DC method. Moreover, we present numerical experiments with particular optimization problems, showing that non-fixed decompositions and regularizations can be a good idea.

4 - A method to compute factorizations for completely positive matrices
Speaker: Patrick Groetzner, University of Trier, DE, talk 141
Co-Authors: *Mirjam Duer*,
A matrix A is called completely positive, if there exists an entrywise nonnegative matrix B such that $A = BB^T$. These matrices play a major role in combinatorial and quadratic optimization. To prove membership to the completely positive cone is known to be NP hard. In this talk I will show a factorization algorithm which, for a given completely positive matrix A, computes the nonnegative factorization. This factorization problem can be formulated as a nonconvex feasibility problem and solved by a method which is based on alternating projections. A local convergence result can be shown for this algorithm. Additionally I will provide a heuristic extension which improves the numerical performance of the algorithm. Extensive numerical tests show that the factorization method is very fast in most instances.

Large-scale convex optimization

SPECIFIC MODELS, ALGORITHMS, AND SOFTWARE
LEARNING - We 5:00pm-6:00pm, Format: 2x20 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

CONTRIBUTED SESSION 479
Chair: Alexander Rogozin, MIPT, RU

1 - Optimal distributed convex optimization on slowly time-varying graphs
Speaker: Alexander Rogozin, MIPT, RU, talk 844
Co-Authors: *Alexander Gasnikov*, *Cesar Uribe*, *Nikolay Malkovsky*, *Angelia Nedich*,
We study the behaviour of several first-order optimization algorithms in case when the aim function changes from one iteration to another, but its point of minimum and optimal value remain the same. This problem statement is connected

to the time-varying graph. Consider a minimization problem

$$\varphi(y) = \sum_{i=1}^{n} \varphi_i(y) \longrightarrow \min_{y \in \mathbb{R}}$$

Since functional φ is separable, this problem will be solved on a network of computers, which is an undirected connected graph with incidence matrix I. The problem can be rewritten as

$$\sum_{i=1}^{n} \varphi_i(y_i) \longrightarrow \min_{y_1=\ldots=y_n}, \; y_i \in \mathbb{R}$$

Further reformulation includes gossip matrix W:

$$W_{ij} = \begin{cases} -I_{ij}, i \neq j \\ \sum_{k=1}^{n} I_{ik}, \; i = j \end{cases}$$

It can be shown that $Wy = 0 \Leftrightarrow y_1 = \ldots = y_n$. The initial problem rewrites as

$$\varphi(y) = \sum_{i=1}^{n} \varphi_i(y_i) \longrightarrow \min_{Wy=0}$$

Distributed algorithms work with the dual function:

$$f(x) = \max_{y \in \mathbb{R}^n} [-\varphi(y) - \langle y, Wx \rangle] \to \min_{x \in \mathbb{R}^n}$$

Suppose the network topology changes due to technical malfunctions. Then the incidence matrix I, and therefore the gossip matrix W and the dual function f change as well. Consequently, a distributed method faces sudden aim function changes. As a result, we prove linear convergence for gradient descent and Nesterov accelerated method in case when the aim function is L-smooth, μ-strongly convex and has a finite number of changes.

2 - Leverage data structure to improve Stochastic Gradient Descent algorithm

Speaker: Tommaso Colombo, Sapienza University of Rome, IT, talk 1110

Co-Authors: *Alberto De Santis*, *Stefano Lucidi*,

In this talk we present a novel analysis on how data structure may influence the well-known Stochastic Gradient Descent iteration. In particular, we show how leveraging similarities between clusters of input data points may guide the algorithm in the choice of search directions. We further propose a suitable scheme to choose such search directions allowing for a more accurate and robust convergence of the iterates to the solution of the Finite Sums Problem.

Stochastic optimization models and applications

Optimization under Uncertainty

Stoch - We 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Contributed Session 495

Chair: F.-Javier Heredia, UPC, ES

1 - Design optimization under uncertainty

Speaker: Geoffrey Oxberry, Lawrence Livermore Laboratory, US, talk 1500

Traditional approaches to formulating stochastic design optimization problems for additive manufacturing tend to use linear combinations of the mean and standard deviation of a design figure of merit (e.g., compliance). However, this choice of objective/constraint underweights tail events for non-normal random variables. We propose replacing these mean-plus-standard-deviation expressions with the conditional value-at-risk (CVaR), and argue that it better compensates for worst-case tail events. We also investigate computing risk measures using polynomial chaos expansions and compare that approach to direct computation of risk measures using quadrature. Depending on the risk measure and application, the objective or constraints of a stochastic design optimization formulation and their derivatives can be expensive to evaluate because their evaluation may require solving one or more partial differential equations at each quadrature point in probability space. To mitigate the expense of these function and gradient evaluations, we discuss algorithmic specializations to improve performance and expose efficient parallelism while preserving numerical stability.

2 - Optimal non-anticipative scenarios for nonlinear hydrothermal power systems

Speaker: Gislaine Pericaro, UNESPAR, BR, talk 734

Co-Authors: *Elizabeth Karas*, *Clovis Gonzaga*,

Electrical energy in Brazil is generated by an interconnected system, composed of over 100 hydro plants complemented by over 50 thermal power plants, distributed in 5 interconnected sub-systems. Monthly inflow scenarios are generated based on 80 years of historical data. Deterministic problem: for a given scenario (typically 60 months), a non-linear programming Filter algorithm with sequential quadratic iterates computes an optimal scenario, i.e, a solution to the operation planning problem with minimum cost of thermal generation and deficit. This is a large scale problem with non-linear constraints due to the effects of head variation on the productivity of hydro plants. Stochastic problem: Given a set of scenarios, a cloud of optimal solutions is the corresponding set of optimal scenarios. A non-anticipative solution for the first stage is obtained by minimizing the expected value of the scenario costs with the extra constraint that the first hydro decision for the reservoir plants must be identical for all scenarios. This is now a larger problem. For small problems, it may be solved directly by the Filter algorithm; for larger problems a decomposition algorithm like Progressive Hedging should be used. A non-anticipative optimal scenario associated with a given hydrological scenario is obtained by sequential iterations of this procedure. In this talk we show solutions for a small system and compare them to other approaches.

3 - A Generalized Risk Parity Model with Application for Hazmat Transportation

Speaker: Alexander Vinel, Auburn University, US, talk 1055

Co-Authors: *Nasrin Mohabbati*,

The concept of Risk Parity (or Equal Risk Contribution) has recently attracted a considerable attention in the area of financial portfolio management. This approach is aimed at explicitly enforcing diversification in the portfolio by ensuring that each asset is equally contributing to the total volatility. In this paper, we consider Risk Parity idea in conjunction with modern risk-averse stochastic optimization (namely coherent measures of risk), study a generalized RP model and propose a combined two stage diversification-risk framework. We then illustrate how this framework can be naturally applied for modelling for transportation of hazardous materials.

4 - A multistage stochastic programming model for the optimal bid of a wind producer

Speaker: F.-Javier Heredia, UPC, ES, talk 1231

Co-Authors: *Marlyn Cuadrado*, *J.-Anton Sánchez*,

Battery Energy Storage Systems (BESS) can be used by wind producers to improve the operation of wind power plants (WPP) in electricity markets. Associating a wind power plant with a BESS (the so-called Virtual Power Plant (VPP)) provides utilities with a tool that converts uncertain wind power production into a dispatchable technology that can operate not only in spot and adjustment markets (day-ahead and intraday markets) but also in ancillary services markets that, up to now, were forbidden to non-dispatchable technologies. We present in this study a multi-stage stochastic programming model to find the optimal operation of a VPP in the day-ahead, intraday and secondary reserve markets while taking into account uncertainty in wind power generation and clearing prices (day-ahead, secondary reserve, intraday markets and system imbalances). A new forecasting procedure for the random variables involved in stochastic programming model has been developed. The forecasting model is based on Time Factor Series Analysis (TFSA) and gives suitable results while reducing the dimensionality of the forecasting mode. The quality of the scenario trees generated using the TFSA forecasting models with real electricity markets and wind production data has been analysed through multistage VSS.

IP-Formulations

Discrete Optimization & Integer Programming

IPtheory - We 5:00pm-6:00pm, Format: 2x30 min

Room: Salle 43 Building: C, 3rd floor, Zone: 1

Contributed Session 516

Chair: Temitayo Ajayi, Rice University, US

1 - The quadratic assignment problem: a comparison of two linearizations

Speaker: Wolfgang Riedl, Universität der Bundeswehr, DE, talk 1566

Co-Authors: *Christine Huber*,

The quadratic assignment problem is a well-known optimization problem with numerous applications. A common strategy to solve it is to use one of its linearizations and then apply the toolbox of mixed integer linear programming methods. One measure of quality of a mixed integer formulation is the quality of its linear relaxation. In this talk, we compare two linearizations of the quadratic assignment problem and prove that the linear relaxation of the linearization of Adams and Johnson is contained in the linear relaxation of the linearization of Xia and Yuan. We furthermore develop a Branch and Cut approach using the insights obtained in the proof that enhances the linearization of Xia and Yuan via a new family of cuts.

2 - Assessing Parametrized Linear Programming Relaxations With Superadditive Duality

Speaker: Temitayo Ajayi, Rice University, US, talk 694

Co-Authors: *Christopher Thomas*, *Andrew Schaefer*,

The integer programming gap is a foundational concept in optimization. Because linear programming relaxations are vital in most integer programming algorithms, it is important to assess the accuracy of linear programs as approxi- mations of integer programs. Studies on gap functions over the past half-century either use abstract algebraic techniques or do not provide exact bounds. In this talk, we present superadditive dual-based formulations to compute various metrics of model quality based on gap functions. Our formulations evaluate families of models parametrized by right-hand sides from discrete sets or hyper- rectangles. We provide the construction of a linear programming formulation of the superadditive dual that is a strong dual over any specified hyper-rectangle. This superadditive dual accepts any integer constraint matrix and there is no restriction to nonnegative entries.

Energy Market Models

Specific Models, Algorithms, and Software

Energy - We 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 23 Building: G, 3rd floor, Zone: 6

Contributed Session 522

Chair: Sauleh Siddiqui, Johns Hopkins University, US

1 - Global Optimization of Multilevel Electricity Market Models

Speaker: Thomas Kleinert, Universität Erlangen-Nürnberg, DE, talk 548

Co-Authors: *Martin Schmidt*,

We consider the combination of a network design and graph partitioning model in a multilevel framework for determining the optimal design of zonal pricing electricity markets. This structure together with nonlinearities due to economic modeling yields extremely challenging mixed-integer nonlinear multilevel models. One solution approach is to reformulate the model to an equivalent bilevel problem and apply a standard KKT transformation. However, this approach is numerically weak and computationally expensive. Hence, we propose a problem-tailored generalized Benders decomposition approach with two types of optimality cuts. We prove that this method yields global optimal solutions and evaluate the effectiveness of both cuts. Finally, in a numerical study we compare the two solution approaches and show that the tailored Benders approach clearly outperforms the standard KKT transformation.

2 - Co-optimization Models with Market-Clearing Equilibrium: A Robust Approach

Speaker: Emre Celebi, Kadir Has University, TR, talk 1313

Key decisions for market participants in the organized electricity markets are prone to uncertainties in supply and demand. The planning and investment decisions of the generation companies are driven by economic considerations in response to uncertain market outcomes. On the other hand, investment decisions for the transmission system are anticipated by the transmission system operator who characterizes reliable and secure market operations. This planning and investment process in generation and transmission assets and the market-clearing equilibrium are closely related and are affected by uncertainties in demand and supply. Hence, this study introduces a robust optimization approach for co-optimization models of transmission/generation investments and market-clearing equilibrium when uncertainties in demand and supply are considered. We propose an open loop simultaneous optimization problem cast as a mixed complementarity problem. We have considered uncertainty sets for demand/supply and a robust counterpart for this model is formulated. We have demonstrated and analyzed this model on two test systems. This robust model will be useful in planning transmission and generation investments as well as in analyzing the relations among these investments and the market outcomes.

3 - Solving Problems with Equilibrium Constraints Applied to Energy Markets

Speaker: Sauleh Siddiqui, Johns Hopkins University, US, talk 442

We provide a new method to obtain stationary points for mathematical and equilibrium problems with equilibrium constraints (MPECs and EPECs). The MPECs and EPECs considered have a complementarity problem at the lower level, with linear complementarity constraints. We use a nonlinear optimization algorithm which finds stationary points of an optimization problem with a bilinear objective function and linear constraints. Our approach is to express the MPEC and EPEC as a complementarity problem by decomposing the dual variables associated with the bilinear constraints. We then solve the problem using techniques for optimizing a bilinear objective function over polytopes. The proposed computation strategy is justified because it involves solving one complementarity problem as opposed to using binary variables or solving a sequence of optimization problems with equilibrium constraints as existing methods do. We leverage previous work by using existing theory of stationary Points for MPECs and EPECs as well as building on existing algorithms for optimization over polytopes. Note that while previous researchers have formulated complementarity-based formulations of EPECs, these formulations contain nonlinear terms in the constraints, which means that standard linear complementarity problem theory cannot be applied for analysis. Numerical evidence shows our method works for moderately sized EPECs, and outperforms current algorithms in terms of computational speed. Along with numerical examples, we provide an application to energy markets to show the usefulness of the method.

Machine Scheduling 2

Specific Models, Algorithms, and Software

Scheduling - We 5:00pm-6:30pm, Format: 3x20 min

Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 529

Chair: Guopeng Song, KU Leuven, BE

1 - Human-Robot Scheduling in Collaborative Environments

Speaker: Cristiane Ferreira, FEUP, PT, talk 459

Co-Authors: *Pedro Amorim*, *Gonçalo Figueira*, *Francisco Machado*,

The term 'Human-Robot Collaboration' has been used to define different types of industrial environments where humans and robots share the same workplace. In this work, we aim to analyze how the application of operational research methods to these new hybrid environments could provide important managerial insights regarding the task design. For that purpose, we present a generalization of the Parallel Machine Scheduling Problem where jobs may be executed by two different types of resources (humans and robots) or even by both simultaneously. This problem arises from the combination of hybrid teams' essential characteristics: heterogeneous performance of resources and the possibility to jointly execute tasks. We implemented a Constraint Programming model that was capable to find the optimal solution for most of the instances generated. We also propose a Genetic Algorithm in order to generate good quality solutions for the set of larger instances. Preliminary experiments show that the possibility of collaborative work can provide large improvement opportunities, particularly in settings with low automation and high levels of precedence constraints.

2 - Parallel machine scheduling with time constraints on machine qualifications

Speaker: Margaux Nattaf, Mines de Saint-Etienne, FR, talk 460

Co-Authors: *Stéphane Dauzère-Pérès*, *Claude Yugma*,

The problem considered in this paper comes from semiconductor manufacturing, when Advanced Process Control constraints are considered in scheduling problems. We address the problem of scheduling lots (jobs) of different families on parallel machines, where not all machines are able to process all job families (non-identical machines). A special time constraint, associated to each job family, must be satisfied for a machine to remain qualified to process jobs of the family. This constraint imposes that the time between the execution of two consecutive jobs of the same family on a qualified machine must not exceed a time threshold for the family. Otherwise, the machine becomes disqualified for the family. The goal is to minimize both the total flow time and the number of families disqualified on machines. We propose two exact methods: An Integer Linear Program and a Constraint Programming model. Two constructive heuristics that can be used as a first solution for the exact methods are also presented. Then, a simple recursive procedure is introduced. This heuristic strongly improves the results obtained by the constructive heuristics. Numerical experiments are performed on randomly generated instances to compare the different solution methods.

3 - The robust machine availability problem

Speaker: Guopeng Song, KU Leuven, BE, talk 863

Co-Authors: *Daniel Kowalczyk*, *Roel Leus*,

We define and solve the robust machine availability problem in a parallel-machine environment, which aims to minimize the required number of identical machines that will still allow to complete all the jobs before a given due date. The deterministic variant of the proposed problem is essentially equivalent to the bin packing problem. A robust formulation is presented, which preserves a user-defined robustness level regarding possible deviations in the job durations. For better computational performance, a branch-and-price procedure is proposed based on a set covering formulation, with the robust counterpart formulated for the pricing problem. Zero-suppressed binary decision diagrams (ZDDs) are introduced for solving the pricing problem, in order to tackle the difficulty entailed by the robustness considerations as well as by extra constraints imposed by branching decisions. Computational results are reported, showing the effectiveness of a pricing solver with ZDDs compared with a MIP solver.

K-adaptability

Optimization under Uncertainty
Robust - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 37 Building: B, Intermediate, Zone: 4

Invited Session 1
Organizer: Anirudh Subramanyam, Carnegie Mellon University, US

1 - Min-max-min Robust Optimization for the Capacitated Vehicle Routing Problem
Speaker: Jannis Kurtz, RWTH Aachen University, DE, talk 355
Co-Authors: *Lars Eufinger*, *Christoph Buchheim*, *Uwe Clausen*,
We investigate a robust approach for solving the capacitated vehicle routing problem (CVRP) with uncertain travel times. It is based on the concept of *K*-adaptability, which allows to calculate a set of *k* feasible solutions in a preprocessing phase. Once a scenario occurs, the corresponding best solution may be picked out of the set of candidates. The aim is to determine the *k* candidates such that the respective best one of them is worst-case optimal, which leads to a min-max-min problem. In this talk, we present an oracle-based algorithm for solving the resulting min-max-min CVRP, calling an exact algorithm for the deterministic problem in each iteration. Moreover, we adjust this approach such that also heuristics for the CVRP can be used. In this way, we derive a heuristic algorithm for the min-max-min problem, which turns out to yield good solutions in a short running time.

2 - Min-Max-Min Robustness for Combinatorial Problems with Budgeted Uncertainty
Speaker: Michael Poss, LIRMM-CNRS, FR, talk 245
Co-Authors: *Andre Chassein*, *Marc Goerigk*, *Jannis Kurtz*,
We consider two-stage robust combinatorial optimization problems, where the decision maker can react to a scenario by choosing from a finite set of first-stage decisions. Also known as min-max-min robustness, it is a viable alternative to otherwise intractable two-stage problems. We focus on the case that the set of possible scenarios is described through a budgeted uncertainty set, distinguishing between discrete and convex variants. For the former case, hardness results and a pseudopolynomial algorithm are presented. For the latter case, we identify cases that can be solved in polynomial time and derive heuristic and exact solution methods. We test our methods on shortest path and knapsack instances that were used in the previous literature, and find that our methods considerably outperform previous approaches. Some instances that were previously not solved within hours can now be solved within few minutes.

3 - K-Adaptibility in Stochastic Programming
Speaker: Jonas Pruente, TU Dortmund, DE, talk 1553
Co-Authors: *Christoph Buchheim*,
We address optimization problems with uncertain objective functions, given by discrete probability distributions. Within this setting, we investigate the so-called K-adaptability approach: the aim is to calculate a set of k feasible solutions such that the objective value of the best of these solutions, calculated in each scenario independently, is optimal in expectation. We show that this problem is NP-hard even if the underlying certain problem is trivial, and present further complexity results concerning approximability and fixed-parameter tractability. Moreover, we present different exact solution methods and a heuristic for this problem and compare them in an extensive experimental evaluation, where the underlying problem is the unconstrained binary optimization problems, the shortest path problem or the spanning tree problem. It turns out that the performance and the ranking of these approaches strongly depends on the parameter k and on the number of scenarios.

4 - K-Adaptability in Two-Stage Mixed-Integer Robust Optimization
Speaker: Anirudh Subramanyam, Carnegie Mellon University, US, talk 353
Co-Authors: *Wolfram Wiesemann*, *Chrysanthos Gounaris*,
We study two-stage robust optimization problems with mixed discrete-continuous decisions in both stages. Despite their broad range of applications, these problems pose two fundamental challenges: (i) they constitute infinite-dimensional problems that require a finite-dimensional approximation, and (ii) the presence of discrete recourse decisions typically prohibits duality-based solution schemes. To address the first challenge, we study a K-adaptability formulation that selects K candidate recourse policies before observing the realization of the uncertain parameters and that implements the best of these policies after the realization is known. We establish conditions under which the K-adaptability problem remains continuous, convex and tractable, and we contrast them to the corresponding conditions for the two-stage robust optimization problem. To address the second challenge, we develop a branch-and-bound scheme that enjoys asymptotic convergence in general and finite convergence under specific conditions. We illustrate the performance of our algorithm in numerical experiments involving benchmark data from several application domains.

First-order methods: advances and applications

Continuous Optimization
NLP - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Invited Session 3
Organizer: Immanuel Bomze, Universitaet Wien, AT

1 - Incremental mirror descent with random sweeping and a proximal step
Speaker: Axel Boehm, University of Vienna, AT, talk 216
Co-Authors: *Radu Ioan Bot*,
We investigate the convergence properties of incremental mirror descent type subgradient algorithms for minimizing the sum of convex functions. In each step we only evaluate the subgradient of a single component function and mirror it back to the feasible domain, which makes iterations very cheap to compute. The analysis is made for a randomized selection of the component functions, which yields the deterministic algorithm as a special case. Under supplementary differentiability assumptions on the function which induces the mirror map we are also able to deal with the presence of another term in the objective function, which is evaluated via a proximal type

step. In both cases we derive convergence rates of $O\left(\frac{1}{\sqrt{k}}\right)$ in expectation for the kth best objective function value and illustrate our theoretical findings by numerical experiments in positron emission tomography and machine learning.

2 - Active-set identification in Frank-Wolfe variants on the standard simplex

Speaker: Immanuel Bomze, Universitaet Wien, AT, talk 253
Co-Authors: *Francesco Rinaldi*, *Samuel Rota Bulo*,
We study variants of the Frank-Wolfe method with away steps for simplex-constrained smooth optimization problems. Under curvature conditions which are met by all (indefinite) quadratic forms, by all convex and all concave functions, we establish global convergence. In addition, it is shown that the active set is correctly identified after finitely many iterations under a mild genericity assumption.

3 - Robust StQP, first-order methods, and applications in social network analysis

Speaker: Michael Kahr, University of Vienna, AT, talk 301
Co-Authors: *Immanuel Bomze*, *Markus Leitner*,
We consider the robust variant of the Standard Quadratic Problem (RStQP), in which a (possibly indefinite) quadratic form is extremized over the standard simplex (which is considered certain), and the quadratic form is uncertain. The uncertain data realizations are assumed to lie in known uncertainty sets, which we model particularly by ellipsoids, polyhedra, and spectrahedra, more precisely, intersections of sub-cones of the copositive matrix cone. We show that the copositive relaxation gap of the RStQP equals the minimax gap under some mild assumptions for arbitrary uncertainty sets, and present conditions under which the RStQP reduces to a deterministic instance of an StQP, which can be solved by an efficient first-order method. These conditions also ensure that the copositive RStQP relaxation is exact. A specific application is community detection in social networks based on profile similarity, for which a computational study is presented.

4 - On the convergence of projection free Hessian Barrier-Gradient Algorithms

Speaker: Mathias Staudigl, Maastricht University, NL, talk 768
Co-Authors: *Panayotis Mertikopoulos*, *Immanuel Bomze*, *Werner Schachinger*,
In this paper we study a large class of algorithms for solving general smooth non-linear programming problems. We are interested in solving problems of the form

$$\min f(x) \quad \text{s.t.: } Ax = b, x \in \bar{C}.$$

$\bar{C}$ is the closure of an open convex set $C \subset \mathbb{R}^n$. A is an $m \times n$ matrix of rank m. We do not impose convexity on the objective function f, but merely solvability of above optimization problem and a that f has a Lipschitz gradient. We are given a matrix-valued function H which is adapted to the geometry of C. We use this function to define a variable metric given by

$$(\forall x \in C)(\forall u, v \in \mathbb{R}^n) : \langle u, v\rangle_{H(x)} := u^\top H(x)v$$

The algorithm we are considering is the recursive scheme

$$x^{k+1} = x^k + \alpha^k P_{x^k} H(x^k)^{-1}\nabla f(x^k),$$

where $P_x := I - H(x)^{-1}A^\top(AH(x)^{-1}A^\top$. The method above can be seen as a Euler discretization of the Hessian-Riemannia dynamics of the form

$$\dot{x}(t) = -P_{x(t)}H(x(t))^{-1}\nabla f(x(t)).$$

Hence, the class of algorithms we consider can be a seen as a discrete version of Riemannian gradient flows on a manifold as studied in an important paper by Alvarez et al. (2004). In some sense, the algorithm allows us to study a proximal algorithm, without actually performing the computationally expensive projection step. We investigate viability, stability, convergence and complexity of the algorithm. A novel rate of convergence for polyhedral constraints is provided as well.

Computer-assisted analyses of optimization algorithms I

Continuous Optimization
SDP - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 20 Building: G, 1st floor, Zone: 6

Invited Session 19
Organizer: Adrien Taylor, INRIA, FR

1 - Efficient First-order Methods for Convex Minimization: A Constructive Approach

Speaker: Yoel Drori, Google, IL, talk 18
Co-Authors: *Adrien Taylor*,
We present a novel technique for devising efficient first-order methods for a wide range of convex minimization problems. The technique takes a non-practical method performing a series of large subspace-searches, then from an accuracy certificate for that method (which can be obtained either analytically or numerically) constructs a fixed-step method that has the same accuracy certificate. We discuss analytical results in the non-smooth and smooth cases showing that the technique yields optimal methods, and some competitive numerical results in some cases where an analytical result is not available.

2 - Optimized first-order method for decreasing gradient of smooth convex functions

Speaker: Donghwan Kim, Dartmouth College, US, talk 19
Co-Authors: *Jeffrey Fessler*,
We optimize the step coefficients of first-order methods in terms of the worst-case convergence bound of the gradient decrease of smooth convex functions, using the performance estimation problem approach. The corresponding worst-case bound of the optimized method is optimal up to constant for large-dimensional smooth convex minimization. We then illustrate that the resulting method, named OGM-G, has a computationally efficient form that is similar to the optimized gradient method (OGM).

3 - The Fastest Known First-Order Method for Smooth Strongly Convex Minimization

Speaker: Bryan Van Scoy, University of Wisconsin, US, talk 146
Co-Authors: *Laurent Lessard*, *Randy Freeman*, *Kevin Lynch*,
In this talk, we both design and analyze a novel gradient-based algorithm for unconstrained convex optimization. When the objective function is smooth and strongly convex, the iterates converge globally and linearly to the optimizer, and the convergence rate is twice as fast as the proven rate for Nesterov's method. We will give a simple convergence proof in the time domain using a Lyapunov function based on convex interpolation, and then provide intuition into the design of

the method using integral quadratic constraints from control theory. Furthermore, we perform a numerical search over the method parameters to show that no other choice of parameters achieves a faster convergence rate.

4 - Analysis of First-Order Algorithms for Distributed Optimization

Speaker: Laurent Lessard, Univ. of Wisconsin-Madison, US, talk 1212

Co-Authors: *Akhil Sundararajan*, *Bryan Van Scoy*, *Bin Hu*,

We present a unified framework for analyzing the convergence of distributed optimization algorithms by formulating a semidefinite program (SDP) which can be efficiently solved to bound the linear rate of convergence. Two different SDP formulations are considered. First, we formulate an SDP that depends explicitly on the gossip matrix of the network graph. This result provides bounds that depend explicitly on the graph topology, but the SDP dimension scales with the size of the graph. Second, we formulate an SDP that depends implicitly on the gossip matrix via its spectral gap. This result provides coarser bounds, but yields a small SDP that is independent of graph size. Our approach improves upon existing bounds for the algorithms we analyzed, and numerical simulations reveal that our bounds are likely tight.

Submodular Maximization

Discrete Optimization & Integer Programming

APPROX - Th 8:30am-10:30am, Format: 4x30 min

Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 29

Organizer: Moran Feldman, Open University of Israel, IL

1 - Deterministic and Combinatorial Algorithms for Submodular Maximization

Speaker: Moran Feldman, Open University of Israel, IL, talk 49

The recent decade has seen a surge of new results in submodular maximization. One of the main driving forces behind this surge has been the development of the multilinear extension and the Continuous Greedy algorithm by Calinescu et al. (2007). As both these tools are continuous in nature, the same is true also for most of the algorithms that have been developed based on them. Thus, these days most of the state of the art algorithms for submodular maximization work in the continuous domain. Unfortunately, continuous algorithms are often problematic from a practical point of view because they tend to be quite involved and slow. An additional issue with these algorithms is that they are all randomized (because there is no known deterministic way to estimate the multilinear extension), and thus, they leave us with a large theoretical gap regarding what can and cannot be done deterministically in many submodular maximization problems. Recently, there has been some work on alleviate these issues by derandomizing algorithms and developing simple combinatorial algorithms that are comparable to state of the art continuous algorithms. In this talk I will survey a few recent results of this kind, and will point out some central submodular maximization problems that still require much work in these directions.

2 - Constrained Submodular Maximization via Greedy Local Search

Speaker: Baruch Schieber, IBM Research, US, talk 71

Co-Authors: *Kanthi Sarpatwar*, *Hadas Shachnai*,

We present a simple combinatorial $\frac{1}{2}(1-\frac{1}{e^2})$-approximation algorithm for maximizing a monotone submodular function subject to a knapsack and a matroid constraint. This classic problem is known to be hard to approximate within any factor better than $1-\frac{1}{e}$. We extend the algorithm to yield a $\frac{1}{k}(1-\frac{1}{e^k})$ approximation for submodular maximization subject to a single knapsack and $k-1$ matroid constraints, for any fixed integer $k>1$. Our algorithms, which combine the greedy algorithm of [Khuller, Moss and Naor, 1999] and [Sviridenko, 2004] with local search, show the power of this natural framework in submodular maximization with combined constraints.

3 - Submodular Maximization through the Lens of Linear Programming

Speaker: Simon Bruggmann, ETH Zurich, CH, talk 67

Co-Authors: *Rico Zenklusen*,

The simplex algorithm for linear programming is based on the fact that any local optimum with respect to the polyhedral neighborhood is also a global optimum. We show that a similar result carries over to submodular maximization. In particular, every local optimum of a constrained monotone submodular maximization problem yields a $1/2$-approximation, and we also present an appropriate extension to the non-monotone setting. Moreover, we describe a very general local search procedure that applies to a wide range of constraint families, and unifies as well as extends previous methods. In our framework, we match known approximation guarantees while disentangling and simplifying previous approaches. Moreover, despite its generality, we are able to show that our local search procedure is slightly faster than previous specialized methods. Furthermore, we negatively answer the open question whether a linear optimization oracle may be enough to obtain strong approximation algorithms for submodular maximization. We do this by providing an example of a constraint family on a ground set of size n for which, if only given a linear optimization oracle, any algorithm for submodular maximization with a polynomial number of calls to the linear optimization oracle has an approximation ratio of only $O(\log n/(\sqrt{n}\cdot\log\log n))$.

4 - Constrained Submodular Maximization via a Nonsymmetric Technique

Speaker: Niv Buchbinder, Tel Aviv University, IL, talk 51

Co-Authors: *Moran Feldman*,

The study of combinatorial optimization problems with a submodular objective has attracted much attention in recent years. Such problems are important in both theory and practice because their objective functions are very general. Obtaining further improvements for many submodular maximization problems boils down to finding better algorithms for optimizing a relaxation of them known as the multilinear extension. In this work we present an algorithm for optimizing the multilinear relaxation whose guarantee improves over the guarantee of the best previous algorithm (by Ene and Nguyen (2016)). Moreover, our algorithm is based on a new technique which is, arguably, simpler and more natural for the problem at hand. In a nutshell, previous algorithms for this problem rely on symmetry properties which are natural only in the absence of a constraint. Our technique avoids the need to resort to such properties, and thus, seems to be a better fit for constrained problems.

Bayesian and Randomized Optimization I

Continuous Optimization

DerFree - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 39

Chair: Stefan Wild, Argonne National Laboratory, US

1 - Improving Bayesian optimization via random embeddings

Speaker: Mickael Binois, Argonne National Laboratory, US, talk 525

Co-Authors: *David Ginsbourger*, *Olivier Roustant*,

The challenge of taking many variables into account in optimization problems may be overcome under the hypothesis of low effective dimensionality. Then, the search of solutions can be reduced to the random embedding of a low dimensional space into the original one, resulting in a more manageable optimization problem. Specifically, in the case of time consuming black-box functions and when the budget of evaluations is severely limited, global optimization with random embeddings appears as a sound alternative to random search. Yet, in the case of box constraints on the native variables, defining suitable bounds on a low dimensional domain appears to be complex. Indeed, a small search domain does not guarantee to find a solution even under restrictive hypotheses about the function, while a larger one may slow down convergence dramatically. Here we tackle the issue of low-dimensional domain selection based on a detailed study of the properties of the random embedding, giving insight on the aforementioned difficulties. In particular, we describe a minimal low-dimensional set in correspondence with the embedded search space. We additionally show that an alternative equivalent embedding procedure yields simultaneously a simpler definition of the low-dimensional minimal set and better properties in practice. Finally, the performance and robustness gains of the proposed enhancements for Bayesian optimization are illustrated on three examples.

2 - Bayesian Optimization of Expensive Integrands

Speaker: Saul Toscano-Palmerin, Cornell University, US, talk 931

Co-Authors: *Peter Frazier*,

We propose a Bayesian optimization algorithm for objective functions that are sums or integrals of expensive-to-evaluate functions, allowing noisy evaluations. These objective functions arise in multi-task Bayesian optimization for tuning machine learning hyperparameters, optimization via simulation, and sequential design of experiments with random environmental conditions. Our method is average-case optimal by construction when a single evaluation of the integrand remains within our evaluation budget. Achieving this one-step optimality requires solving a challenging value of information optimization problem, for which we provide a novel efficient discretization-free computational method. We also provide consistency proofs for our method in both continuum and discrete finite domains for objective functions that are sums. In numerical experiments comparing against previous state-of-the-art methods, including those that also leverage sum or integral structure, our method performs as well or better across a wide range of problems and offers significant improvements when evaluations are noisy or the integrand varies smoothly in the integrated variables.

3 - Using Models in Allocate and Partition Algorithms

Speaker: Clément Royer, UW-Madison, US, talk 1022

Co-Authors: *Jeffrey Larson*, *Stefan Wild*,

In dealing with simulation-based problems, one often faces the challenge of optimizing an objective using a fixed budget for sampling noisy values. Common practice relies on replicating evaluations at sampled points, together with efficient procedures to allocate samples between points. Space exploration techniques can also employ replicative sampling to compute pointwise estimates of the objective over subsets with continuous or discrete elements. In this talk, we describe a framework for noisy optimization. It combines an allocating phase, where an incremental budget is split among regions of the search space, and a partitioning phase, where we gradually refine a partition of our domain. In both cases, the process involves building an allocating or a partitioning model of the objective. Our approach encompasses techniques based on both replicative and non-replicative sampling, and applies to discrete or continuous settings. Focusing on the latter, we describe several model choices, and provide theoretical and numerical motivation for their use as allocating or partitioning models.

4 - A Rigorous Framework for Efficient Global Optimization

Speaker: Youssef Diouane, ISAE-SUPAERO, FR, talk 414

Co-Authors: *Alexandre Scotto*, *Michel Salaun*,

Bayesian optimization has been successful at global optimization of expensive-to-evaluate black-box functions. One relevant instance of bayesian optimization methods is Efficient Global Optimization (EGO) method. In this work, we propose, first, to analyze a globally convergent framework for a modified EGO method. The modifications consist essentially of the incorporation of a step length parameter in EGO and its control using a sufficient decrease condition on the objective function values. Second, we propose a final algorithm as a hybridation of the globally convergent EGO and a smart multi-starting strategy based on EGO itself. Our numerical experiments show that the resulting algorithms are highly competitive with other bayesian optimization methods.

Universal methods in non-smooth analysis

Continuous Optimization

NonSmooth - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle LC4 Building: L, Intermediate 1, Zone: 9

Invited Session 53

Organizer: Alexander Gasnikov, MIPT, RU

1 - Universal Nesterov's gradient method in general model conception

Speaker: Alexander Tyurin, HSE, RU, talk 542

Co-Authors: *Pavel Dvurechensky*, *Alexander Gasnikov*,

In this talk, we present a new concept of (δ, L)-model of a function, which generalizes the concept (δ, L)-oracle introduced in O. Devolder, F. Glineur, Yu. Nesterov, First-order methods of smooth convex optimization with inexact oracle, Math. Prog., 2014. Using our (δ, L)-model of the objective, we propose a gradient-based method and its accelerated version. This allows to propose a unified view on different optimization methods. In particular, we show that Nesterov's universal fast gradient method, accelerated method for composite optimization problems, conditional gradient (Frank-Wolfe) method, proximal methods can be obtained as special cases of our general framework. We believe that our approach is flexible, simple, and can be used in many challenging optimization problems.

2 - Dual universal conjugate gradient type methods.
Speaker: Sergey Guminov, MIPT, RU, talk 352
Co-Authors: *Alexander Gasnikov*, *Alexander Gornov*, *Anton Anikin*,
In the late sixties, N. Shor and B. Polyak independently proposed optimal first-order methods for non-smooth convex optimization problems. In 1982 A. Nemirovski proposed optimal first-order methods for smooth convex optimization problems, which utilized auxiliary line search. In 1985 A. Nemirovski and Yu. Nesterov proposed a parametric family of optimal first-order methods for convex optimization problems with intermediate smoothness. In 2013 Yu. Nesterov proposed a universal gradient method which combined all the good properties of the previous methods, except the possibility of using auxiliary line search. One can typically observe that in practice auxiliary line search improves performance for many tasks. In this paper, we propose the apparently first such method of non-smooth convex optimization allowing for the use of the line search procedure. Moreover, it is based on the universal gradient method, which does not require any a priori information about the actual degree of smoothness of the problem. Numerical experiments demonstrate that the proposed method is, in some cases, considerably faster than Nesterov's universal gradient method.

3 - Universal Proximal Method for Variational Inequalities
Speaker: Alexander Tytov, MIPT, RU, talk 635
Co-Authors: *Fedor Stonyakin*, *Mohammad Alkousa*, *Pavel Dvurechensky*, *Alexander Gasnikov*,
The report is devoted to proposing a new analogue of A.S. Nemirovsky's proximal mirror method for variational inequalities with a Lipshitz-continuous field. The main idea of this method is the adaptive choice of constants in minimized prox-mappings at each iteration. These constants are related to the Lipschitz constant of the field. It does not need to specify the exact value of this constant, because the proposed method allows to find a suitable constant at each iteration. Estimates of the necessary number of iterations are obtained to achieve a given quality of the variational inequality solution. It is shown, how it is possible to generalize the proposed approach to the case of a Holder-continuous field (see https://arxiv.org/pdf/1711.00394.pdf, Remark 5.1). A modification of the method in question in the case of an inexact oracle is proposed. Applications to the problem of finding saddle points are considered.

4 - Universal Intermediate Gradient Method for Convex Problems with Inexact Oracle
Speaker: Dmitry Kamzolov, MIPT Moscow, RU, talk 1433
Co-Authors: *Pavel Dvurechensky*, *Alexander Gasnikov*,
In this paper, we propose new first-order methods for minimization of a convex function on a simple convex set. We assume that the objective function is a composite function given as a sum of a simple convex function and a convex function with inexact Hölder-continuous subgradient. We propose Universal Intermediate Gradient Method. Our method enjoys both the universality and intermediateness properties. Following the paper by Y. Nesterov (Math.Prog., 2015) on Universal Gradient Methods, our method does not require any information about the Hölder parameter and constant and adjusts itself automatically to the local level of smoothness. On the other hand, in the spirit of the preprint by O. Devolder, F.Glineur, and Y. Nesterov (CORE DP 2013/17), our method is intermediate in the sense that it interpolates between Universal Gradient Method and Universal Fast Gradient Method. This allows to balance the rate of convergence of the method and rate of the oracle error accumulation. Under additional assumption of strong convexity of the objective, we show how the restart technique can be used to obtain an algorithm with faster rate of convergence. Link to the full paper: https://arxiv.org/abs/1712.06036

Recent advances in interior point methods and NLP

CONTINUOUS OPTIMIZATION
NLP - Th 8:30am-10:30am, Format: 4x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

INVITED SESSION 77
Organizer: Michael Todd, Cornell University, US

1 - The ellipsoid method redux
Speaker: Michael Todd, Cornell University, US, talk 204
We reconsider the ellipsoid method for linear inequalities or optimization. Particular attention is paid to representation of the ellipsoids, to decrease and drop iterations, and to initialization. The goal is an algorithm for problems in the real number model with complexity bounded in terms of condition numbers.

2 - MILP Formulations for Globally Solving Nonconvex Standard Quadratic Programs
Speaker: E. Alper Yildirim, Koc University, TR, talk 733
Co-Authors: *Jacek Gondzio*,
A standard quadratic program involves minimizing a homogeneous (nonconvex) quadratic function over the unit simplex. Standard quadratic programs have numerous applications and play an important role in copositivity detection. We consider two equivalent reformulations of a standard quadratic program as a mixed integer linear programming (MILP) problem. The MILP formulations allow us to compute globally optimal solutions of nonconvex standard quadratic programs or to obtain feasible solutions that are guaranteed to be within a predefined range of the optimal value. In the resulting MILP formulations, we consider alternative approaches to obtain bounds on the big-M parameters. We discuss several ways to enhance the performance of the MILP models. We present computational results on a variety of instances. Our computational results illustrate that our formulations can be a competitive alternative for globally solving standard quadratic programs.

3 - A One-phase Interior Point Method For Nonconvex Optimization
Speaker: Yinyu Ye, Stanford University, US, talk 869
Co-Authors: *Oliver Hinder*,

The work of Wachter and Biegler suggests that infeasible-start interior point methods (IPMs) developed for linear programming cannot be adapted to nonlinear optimization without significant modification, i.e., using a two-phase or penalty method. We propose an IPM that, by careful initialization and updates of the slack variables, is guaranteed to find a first-order certificate of local infeasibility, local optimality, or unboundedness of the (shifted) feasible region. Our proposed algorithm differs from other IPM methods for nonconvex programming because we reduce primal feasibility at the same rate as the barrier parameter as it was achieved in the homogeneous and self-dual LP algorithms. This gives an algorithm with more robust convergence properties and closely resembles successful algorithms from linear programming. We implement the algorithm and compare with IPOPT on a subset of CUTEst problems. Our algorithm requires a similar median number of iterations, but fails on only 9**4 - A polynomial time interior point method for problems with nonconvex constraints**

Speaker: Oliver Hinder, Stanford, US, talk 881

Co-Authors: *Yinyu Ye*,

Interior point methods (IPMs) that handle nonconvex constraints such as IPOPT, KNITRO and LOQO have had enormous practical success. Unfortunately, all known analysis of log barrier IPMs with general constraints (implicitly) prove runtimes with exponential dependencies on $1/\mu$ where μ is the barrier penalty parameter. This work provides an IPM that finds a μ-approximate John Fritz point in $O(\mu^{-7/4})$ iterations when the objective and constraints have Lipschitz first and second derivatives. For this setup, the results represent both the first polynomial time dependence in $1/\mu$ for a log barrier IPM and the best known runtime for finding John Fritz points.

Cycles and Trees

Discrete Optimization & Integer Programming

APPROX - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 90

Organizer: Tobias Mömke, University of Bremen, DE

1 - Coloring and Dominating Set on Digraphs with Bounded Independence Number

Speaker: Alantha Newman, CNRS and G-SCOP, Grenoble, FR, talk 697

Co-Authors: *Ararat Haratyunyan*, *Tien-Nam Le*, *Stéphan Thomassé*,

Some optimization problems exhibit the phenomena that a bound for the problem on tournaments can be transferred to a bound on general digraphs with an additional factor of alpha, where alpha is the size of the maximum independent set. This motivates studying problems, for which good bounds on tournaments exist, on digraphs with bounded independence number. In this talk, we present algorithms for coloring and dominating sets on such digraphs.

2 - A PTAS for TSP with Hyperplane Neighborhoods

Speaker: Antonios Antoniadis, UdS and MPII, DE, talk 184

Co-Authors: *Krzysztof Fleszar*, *Ruben Hoeksma*, *Kevin Schewior*,

In the Traveling Salesman Problem with Neighborhoods (TSPN), we are given a collection of geometric regions in some space. The goal is to output a tour of minimum length that visits at least one point in each region. TSPN is known to be APX-hard, which gives rise to studying more tractable special cases of the problem. In this talk, we focus on regions that are hyperplanes in the d-dimensional Euclidean space. While for $d = 2$ an exact polynomial-time algorithm is known, settling the exact approximability of the problem for $d = 3$ has been repeatedly posed as an open question. Previously, only an approximation algorithm with guarantee exponential in d was known. For arbitrary fixed d, we develop a PTAS that works for both the tour and path version of TSPN. Our algorithm is based on approximating the convex hull of the optimal tour by a convex polytope of bounded complexity. Such polytopes are represented as solutions of a sophisticated LP formulation, which we combine with the enumeration of crucial properties of the tour. In the analysis of our approximation scheme, we show that our search space includes a sufficiently good approximation of the optimum. To do so, we develop a novel sparsification technique to transform an arbitrary convex polytope into one with a constant number of vertices and, in turn, into one of bounded complexity in the above sense. Hereby, we maintain important properties of the polytope. We believe that both the LP formulation representing polytopes of adjustable complexity and the sparsification techniques are of independent interest.

3 - Maximum Scatter TSP in doubling metrics

Speaker: László Kozma, TU Eindhoven, NL, talk 222

Co-Authors: *Tobias Mömke*,

We study the problem of finding a tour of n points in which every edge is long. More precisely, we wish to find a tour that visits every point exactly once, maximizing the length of the shortest edge in the tour. The problem is known as Maximum Scatter TSP, and was introduced by Arkin et al. (SODA 97), motivated by applications in manufacturing and medical imaging. Arkin et al. gave a 2-approximation for the metric version of the problem and showed that this is the best possible ratio achievable in polynomial time (assuming $P \neq NP$). Arkin et al. raised the question of whether a better approximation ratio can be obtained in geometric settings, such as the Euclidean plane. We answer this question in the affirmative in a more general setting, by giving an efficient polynomial time approximation scheme for d-dimensional doubling metrics.

4 - Approximabilty of Hub Allocation Problems

Speaker: Ralf Klasing, CNRS, University of Bordeaux, FR, talk 662

Given a metric graph $G = (V, E, w)$, a center $c \in V$, and an integer p, the Star p-Hub Center problem is to find a depth-2 spanning tree T of G rooted at c such that c has exactly p children and the diameter of T is minimized. The children of c in T are called hubs. A similar problem called the Single Allocation p-Hub Center problem is to find a spanning subgraph H^* of G such that (i) C^* is a clique of size p in H^*; (ii) $V \setminus C^*$ forms an independent set in H^*; (iii) each $v \in V \setminus C^*$ is adjacent to exactly one vertex in C^*; and (iv) the diameter $D(H^*)$ is minimized. The vertices selected in C^* are called hubs and the rest of the vertices are called non-hubs. Both Star p-Hub Center problem and Single Allocation p-Hub Center problem are NP-hard and have applications in transportation systems, telecommunication systems, and post mail systems. In this talk, I will present 5/3-approximation algorithms for both problems. Moreover, I will show that for any $\varepsilon > 0$, both problems have no $(1.5 - \varepsilon)$-approximation algorithm unless P=NP. If the input graph G is a Δ_β-metric, for some $\beta \geq 1/2$ (i.e., G satisfies the β-triangle inequality: $w(u,v) \leq \beta(w(u,x) + w(x,v))$ for all vertices $u, v, x \in V$), we can further show that for any $\varepsilon > 0$, to approximate the two hub allocation problems to a ratio $g(\beta) - \varepsilon$ is NP-hard and we give $r(\beta)$-approximation algorithms where $g(\beta)$ and $r(\beta)$ are functions of β.

Unit Commitment Problem and Applications

Specific Models, Algorithms, and Software
Energy - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 23 Building: G, 3rd floor, Zone: 6

Invited Session 94
Organizer: Tiziano Parriani, Optit S.r.l., IT

1 - Off-line/on-line optimization under uncertainty on energy management
Speaker: Allegra De Filippo, University of Bologna, IT, talk 841
Co-Authors: *Michele Lombardi*, *Michela Milano*,
We focus on optimization under uncertainty by proposing methods to merge off-line and on-line decision stages in the energy sector: we start with a two stage off-line approach coupled with an on-line heuristic. We improve this baseline model in two directions: 1) by replacing the on-line heuristics with an anticipatory method; 2) by making the off-line component aware of the on-line heuristic. Our approach is grounded on a virtual power plant management system, where the load shifts can be planned off-line and the energy balance should be maintained on-line. The goal is to find the minimum cost energy flows at each point in time considering (partially shiftable) electric loads, renewable and non-renewable energy generators, and electric storages. We compare our models with an oracle operating under perfect information and in terms of computation time and complexity of the off-line and on-line optimization techniques.

2 - A Constrained Shortest Path formulation for the Hydro Unit Commitment Problem
Speaker: Dimitri Thomopulos, LIX, Ecole Polytechnique, FR, talk 988
Co-Authors: *Claudia D Ambrosio*, *Wim van Ackooij*, *Pascal Benchimol*,
Managing the hydroelectricity produced by the plants in hydro valleys is called the hydro unit commitment problem (HUCP). Solving efficiently and rapidly HUCP, especially when considering the optimization of cascaded reservoirs, is particularly difficult. The main reason for this mostly arises from the need to model reality as accurately as possible. One particular way of dealing with this difficulty is by disposing of an a priori discretization, i.e., considering a specific set of operational points, typically chosen in order to have maximal efficiency (highest derivatives). It is intuitive that a decomposition method is a valid strategy to tackle the hydro valley HUCP problem. However, it is also clear that the effectiveness of the method is subject to the efficiency of solving the obtained sub-problems. Our main postulate is that a two-reservoir single turbine hydro unit commitment problem (2RST-HUCP) is the essential building stone of these subproblems and can be handled efficiently. We focus on the deterministic price-taker model with a two-reservoirs and potentially many discrete operational points for the underlying units. We extend a path formulation for the single reservoir hydro unit commitment problem presented in van Ackooij et al. (2018). In particular, we propose a path formulation, a dynamic programming approach to handle the 2RST-HUCP, and some pruning techniques in order to reduce the size of the graph.

3 - Stochastic Hydrothermal Unit Commitment via Multilevel Scenario Trees
Speaker: Rafael Lobato, State University of Campinas, BR, talk 1074
Co-Authors: *Erlon Finardi*, *Vitor de Matos*, *Claudia Sagastizabal*, *Asgeir Tomasgard*,
We present an efficient multi-horizon, multi-stage approach to deal with nonlinear mixed 0-1 stochastic programming problems arising in hydrothermal scheduling. The multi-horizon formulation includes two time scales: long-term (strategic) and short-term (operational). In the long-term time scale, typically a block of hours, decisions are made on turning generation units on and off. In the short-term time scale, operational decisions are made hourly, given the status of the generation units and the uncertainty realization (demand, wind power, and inflows). The considered setting can be seen as a trade-off between two-stage formulations and the dimensionality explosion, typical of multistage scenario trees. Encouraging numerical results are obtained on a power system that, even though of reduced size, represents well the features of the Brazilian power mix, including an adequate nonlinear representation of the production function for the hydro-power units. Joint work with E. C. Finardi, V. L. de Matos, C. Sagastizábal, and A. Tomasgard.

4 - CHP Systems Optimization in Presence of Time Binding Constraints
Speaker: Tiziano Parriani, Optit S.r.l., IT, talk 769
Co-Authors: *Angelo Gordini*, *Matteo Pozzi*,
A Combined Heat and Power (CHP) system generates electricity and heat at the same time. Unit Commitment (UC) is a key problem in this context. The goal in UC is to determine a schedule for the machines that maximize the operative margin, satisfying a forecasted heat demand as well as functional and regulatory constraints deriving from system composition and placement. Such constraints bind together several time intervals going from intra-day operative constraints to regulatory limitations defined over the legislative year. In this work we present a time-decomposition based metaheuristic for the optimization of short and mid-term UC problems for CHP systems. In this approach, simplified MILP formulations for longer time horizons are solved to allocate binding constraints contributions to shorter subproblem solved by finer MILP models. The methodology proposed is currently in use by an Italian major multiutility for the daily definition of machine schedule of several CHP systems connected to urban district heating networks.

Advanced Linear(ized) MIP Formulations for Zero-One Programs

Discrete Optimization & Integer Programming
IPpractice - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Invited Session 127
Organizer: Sven Mallach, University of Cologne, DE

1 - Mixed-Integer Programming for Clustering in Non-reversible Markov Processes
Speaker: Leon Eifler, ZIB, DE, talk 344
Clustering methods are commonly used to analyze Markov state models that arise from the simulation of biological and chemical processes. We introduce a new, optimization-based clustering model for processes that express cyclic behavior, such as catalysts. In this case, the underlying Markov process is non-reversible, i.e., the forward and backward transition probabilities for states are not equal. The objective of the model is to maximize the net flow between clusters along the cycle, defined as the difference between forward and backward transition probability. We develop a compact, problem-specific linearization technique for a mixed integer nonlinear programming formulation of this problem. We compare this linearization technique to existing linearization methods from the literature and study the polytope associated with our formulation of the problem.
2 - A new ILP for the Steiner Tree Problem with Revenues, Budget and Hop Constraints
Speaker: Adalat Jabrayilov, TU Dortmund University, DE, talk 551
Co-Authors: *Petra Mutzel*,
The Steiner tree problem with revenues, budgets and hop constraints (STPRBH) is a variant of the classical Steiner tree problem. This problem asks for a subtree with maximum revenues corresponding to its nodes, where its total edge costs respect the given budget, and the number of edges between each node and its root does not exceed the hop limit. We introduce a new binary linear program with polynomial size based on partial-ordering, which (up to our knowledge) for the first time solves all STPRBH instances from the DIMACS benchmark set. The set contains graphs with up to 500 nodes and 12,500 edges.
3 - An extended formulation for the Steiner Forest Problem
Speaker: Daniel Schmidt, Universität zu Köln, DE, talk 813
Co-Authors: *Bernd Zey*, *Francois Margot*,
Given a weighted undirected graph G and a finite number of terminal sets, the Steiner Forest problem is to find a minimum weight forest F in G such that each terminal set is connected in F. Current MIP formulations for the problem are either too large to be practical or yield weak linear programming bounds. We propose an extended formulation for the problem. The new formulation can be dynamically generated and provides strong linear programming bounds in practice. We evaluate its performance in a branch-and-cut algorithm.
4 - Compact Linearization for Zero-One Quadratic Programs
Speaker: Sven Mallach, University of Cologne, DE, talk 293
Compact Linearization is a general linearization method designed for and known to work well with zero-one quadratic problems that comprise some assignment constraints, in particular the quadratic assignment problem itself. In this talk, we present necessary and sufficient criteria for a more general class of zero-one QPs to exhibit such a compact linearization. We start with new simple criteria for assignment constraints and show how to generate a compact linearization of a given such program automatically. Then, we develop under which circumstances the approach can also be used to linearize zero-one QPs with arbitrary linear equation constraints.

Nonlinear Optimization and Variational Inequalities I

Continuous Optimization
Variat - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 140
Organizer: Xin Liu, Chinese Academy of Sciences, CN

1 - Theory and Applicaiton of p-regularized subproblem with $p > 2$
Speaker: Yaxiang Yuan, Chinese Academy of Sciences, CN, talk 63
Co-Authors: *Yong Tsia*, *S.-L. Sheu*,
The p-regularized subproblem (p-RS) is the key content of a regularization technique in computing a Newton-like step for unconstrained optimization. The idea is to incorporate a local quadratic approximation of the objective function with a weighted regularization term $(\sigma/p)\|x\|^p$ and then globally minimize it at each iteration. In this paper, we establish a complete theory of the p-RSs for general p>2 that covers previous known results on p=3 or p=4. The theory features necessary and sufficient optimality conditions for the global and also for the local non-global minimizers of (p-RS). It gives a closed-form expression for the global minimum set of (p-RS) and shows that (p-RS), p>2 can have at most one local non-global minimizer. Our theory indicates that (p-RS) have all properties that the trust region subproblems do. In application, (p-RS) can appear in natural formulation for optimization problems. We found two examples. One is to utilize the Tikhonov regularization to stabilize the least square solution for an over-determined linear system; and the other comes from numerical approximations to the generalized Ginzburg–Landau functionals. Moreover, when (p-RS) is appended with m additional linear inequality constraints, denoted by $(p - RS_m)$, the problem becomes NP-hard. We show that the partition problem, the k-dispersion-sum problem and the quadratic assignment problem in combinatorial optimization can be equivalently formulated as special types of $(p - RS_m)$ with p=4. In the end, we develop an algorithm for solving $(p - RS_m)$.
2 - A semidefinite relaxation algorithm for polynomial equations
Speaker: Jinyan Fan, Shanghai Jiao Tong University, CN, talk 319
In this talk, we discuss how to find all real solutions of polynomial equations, if there are finitely many ones. We propose a semidefinite relaxation algorithm for computing them sequentially. Each solution can be obtained by solving a hierarchy of semidefinite relaxations. Convergence properties of the algorithm are also discussed.
3 - On a special robust optimization problem
Speaker: Cong Sun, Beijing Univ. Post. Telecomm., CN, talk 61
We consider a robust optimization problem arising from wireless communications. In a relay-aided wiretap network, we minimize the total relay transmit power, while requiring that the achieved rate at the supported users are above some

thresholds, and that at the eavesdropper is below a standard. This problem is modeled as an optimization problem with one robust constraint. We propose an algorithm to solve the problem iteratively while preserving the feasibility during the iteration. The problem with tightened worst case constraint is solved as the algorithm initialization. We apply the line-search technique to update the feasible iterative point. All the subproblems are solved optimally and the convergence of the objective function is proved. The optimality condition of the robust optimization problem is analyzed. Simulation results show that our algorithm outperforms the state of the art, and has little loss compared to the result with perfect channel state information.

4 - Limited memory algorithms with cubic regularization
Speaker: Liang Zhao, Chinese Academy of Sciences, CN, talk 107
Co-Authors: *Oleg Burdakov*, *Yaxiang Yuan*,
We consider a model with a cubic regularization where the cubic term is determined by the eigendecomposition of a limited memory Hessian approximation. Although the model function may potentially have an exponential number of distinct local minima, its global minimizer can be obtained in closed form. The required eigenvalue decomposition is produced using an efficient approach introduced recently for limited memory Hessian approximations. Convergence results are presented for a standard cubic regularization framework. The efficiency of our algorithms is demonstrated by results of numerical experiments.

Integer linear programming, convex geometry, and lattices

Discrete Optimization & Integer Programming
IPtheory - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 142
Organizer: Sinai Robins, University of Sao Paulo, BR

1 - Exploiting Linear Symmetries in Integer Convex Optimization
Speaker: Achill Schürmann, University of Rostock, DE, talk 1145
Standard techniques for integer optimization problems appear to work often quite poorly on symmetric problems. Several problem specific approaches have been developed over the last decade, but there is still no good general approach to make use of symmetries so far. In this talk we give a survey about linear symmetry groups of convex optimizations problems (as for instance found in MIPLIB) and we present some ideas to exploit these symmetries based on reformulations which depend on the group.

2 - On the reverse isodiametric problem
Speaker: Matthias Schymura, EPFL, CH, talk 451
Co-Authors: *Bernardo González Merino*,
Motivated by an old question of Makai Jr. on the thinnest non-separable arrangement of convex bodies, we study a reverse form of the classical isodiametric inequality. More precisely, we are interested in estimating the maximal isodiametric quotient that an affine image of a given convex body can have. After an early solution of Behrend (1937) in the plane, the problem seemed to be forgotten and is open starting from three dimensions. In the talk, we shall briefly explain the connection to densities of non-separable arrangements, and then illustrate how concepts such as the Löwner-position and well-distributed point configurations on the sphere naturally appear in this context. As a result we obtain the currently best asymptotic solution to the reverse isodiametric problem.

3 - The Complexity of Presburger Arithmetic in Fixed Dimension
Speaker: Kevin Woods, Oberlin College, US, talk 281
Integer Programming is the problem of finding integer solutions to a *conjunction* of linear inequalities. Presburger Arithmetic generalizes this to allow 1) arbitrary Boolean combinations and 2) quantifiers ($\exists$, $\forall$). A classic result of Lenstra is that integer programming in fixed dimension can be solved in polynomial time, and Barvinok generalized this to counting the number of solutions to an integer program. We discuss generalizations to Presburger Arithmetic. In particular, Barvinok and Woods gave polynomial time results when quantifiers are only existential ($\exists x_1, ..., x_n$); this corresponds to examining the projection of the integer points in a polytope. Nguyen and Pak recently showed that more complicated quantification (quantifier alternation) yields NP-hard problems.

4 - Fourier transforms of polytopes, solid angle sums, and discrete volumes
Speaker: Sinai Robins, University of Sao Paulo, BR, talk 1174
Given a real closed polytope P, we first describe the Fourier transform of its indicator function by using iterations of Stokes' theorem in $\mathbb{R}^d$. We then use the ensuing Fourier transform formulations, together with the Poisson summation formula, to give a new algorithm to count fractionally-weighted lattice points inside the one-parameter family of all real dilates of P. The combinatorics of the face poset of P plays a central role in the description of the Fourier transform of P. We also obtain a closed form for the codimension-1 coefficient that appears in an expansion of this sum in powers of the real dilation parameter t, with reference to the dilation tP. This closed form generalizes some known results about the Macdonald solid-angle polynomial, which is the analogous expression traditionally obtained by requiring that t assumes only integer values. Although most of the present methodology applies to all real polytopes, a particularly nice application is to the study of all real dilates of integer (and rational) polytopes. This is joint work with Ricardo Diaz and Quang-Nhat Le.

Geometry and duality in convex optimization

Continuous Optimization
SDP - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

Invited Session 160
Organizer: Javier Pena, Carnegie Mellon University, US

1 - Condition Numbers for Convex Functions with Polytope Domains
Speaker: David Gutman, Carnegie Mellon University, US,

talk 1282
Co-Authors: *Javier Pena*,
We propose a condition number of a smooth convex function relative to a reference polytope. This relative condition number is defined as the ratio of a relative smooth constant to a relative strong convexity constant of the function, where both constants are relative to the reference polytope. The relative condition number extends the main properties of the traditional condition number. In particular, we show that the condition number of a quadratic convex function relative to a polytope is precisely the square of the diameter-to-facial-distance ratio of a scaled polytope for a canonical scaling induced by the function. Furthermore, we illustrate how the relative condition number of a function bounds the linear rate of convergence of first-order methods for minimization of the function over the polytope.

2 - Conditioning of conic systems via the Grassmannian manifold
Speaker: Javier Pena, Carnegie Mellon University, US, talk 1014
Co-Authors: *Vera Roshchina*,
Consider the following fundamental question: How well-posed is the conic feasibility problem "find a non-trivial $x \in L \cap K$" where L and K are respectively a linear subspace and a regular convex cone in some ambient Euclidean space E? There exist various approaches to answering this question. Indeed, several authors have proposed various types of condition measures for the above conic feasibility problem, each with different merits and limitations. We show that most of these seemingly different approaches can be naturally related to an abstract type of condition measure in the Grassmannian manifold of linear subspaces of E with dimension equal to the dimension of L. The new Grassmannian perspective readily suggests several preconditioning procedures for conic systems. The condition measure in the Grassmannian manifold can also be further specialized when the cone K has additional structure such as that of symmetric cones.

3 - Solving linear inequalities via non-convex optimization
Speaker: Jourdain Lamperski, MIT, US, talk 1190
We mainly consider solving homogeneous linear inequalities. We formulate a non-convex optimization problem in a slightly lifted space, whose critical points map to feasible solutions of the linear inequalities. We show various properties of the non-convex objective function and develop an algorithm that computes critical points thereof, thus yielding an algorithm for linear inequalities. We establish convergence guarantees for the algorithm and further investigate its performance via computational experiments.

4 - On positive duality gaps in semidefinite programming
Speaker: Gabor Pataki, UNC Chapel Hill, US, talk 283
We study semidefinite programs (SDPs) whose optimal value differs from the optimal value of their dual. Such SDPs are said to have a positive duality gap, they are often seen as extremely pathological and are very difficult to solve. They also serve as models of more general pathological convex programs. We characterize positive duality gaps in several classes in SDPs by transforming them into a canonical form, from which the positive gap is easy to recognize. The transformation is very simple, as it relies mostly on elementary row operations coming from Gaussian elimination. As a byproduct, we generate a library of SDPs with positive duality gaps, and present a computational study.

Mining Applications

Specific Models, Algorithms, and Software
Energy - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6

Invited Session 172
Organizer: Alexandra Newman, Colorado School of Mines, US

1 - Lane's Algorithm Revisisted
Speaker: Marcos Goycoolea, Universidad Adolfo Ibáñez, CL, talk 1352
Co-Authors: *Patricio Lamas*, *Bernardo Pagnoncelli*, *Adriana Piazza*,
In 1964 Kenneth Lane proposed an algorithm for optimizing, over discrete time, the cut-off grade in a single-metal, single-processor open pit mine production schedule. Though Lane's algorithm is used today in multiple commercial software systems and taught to every mining engineer as a student, it is widely considered heuristic, and little is known regarding the quality of solutions it produces. We formally study Lane's problem from a dynamic and mathematical programming perspective. We show that Lane's algorithm can be viewed as an approximate dynamic programming scheme, and that its limiting economic cut-off grades are actually optimality conditions of a continuous-time extension of his problem. Finally, by reformulating, we show that Lane's problem can be solved using convex mixed integer programming. Though hypothetical counter-examples can be constructed, computational experiments show that Lane's algorithm produced the optimal solution in every real data-set tested, lending solid support for its use in practice.

2 - A MILP-based approach for loader assignment in open pit scheduling
Speaker: Peter Malkin, Datamine Software, GB, talk 923
Co-Authors: *Abdallah Jarray*,
The assignment of the loader fleet to different mining areas of an open pit is a challenging optimisation problem for the long and medium-term planning of open-pit mining operations. In existing approaches to this problem, the loaders are iteratively assigned, guided by a solving relaxation where only the total mining capacity of the loader fleet is considered. This relaxation ignores loader movement, which is costly and may result in an impractical assignment of loaders or a lower quality schedule. In this talk, we present a Mixed-Integer Linear Programming approach to modelling the assignment of loader fleets to different areas of the mine. Using a case-study we highlight the impact on the output schedule of modelling loader assignment within the optimisation; loader movements were reduced by 30 – 40**3 - Optimal Selection of Support Pillars in an Underground Mine**
Speaker: Levente Sipeki, CSM, US, talk 788
Co-Authors: *Alexandra Newman*, *Candace Yano*,
We address the design optimization problem for a mine utilizing the top-down open-stope retreat mining method. In such a mine, a large volume of earth below the surface is envisioned for extraction and is conceptually divided into three-dimensional rectangular blocks on each of several layers. The mine design specifies which blocks are left behind as pillars to provide geotechnical structural stability; the remainder are extracted and processed to obtain ore. We seek a design that

maximizes profit subject to geotechnical stability constraints. We formulate the problem as a set partitioning model with side constraints in which both the side constraints and the decision variables contribute to addressing the geotechnical requirements. Due to the complex geotechnical considerations, a formulation that guarantees feasibility would require exponentially large numbers of variables and constraints. We devise a method to limit the number of variables that need to be included and develop an iterative heuristic in which violated constraints are incorporated into the formulation until all required geotechnical constraints are satisfied. In numerical examples, some based on real data, our approach provides solutions whose estimated profit is tens of millions of dollars larger than those generated using the firm's current methods.

4 - Mathematical Methods for Complex Underground Design and Scheduling Problems

Speaker: Alexandra Newman, Colorado School of Mines, US, talk 792

Co-Authors: *Levente Sipeki*, *Peter Nesbitt*,

Underground mining requires determining both design and scheduling decisions. For deposits that extend deep underground, the mining method most profitable at the highest vertical level may not be the most profitable at the deepest level. We consider two mining methods: top-down open stoping (in which mining starts at the highest vertical level of extraction, but the percentage of extraction decreases with each vertical level) and bottom-up stoping with backfilling (in which the percentage of extraction remains favorably high, but excavation begins later at the deepest level first). These methods offer competing advantages regarding time to extraction and overall extraction rate. However, there is no industry standard regarding which method maximizes profitability over the life of the mine. These design decisions are coupled with complex sequencing of activities. We present an optimization-based heuristic that determines a schedule, including method of extraction, while incorporating the rules on viable extraction sequences. Our methodology consists of (i) preprocessing, (ii) integer programming, and (iii) a heuristic. We solve the integer programming models with state-of-the-art algorithms that exploit underlying precedence-constrained knapsack problem structure. Our results demonstrate that we are able to determine designs and corresponding production schedules with resulting net present value that is a significant improvement over industry current practice.

Machine learning for optimisation

Continuous Optimization

NLP - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 176

Organizer: Coralia Cartis, University of Oxford, GB

1 - Dimensionality reduction for global optimisation: adaptive random embeddings

Speaker: Adilet Otemissov, The Alan Turing Institute, GB, talk 839

Co-Authors: *Coralia Cartis*,

We show that the scalability challenges of Global Optimisation (GO) algorithms can be overcome for functions with low effective dimensionality, which are constant along certain linear subspaces. We propose the use of random subspace embeddings within a(ny) global minimisation algorithm, extending the approach in Wang et al (2013). We introduce two new frameworks, REGO (Random Embeddings for GO) and AREGO (Adaptive REGO), which transform the high-dimensional optimization problem into a low-dimensional one. In REGO, a new low-dimensional problem is formulated with bound constraints in the reduced space and solved with any GO solver. Using random matrix theory, we provide probabilistic bounds for the success of REGO, which indicate that this is dependent upon the dimension of the embedded subspace and the intrinsic dimension of the function, but independent of the ambient dimension. Numerical results show that high success rates can be achieved with only one embedding and that rates are independent of the ambient dimension of the problem. AREGO repeatedly solves a low-dimensional problem, each time with a different random subspace that is chosen using past information. Using results from conic integral geometry, we derive probabilistic bounds on the success of the reduced problem and show that AREGO is globally convergent with probability one for any Lipschitz function. In our numerical tests, we investigate the invariance of the computational cost of AREGO to the ambient dimension of the problem.

2 - Stochastic trust-region with global rate to second-order criticality

Speaker: Coralia Cartis, University of Oxford, GB, talk 785

Co-Authors: *Katya Scheinberg*,

We propose a novel framework for analyzing convergence rates of stochastic optimization algorithms based on analysing an underlying generic stochastic process. We first introduce this framework and the related process and derive a bound on the expected stopping time of this process. Then, we utilize this framework to analyze the bound on expected global convergence rate of a stochastic variant of a traditional trust region method, introduced in Chen et al (2014), to second order critical points. While traditional trust region methods rely on exact computations of the gradient and values of the objective function, this method assumes that these values are available up to some dynamically adjusted accuracy. Moreover, this accuracy is assumed to hold only with some sufficiently large, but fixed, probability, without any additional restrictions on the variance of the errors. This setting applies, for example, to standard stochastic optimization and machine learning formulations. We show that the stochastic process defined by the algorithm satisfies the assumptions of our proposed general framework, with the stopping times defined as reaching approximate second-order optimality. The resulting bound for this stopping time is $O(\epsilon^{-3})$, under the assumption of sufficiently accurate stochastic gradient/Hessian, and they are the first second-order global complexity bounds for a stochastic trust-region method.

3 - Online generation via offline selection of strong linear cuts from QP SDP relax.

Speaker: Radu Baltean-Lugojan, Imperial College London, GB, talk 1041

Co-Authors: *Ruth Misener*,

Convex and in particular semidefinite relaxations (SDP) for non-convex continuous quadratic optimization can provide tighter bounds than traditional linear relaxations. However, using SDP relaxations directly in Branch- and -Cut is impeded by lack of warm starting and inefficiency when combined with other cut classes, i.e. the reformulation-linearization technique. We present a general framework based on machine learning for a strong linear outer-approximation that can retain most tightness of such SDP relaxations, in the form of few strong low dimensional linear cuts selected offline. The cut selection complexity is taken offline by using a neural network estimator (trained before installing solver software) as a selection device for the strongest cuts. Lastly, we present results of our method on several non-convex application problems.

4 - Global optimization in Hilbert Space
Speaker: Boris Houska, ShanghaiTech, CN, talk 1517
Co-Authors: *Mario Villanueva*, *Benoit Chachuat*,
This talk is about a complete-search algorithm for solving a class of non-convex, possibly infinite-dimensional, optimization problems to global optimality. We assume that the optimization variables are in a bounded subset of a Hilbert space, and we determine worst-case run-time bounds for the algorithm under certain regularity conditions of the cost functional and the constraint set. Because these run-time bounds are independent of the number of optimization variables and, in particular, are valid for optimization problems with infinitely many optimization variables, we prove that the algorithm converges to an ϵ-suboptimal global solution within finite run-time for any given termination tolerance $\epsilon > 0$. The talk focuses particularly on how the presented techniques can be used to develop practical and highly scalable global optimization methods, which can exploit the particular structures of variational and optimal control problems.

First-order methods for nonconvex and pathological convex problems

Continuous Optimization
NonSmooth - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 183
Organizer: Wotao Yin, UCLA, US

1 - Alternating structure-adapted proximal gradient descent for nonconvex problems
Speaker: Mila Nikolova, CMLA, CNRS, ENS Cachan, FR, talk 901
Co-Authors: *Pauline Tan*,
There has been an increasing interest in nonsmooth nonconvex block-regularized optimization problems. A very successful approach, known as proximal-linearized block-coordinate descent (BCD) or proximal alternating linearized minimization (PALM) has been proposed in 2013. It can be seen as the the one side of the general family of proximal-linearized BCD algorithms. In this talk, we present and develop the other side of this approach, called the Alternating Structure-Adapted Proximal gradient descent algorithm (ASAP). Its properties are quite different from PALM but the numerical complexity remains the same. Subsequential convergence of ASAP is shown to hold under mild and easily verified conditions. A critical analysis of the assumptions is provided. Global convergence of the algorithm to a critical point is proved using the so-called Kurdyka-Lojasiewicz property. Moreover, we prove that a large class of useful objective functions obeying our assumptions are subanalytic and thus satisfy the Kurdyka-Lojasiewicz property. Applications of the ASAP algorithm to various imaging problems are presented as well.

2 - ADMM for Multiaffine Constrained Optimization
Speaker: Wenbo Gao, Columbia University, US, talk 520
Co-Authors: *Donald Goldfarb*, *Frank Curtis*,
The alternating direction method of multipliers (ADMM) is an alternating minimization method which was proposed for solving linearly-constrained problems. In this talk, I will show that ADMM can also be used to solve the more general class of problems with multiaffine constraints, a natural extension of linear constraints which preserves the structure of ADMM subproblems. Under suitable assumptions, ADMM can be shown to converge to the set of constrained stationary points. I will also present several examples of applications in this framework.

3 - Douglas-Rachford Splitting for Pathological Convex Optimization
Speaker: Ernest Ryu, UCLA, US, talk 956
Co-Authors: *Yanli Liu*, *Wotao Yin*,
Despite the vast literature on DRS, there has been very little work analyzing their behavior under pathologies. Most analyses assume a primal solution exists, a dual solution exists, and strong duality holds. When these assumptions are not met, i.e., under pathologies, the theory often breaks down and the empirical performance may degrade significantly. In this paper, we establish that DRS only requires strong duality to work, in the sense that asymptotically iterates are approximately feasible and approximately optimal.

4 - Polynomial-Time Run-and-Inspect Method for Certain Nonconvex Optimization
Speaker: Wotao Yin, UCLA, US, talk 1213
Co-Authors: *Yifan Chen*, *Yuejiao Sun*,
Many optimization algorithms provably converge to stationary points. When the underlying problem is nonconvex, those algorithms may get trapped at local minimizers and occasionally stagnate near saddle points. We propose the Run-and-Inspect Method, which adds an "inspection" step to existing algorithms that helps escape from local minimizers and stationary points that are not globally optimal. The "inspection" step either finds a sufficient descent or ensures that the current point is an approximate "R-local minimizer." We show that an exact R-local minimizer is globally optimal for sufficiently large (but finite) R if the objective function can be implicitly decomposed into a smooth convex function plus a restricted function that is possibly nonconvex, nonsmooth. Deterministic and stochastic inspections are developed. Coupling with gradient descent, coordinate descent, EM, and prox-linear algorithms, the Run-and-Inspect Method worked well on tested nonconvex problems. We show the stochastic approach finds an approximate global minimizer in polynomial time.

Recent Advances on Stochastic Algorithms and Machine Learning

Continuous Optimization
RandomM - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 202
Organizer: Shiqian Ma, UC Davis, US

1 - Level-Set Methods for Finite-Sum Constrained Convex Optimization
Speaker: Qihang Lin, University of Iowa, US, talk 357
Co-Authors: *Runchao Ma*, *Tianbao Yang*,
We consider the constrained optimization where the objective function and the constraints are defined as summation of finitely many loss functions. This model has applications in machine learning such as Neyman-Pearson classification. We consider two level-set methods to solve this class of problems, an existing inexact Newton method and a new feasible level-set method. To update the level parameter towards the optimality, both methods require an oracle that generates upper and lower bounds as well as an affine-minorant of the level function. To construct the desired oracle, we reformulate the level function as the value of a saddle-point problem using the conjugate and perspective of the loss functions. Then a stochastic variance-reduced gradient method with a special Bregman divergence is proposed as the oracle for solving that saddle-point problem. The special divergence ensures the proximal mapping in each iteration can be solved in a closed form. The total complexity of both level-set methods using the proposed oracle are analyzed.
2 - Estimation of Markov Chain via Rank-constrained Likelihood
Speaker: Xudong Li, Princeton University, US, talk 413
Co-Authors: *Mengdi Wang*, *Anru Zhang*,
In this talk, we study the recovery and state compression of low-rank Markov chains from empirical trajectories. We propose a non-convex estimator based on rank-constrained likelihood maximization. Statistical upper bounds are provided for the Kullback-Leiber divergence and the ℓ_2 risk between the estimator and the true transition matrix. The estimator reveals a compressed state space of the Markov chain. We also develop a novel DC (difference of convex function) programming algorithm to tackle the rank-constrained non-smooth optimization problem. Convergence results are established. Experiments with taxi trip data show that the estimator is able to identify the zoning of Manhattan city.
3 - Random gradient extrapolation for distributed and stochastic optimization
Speaker: Guanghui Lan, Georgia Institute of Technolog, US, talk 1584
we consider a class of finite-sum convex optimization problems defined over a distributed multiagent network with m agents connected to a central server. In particular, the objective function consists of the average of m (>=1) smooth components associated with each network agent together with a strongly convex term. Our major contribution is to develop a new randomized incremental gradient algorithm, namely random gradient extrapolation method (RGEM), which does not require any exact gradient evaluation even for the initial point, but can achieve the optimal $O(\log(1/\epsilon))$ complexity bound in terms of the total number of gradient evaluations of component functions to solve the finite-sum problems. Furthermore, we demonstrate that for stochastic finite-sum optimization problems, RGEM maintains the optimal $O(1/\epsilon)$ complexity (up to a certain logarithmic factor) in terms of the number of stochastic gradient computations, but attains an $O(\log(1/\epsilon))$ complexity in terms of communication rounds (each round involves only one agent). It is worth noting that the former bound is independent of the number of agents m, while the latter one only linearly depends on m or even square root m for ill-conditioned problems. To the best of our knowledge, this is the first time that these complexity bounds have been obtained for distributed and stochastic optimization problems. Moreover, our algorithms were developed based on a novel dual perspective of Nesterov's accelerated gradient method.
4 - An Accelerated Algorithm for Stochastic Three-composite Optimization
Speaker: Renbo Zhao, NUS ISEM, MIT ORC, SG, talk 261
Co-Authors: *William Haskell*, *Vincent Tan*,
We develop an accelerated primal-dual fist-order algorithm for a class of stochastic three-composite convex optimization problems. This problem class includes many important instances, such as (graph-guided) fused Lasso, sparse portfolio optimization and robust matrix recovery. Our algorithm applies to both convex and strongly convex objective functions. We derive the convergence rates of our algorithm in both the convex and strongly convex cases (in expectation and with high probability). In both cases, our algorithm leads to significantly improved convergence rates compared to the state-of-the-art. In particular, the convergence rate is optimal in the convex case. We extend our algorithm to solve multi-composite convex optimization problems, e.g., sparse overlapping group Lasso. In addition, we connect our algorithm to the accelerated stochastic alternating direction method of multipliers (ADMM) algorithm.

Graphs and clutters

Discrete Optimization & Integer Programming
COMB - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 41 Building: C, 3rd floor, Zone: 1
Invited Session 263
Organizer: Gerard Cornuejols, Carnegie Mellon University, US

1 - Packing cycles in a tournament
Speaker: Guoli Ding, Louisiana State University, US, talk 1593
We characterize tournaments for which its arc sets of directed cycles is Mengerian.
2 - Min-Max Theorems for Packing and Covering Odd (u,v)-trails
Speaker: Sharat Ibrahimpur, University of Waterloo, CA, talk 1172
Co-Authors: *Chaitanya Swamy*,
We investigate the problem of packing and covering edge-disjoint odd (u, v)-trails in a graph. A (u, v)-trail is a (u, v)-walk that is allowed to have repeated vertices but no repeated edges. We call a trail odd if the number of edges in the trail is odd. Let $\nu(u, v)$ denote the maximum number of edge-disjoint odd (u, v)-trails, and $\tau(u, v)$ denote the minimum size of an edge-set that intersects every odd (u, v)-trail. We prove that $\tau(u, v) \leq 2 \cdot \nu(u, v) + 1$ and provide examples to show that the bound is tight. Our proof also yields a polynomial-time algorithm for finding a cover and a collection of trails satisfying the above bounds. Our proof is simple and has two main ingredients. We show that the problem can be reduced to that of packing/covering odd $(\{u, v\}, \{u, v\})$-trails (trails with both endpoints in $\{u, v\}$). In doing so, we lose a factor of 2 either in the number of trails found, or in the size of the cover. Complementing this, we show that the packing and covering problems for odd $(\{u, v\}, \{u, v\})$-trails can be tackled

by exploiting a powerful min-max result of Chudnovsky et al. for packing vertex-disjoint nonzero A-paths in group-labeled graphs. We also provide a tight min-max theorem for the packing number of edge-disjoint odd $(\{u,v\},\{u,v\})$-trails in terms of bipartite subgraphs of G that contain u and v on the same side of the bipartition.

3 - Cuboids, a class of clutters

Speaker: Ahmad Abdi, University of Waterloo, CA, talk 633

Co-Authors: *Gerard Cornuejols*, *Dabeen Lee*, *Natalia Guricanova*,

The Tau=2 Conjecture, the Replication Conjecture and the f-Flowing Conjecture, and the classification of binary matroids with the sums of circuits property are foundational to Clutter Theory and have far-reaching consequences in Combinatorial Optimization, Matroid Theory and Graph Theory. We prove that these conjectures and result can equivalently be formulated in terms of *cuboids*, which form a special class of clutters. Cuboids are used as means to (a) manifest the geometry behind primal integrality and dual integrality of set covering linear programs, and (b) reveal a geometric rift between these two properties, in turn explaining why primal integrality does not imply dual integrality for set covering linear programs. Along the way, we see that the geometry supports the Tau=2 Conjecture. Studying the geometry also leads to over 700 new ideal minimally non-packing clutters over at most 14 elements, a surprising revelation as there was once thought to be only one such clutter.

4 - Deltas, extended odd holes and their blockers

Speaker: Dabeen Lee, Carnegie Mellon University, US, talk 627

Co-Authors: *Ahmad Abdi*,

A delta is the clutter over ground set 1, 2, ..., n whose members are 1, 2, 1, 3, ..., 1, n, 2, 3, ..., n, where n is an integer at least 3. An extended odd hole is any clutter over ground set 1, 2, ..., n whose minimum cardinality members are 1, 2, 2, 3, ..., n-1, n, n, 1, where n is an odd integer at least 5. Deltas, extended odd holes and their blockers are the simplest classes of non-ideal clutters, as pointed out by Alfred Lehman. Now let C be a clutter without a member of cardinality one. If nonnegative weights can be assigned to the elements of C so that every member gets its weight more than half the sum of all weights, then C is non-ideal by Alfred Lehman's width-length inequality. In fact, it turns out that such a clutter must contain a delta or the blocker of an extended odd hole as a minor. In this talk, we will sketch a proof of this result, which relies on tools for finding delta minors and extended odd hole minors. This is joint work with Ahmad Abdi

Numerically Efficient Methods for Piecewise Algorithmic Differentiation II

Specific Models, Algorithms, and Software

Algo - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 22 Building: G, 2nd floor, Zone: 6

Invited Session 270

Organizer: Torsten Bosse, FSU Jena, DE

1 - Pushing the Algorithmic Differentiation tool Tapenade towards new languages

Speaker: Laurent Hascoet, INRIA, FR, talk 1534

Co-Authors: *Valerie Pascual*,

Software tools for Algorithmic Differentiation (AD) face the challenge of increasingly varied application languages. Potential application codes are no longer only in Fortran, but now in C, C++, Java, Python, and many others. While these languages offer greater elegance and flexibility to the programmer, they use constructs that are challenging for AD, such as dynamic memory, objects, dynamic types, overloading, various flavors of preprocessors, etc. The AD tool (Tapenade) developed by our team is a source-to-source transformation tool and as such is very sensitive to the issues that these constructs pose for static code analysis. Still, source-to-source AD is very desirable for the efficient derivative code that it provides. We will present recent developments in our AD tool that address two of these challenges: management of Objects and polymorphism, and differentiation of codes that mix different languages. On Objects, we connected our tool to a Clang-based front-end and then adapted our program internal representation to hold classes. Our memory representation, which is the basis of all our static data-flow analysis, had to be deeply reorganized to handle objects and inheritance. For AD of mixed-language applications, we extended the inter-procedural capacity of our tool to accomodate cross-language calls. We put particular emphasis on supporting the Fortran 2003 standard for interaction with C. We will demonstrate a first successful application to the structural mechanics library Calculix.

2 - Generalized Sensitivity Analysis of Nonlinear Programs

Speaker: Peter Stechlinski, University of Maine, US, talk 340

Co-Authors: *Kamil Khan*, *Paul Barton*, *Amir Akbari*, *Johannes Jaschke*,

Generalized sensitivity analysis theory is presented for solutions of parametric NLPs exhibiting active set changes. Motivated by problems in, for example, nonlinear model predictive control, local sensitivity information is obtained in the form of generalized derivative elements. Such elements can be supplied to dedicated nonsmooth methods with guaranteed attractive convergence properties, and are therefore computationally relevant. Moreover, the newly created theory is practically implementable. A new tool in nonsmooth analysis called the lexicographic directional derivative is used extensively in this work. Two distinct approaches are discussed: first, an application of a nonsmooth implicit function theorem to a nonsmooth NLP KKT system reformulation is considered. Under appropriate regularity conditions (i.e. LICQ and SSOSC), this approach yields a nonsmooth sensitivity system that admits primal and dual variable sensitivities as its unique solution. The classical results of Fiacco and McCormick are recovered in the absence of active set changes. Next, generalized derivative information is furnished via solving a sequence of quadratic programs under the same regularity conditions, followed by relaxed regularity conditions (i.e. MFCQ, CRCQ and GSSOSC) using multiparametric programming theory.

3 - Evaluating generalized derivatives efficiently for nonsmooth composite functions

Speaker: Kamil Khan, McMaster University, CA, talk 1435

Several established methods for nonsmooth optimization and nonsmooth equation-solving rely on generalized derivatives to provide useful local sensitivity information. These generalized derivatives include elements of Clarke's generalized Jacobian and Nesterov's lexicographic derivatives. In recent years, the first automatable and computationally tractable methods have been developed for computing these generalized derivatives for finite compositions of smooth functions and simple nonsmooth functions. This presentation describes a efficient “branch-locking” method that improves on these methods by drawing on the efficient reverse mode of automatic differentiation for smooth functions. When applied to a nonsmooth composite function, this method first carries out an inexpensive probing phase to strategically determine a smooth auxiliary function – a “branch” – whose derivative is a generalized derivative of the original function. The derivative of the smooth branch is then computed efficiently using automatic differentiation. Implications and examples are discussed.

4 - Optimality Conditions for Nonsmooth Constrained Optimization Problems

Speaker: Lisa Hegerhorst, Leibniz Universität Hannover, DE, talk 726

Nonsmoothness arises in many practical optimization problems. We discuss as an example the stationary gas network planning, in particular mixing and propagation equations. Here, nonsmoothness can be expressed by means of min(·) and max(·). This can be recast in so-called abs-normal form where every occurence of nonsmoothness is expressed in terms of the absolute value function. For the class of unconstrained nonlinear nonsmooth minimization there have recently been developed necessary as well as sufficient first- and second-order optimality conditions. We extend the theory to nonsmooth constrained optimization and discuss illustrative examples.

High-Performance Computing in Optimization I

Specific Models, Algorithms, and Software

Algo - Th 9:00am-10:30am, Format: 3x30 min

Room: Salle 18 Building: I, 1st floor, Zone: 7

Invited Session 271

Organizer: Kibaek Kim, ANL, US

1 - Performance Assessment for Parallel MILP Solvers

Speaker: Ted Ralphs, Lehigh University, US, talk 1347

Co-Authors: *Stephen Maher*, *Yuji Shinano*,

This talk focuses both on the challenges of achieving good performance when parallelizing an MILP solver and on the challenges of assessing that performance. Performance measurement for parallel solvers presents many challenges, especially since parallel solvers must be assessed both on their raw performance and on their scalability. We describe the challenges associated with performing "traditional" analyses for both scalability and performance, including that of choosing an appropriate test set. This is particularly difficult in the case of parallel MILP both because solvers may have much different strengths and because we typically require instances to be solvable on a single core, which may be unrealistic. We focus on methods by which solvers with disparate capabilities can still be compared in terms of scalability and performance, as well as on methods by which unsolvable instances can still be incorporated into test sets. We also propose some new methods of assessing scalability and visualizing computational comparison data.

2 - Ubiquity Generator Framework to parallelize state-of-the-art B and B based solvers

Speaker: Yuji Shinano, Zuse Institute Berlin, DE, talk 1181

The Ubiquity Generator (UG) framework, a software package that allows to parallelize branch-and-bound solvers in particular solvers for mixed integer linear programming (MILP) problems. ParaSCIP, which is realized by UG, is the most successful parallel MILP solver in terms of solving previously unsolvable instances from the well-known benchmark instance set MIPLIB by using supercomputers. It has solved two instances from MIPLIB2003 and 12 from MIPLIB2010 for the first time to optimality by using up to 80,000 cores on supercomputers. A customized ParaSCIP for the Steiner Tree Problem has solved three open instances from SteinLib. ParaXpress, which is another parallel MILP solver realized by UG, has solved three open instances and has the potential to run over a million CPU cores. This talk presents the ground design and general features of UG, and the current development.

3 - Branching Strategies on Decomposition Methods for Mixed-Integer Programming

Speaker: Kibaek Kim, ANL, US, talk 1510

Co-Authors: *Brian Dandurand*,

We consider a parallel dual decomposition that decouples a large-scale MIP problem into tractable smaller subproblems by the Lagrangian relaxation of coupling constraints in the problem. On top of it, a branch-and-bound method can be run in order to ensures integer feasibility with respect to the primal integer variables. We have implemented the branch-and-bound on parallel dual decomposition in the software framework DSP. This allows us to experiment several branching strategies for the decomposition setting. We also present the implementation details for data structure, methods, and parallelization. Computational results are presented for various problem instances.

Parallel Computing and Sustainability

Discrete Optimization & Integer Programming

CP - Th 8:30am-10:30am, Format: 4x30 min

Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 296

Organizer: Bistra Dilkina, Univ of Southern California, US

1 - Designing the game to play in security and sustainability domains

Speaker: Fei Fang, Carnegie Mellon University, US, talk 70

Co-Authors: *Zheyuan Shi*, *Ziye Tang*, *Long Tran-Thanh*, *Rohit Singh*,

Legislation agencies can determine the amount of penalty when a poacher gets caught at different locations in protected areas. Inspired by this problem, we study Stackelberg Security Games where the defender, in addition to allocating defensive resources to protect targets from the attacker, can strategically manipulate the attacker's payoff under budget constraints in weighted L^p-norm form regarding the amount of change. For weighted L^1-norm case, we first present a discretized mixed integer linear program model with approximation guarantee. Together with a greedy algorithm, we design a branch-and-bound based algorithm which employs effective pruning. Further, we present a polynomial time approximation scheme for a special but practical class of problems. In addition, we show polynomial time algorithms for L^{inf} and L^0 case. Extensive numerical experiments are performed to demonstrate the effectiveness of our solution methods. In L^1-norm case, we show the branch-and-bound algorithm with an approximation guarantee can solve real-world sized problems efficiently. In L^0 case, we show the proposed polynomial time algorithm with optimality guarantee significantly outperforms MILP approach in runtime.

2 - A Robust Optimization Model for an Invasive Species Management Problem

Speaker: Nahid Jafari, SUNY Farmingdale, US, talk 893

Co-Authors: *Austin Phillips*, *Panos Pardalos*,

Invasive species pose a significant threat to global biodiversity. Managing invasive species often involves modeling the species' spread pattern, estimating control costs and damage costs due to the invasion, designing control efforts, and accounting for uncertainties in model parameters. Dealing with uncertainty is arguably the most important part of the process, since biological, environmental, and economic factors can cause parameter values to vary greatly. Managers need decision tools that are robust to such limited or variable information. Here, we present a robust spatial optimization model to select treatment sites in a way that maximally reduces the size of an invasive population, given a constraint on financial resources. We develop an integer programming model that includes population dynamics and management costs over space and time. The model incorporates uncertainty in the available budget and the invasive spread rate as sets of discrete scenarios to determine a robust, cost-effective management plan in a novel way.

3 - Parallel HYbridization for Simple Heuristics

Speaker: Salvador Abreu, University of Évora, PT, talk 25

Co-Authors: *Danny Múnera*, *Daniel Diaz*, *Jheisson Lopez*,

Many applications can be naturally formulated as Combinatorial Optimization Problems, the solution of which is often challenging due to their intrinsic difficulty. At present, the most effective methods to address the hardest problems entail the hybridization of metaheuristics and cooperative parallelism. Recently, a framework called CPLS has been proposed, which eases the cooperative parallelization of local search solvers. Being able to run different heuristics in parallel, CPLS has opened a new way to hybridize metaheuristics, thanks to its cooperative parallelism mechanism. However, CPLS is mainly designed for local search methods. In the present work we seek to overcome the current CPLS limitation, extending it to enable population-based metaheuristics in the hybridization process. We discuss an initial prototype implementation for Quadratic Assignment Problem combining a Genetic Algorithm with two local search procedures. Our experiments on hard instances of QAP show that this hybrid solver performs competitively w.r.t. dedicated QAP parallel solvers.

4 - Parallel Search, Ordering, Reproducibility, and Scalability

Speaker: Ciaran McCreesh, University of Glasgow, GB, talk 214

Co-Authors: *Blair Archibald*, *Ruth Hoffmann*, *Patrick Prosser*, *Phil Trinder*,

Parallel combinatorial search is complicated: as well as extreme irregularity, for decision and optimisation problems, the size of the search space can vary massively depending upon how quickly a solution is found. I'll review some early work on parallel branch and bound algorithms, which gives theoretical guarantees on how to achieve reproducibility (the same algorithm on the same instance on the same hardware takes roughly the same amount of time when repeated) and scalability (parallel can never be substantially worse than sequential, and having more processors can never make things worse). I'll discuss how these guarantees can and cannot be extended to support features used in more modern constraint programming search algorithms. I'll also present empirical evidence that work balance (keeping each processor busy) is often not the most significant problem when parallelising search. There has been considerable work on variable- and value-ordering heuristics, and for best results, parallel search must be designed with a deep understanding of sequential search strategies in mind. Finally, I'll give an overview of a possible way forward, which could make parallel search both easier to implement and less risky to use: I'll introduce ongoing work on abstracting search using algorithmic skeletons with programmable schedulers.

Performance Analysis

Discrete Optimization & Integer Programming

CP - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 47 Building: A, 3rd floor, Zone: 1

Invited Session 298

Organizer: Charlotte Truchet, Université de Nantes, FR

1 - The Shapley Value and the Temporal Shapley Value for Algorithm Analysis

Speaker: Lars Kotthoff, University of Wyoming, US, talk 1138

Co-Authors: *Alexandre Fréchette*, *Alexandre Fréchette*, *Alexandre Fréchette*, *Alexandre Fréchette*, *Alexandre Fréchette*,

It is surprisingly difficult to quantify an algorithm's contribution to the state of the art. Reporting an algorithm's standalone performance wrongly rewards near-clones while penalizing algorithms that have small but distinct areas of strength. Measuring an algorithm's marginal contribution is better, but penalizes sets of strongly correlated algorithms, thereby obscuring situations in which it is essential to have at least one algorithm from such a set. Neither of these measures takes time into account, penalizing algorithms that are no longer state-of-the-art, but were when they were introduced. In this talk, I will argue that contributions should be analyzed via a measure drawn from coalitional game theory, the Shapley value, and its time-sensitive cousin, the temporal Shapley value. The temporal Shapley Value maintains the desirable properties of the Shapley Value, but allows to take the time algorithms were introduced into account, with the context of the state of the art at the time. These measures characterize the contribution of an algorithm fairly and can yield insight into a research community's progress over time. The proposed measures are applied to the famous quicksort algorithm and algorithms from the AI areas of satisfiability and constraint programming. The results illustrate the benefits of the Shapley Value and its temporal cousin, and allow insights into how the respective fields have developed.

2 - Phase transitions in random constraint satisfaction problems

Speaker: Guilhem Semerjian, LPT-ENS, FR, talk 510

In the 90's numerical simulations have unveiled striking properties of random ensembles of constraint satisfaction problems (satisfiability and graph coloring in particular). When a parameter of the ensemble (the density of constraints per variable) increases the probability of a satisfying instance drops abruptly from 1 to 0 in the large size limit. This threshold phenomenon has motivated a lot of research activity in theoretical computer science, mathematics, and statistical physics. The latter perspective, that will be reviewed during this talk, has yielded quantitative conjectures on the location of the satisfiability threshold, a much more detailed description of the structure of the satisfiable phase, and suggested new algorithmic strategies. Some of these insights have been later on turned into mathematically rigorous results.

3 - A probabilistic study of the propagation of the AllDifferent constraint

Speaker: Charlotte Truchet, Université de Nantes, FR, talk 906

Co-Authors: *Xavier Lorca*, *Danièle Gardy*,

We will present a probabilistic analysis of the behaviour of the propagation of the AllDifferent constraint. In Constraint Programming, the propagation mechanism is one of the key tools for solving hard combinatorial problems. Propagators are called a large number of times during the resolution process. But in practice, these algorithms may do nothing: their output is equal to their input. Our goal is to recognize such situations, so as to avoid useless calls. We propose to quantify this phenomenon in the particular case of the AllDifferent constraint (bound consistency propagator). We will introduce a probabilistic model for the constraint propagation, and compute the probability that a call to the propagation algorithm for AllDifferent does modify its input. We give an asymptotic approximation of this probability, depending on some macroscopic quantities related to the variables and the domains, that can be computed in constant time. This reveals two very different behaviors depending of the sharpness of the constraint. We will finally present preliminary results on extensions of this work to other cardinality constraints.

4 - Improving Energetic Propagations for Cumulative Scheduling

Speaker: Alexander Tesch, Zuse Institute Berlin, DE, talk 727

We consider the Cumulative Scheduling Problem (CuSP) in which n non-preemptive multiprocessor jobs are scheduled on parallel machines according to release and due dates. In scheduling terms, the CuSP corresponds to the feasibility version of $P|r_j, size_j|L_{max}$ where $L_{max} = 0$ iff the CuSP is feasible. In constraint programming, the CuSP is modeled as *cumulative* constraint. The CuSP is strongly NP-complete and is solved by branching combined with propagation algorithms to compute stronger release and due dates of the jobs. Among the most common propagation algorithms, there are Edge-Finding and Energetic Reasoning. We present a novel stronger propagation rule that improves the current $O(n^3)$ complexity of Energetic Reasoning to $O(n^2 \log n)$. We further show that a special case yields a complete edge-finding algorithm with complexity of $O(n^2)$ that also improves upon the current $O(kn \log n)$ complexity where $k \leq n$ is the number of different $size_j$ values. The improvement is achieved from a single machine relaxation of the problem. We also present first computational results and possible enhancements.

First-order methods for large-scale convex problems

Specific Models, Algorithms, and Software Learning - Th 8:30am-10:30am, Format: 4x30 min

Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 316

Organizer: Stephen Vavasis, University of Waterloo, CA

1 - A single potential governing convergence of CG, AG and Geometric Descent

Speaker: Stephen Vavasis, University of Waterloo, CA, talk 582

Co-Authors: *Sahar Karimi*,

Nesterov's accelerated gradient (AG) method for minimizing a smooth strongly convex function f is known to reduce $f(x_k) - f(x^*)$ by a factor of $\epsilon \in (0,1)$ after $k = O(\sqrt{L/\ell}\log(1/\epsilon))$ iterations, where ℓ, L are the two parameters of smooth strong convexity. Furthermore, it is known that this is the best possible complexity in the function-gradient oracle model of computation. Modulo a line search, the geometric descent (GD) method of Bubeck, Lee and Singh has the same bound for this class of functions. The method of linear conjugate gradients (CG) also satisfies the same complexity bound in the special case of strongly convex quadratic functions, but in this special case it can be faster than the AG and GD methods. Our main result is analyses of the three methods that share several common threads: all three analyses show a relationship to a certain "idealized algorithm", all three establish the convergence rate through the use of the Bubeck-Lee-Singh geometric lemma, and all three have the same potential that is computable at run-time and exhibits decrease by a factor of $1 - \sqrt{\ell/L}$ or better per iteration.

2 - Robust Accelerated Gradient Method

Speaker: Mert Gurbuzbalaban, Rutgers University, US, talk 1106

We study the trade-off between rate of convergence and robustness to gradient errors in designing a first-order algorithm. In particular, we focus on gradient descent (GD) and Nesterov's accelerated gradient (AG) method for strongly convex quadratic objectives when the gradient has random errors in the form of additive white noise. To characterize robustness, we consider the asymptotic normalized variance of the centered iterate sequence which measures the asymptotic accuracy of the iterates. Using tools from robust control theory, we develop a tractable algorithm that allows us to set the parameters of each algorithm to achieve a particular trade-off between these two performance objectives. Our results show that there is a fundamental lower bound on the robustness level of an algorithm for any achievable rate. For the same achievable rate, we show that AG with tuned parameters is always more robust than GD to gradient errors. Similarly, for the same robustness level, we show that AG can be tuned to be always faster than GD. Our results show that AG can achieve acceleration while being more robust to random gradient errors. This behavior is quite different than previously reported in the deterministic gradient noise setting. This is joint work with Necdet Serhat Aybat, Alireza Fallah and Asu Ozdaglar.

3 - Randomized methods for convex feasibility problems and applications to ML

Speaker: Peter Richtarik, KAUST, SA, talk 385

Co-Authors: *Ion Necoara*, *Andrei Patrascu*,

Finding a point in the intersection of a collection of closed convex sets, i.e., the convex feasibility problem, represents the main modeling strategy for many computational problems. In this paper we analyze new stochastic reformulations of the convex feasibility problem in order to facilitate the development of new algorithms. We also analyze the conditioning problem parameters using certain (linear) regularity assumptions on the individual convex sets. Then, we introduce a general random projection algorithmic framework, which extends many existing projection schemes designed for the general convex feasibility problem to random projection schemes. Our general random projection algorithm allows to project simultaneously on several sets, thus providing great flexibility in matching the implementation of the algorithm to the parallel architecture at hand. Based on the conditioning parameters, besides the asymptotic convergence results, we also derive explicit sublinear and linear convergence rates for this general algorithmic framework. Finally, we describe applications to machine learning.

4 - Bregman Divergence for Stochastic Variance Reduction

Speaker: Yaoliang Yu, University of Waterloo, CA, talk 937

Co-Authors: *Xinhua Zhang*, *Zhan Shi*,

Adversarial machines, where a learner competes against an adversary, have regained much recent interest in machine learning. They are naturally in the form of saddle-point optimization, often with separable structure but sometimes also with unmanageably large dimension. In this work we show that adversarial prediction under multivariate losses can be solved much faster than they used to be. We first reduce the problem size exponentially by using appropriate sufficient statistics, and then we adapt the new stochastic variance-reduced algorithm of Balamurugan and Bach (2016) to allow any Bregman divergence. We prove that the same linear rate of convergence is retained and we show that for adversarial prediction using KL-divergence we can further achieve a speedup of example times compared with the Euclidean alternative. We verify the theoretical findings through extensive experiments on two example applications: adversarial prediction and LPboosting.

Large-scale learning

Specific Models, Algorithms, and Software

Learning - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 335

Organizer: Lorenzo Rosasco, university of genoa-iit-mit, IT

1 - The power of interpolation: on the effectiveness of SGD in modern learning

Speaker: Mikhail Belkin, Ohio State University, US, talk 930

A striking feature of modern supervised machine learning is its pervasive over-parametrization. Deep networks contain millions of parameters, often exceeding the number of data points by orders of magnitude. These networks are trained to nearly interpolate the data by driving the training error to zero. While we still don't understand these interpolated solutions generalize so well to test data, we can now understand why the ubiquitous stochastic gradient descent (SGD) is so effective at minimizing the loss despite mixed theoretical evidence. Specifically, I will show that in the interpolated regime SGD is far more computationally efficient than full gradient descent (up to a factor proportional to the data size). I will provide an analysis of the computational efficiency of SGD as a function of mini-batch size and describe the best step size, and the optimal batch size selection. I will also discuss how these funding can be used to adapt algorithms to optimally use computational resources, such as GPU. Joint work with Siyuan Ma and Raef Bassily.

2 - Precision on the Brain: Low-Precision to High-Precision for Machine Learning

Speaker: Chris Re, Stanford, US, talk 1302

This talk describes two algorithms at the opposite end of the precision spectrum that share a nascent technical link. The first algorithm called HALP (High-Accuracy, Low-Precision) uses low precision iterates to compute high-precision solutions using a simple bit re-centering technique and is able to take advantage of new hardware architectures. For strongly convex problems that are mildly well conditioned, HALP converges at a linear rate. The second is an algorithm for a form of principal geodesic analysis in the Poincaré disk model of hyperbolic space that requires a high-precision solver. In both cases, reasoning about a link between precision and an appropriate notion of conditioning is the key to providing convergence guarantees and giving practical run-time guidance.

3 - Iterate averaging as regularization for stochastic gradient descent

Speaker: Gergely Neu, Universitat Pompeu Fabra, ES, talk 776

Co-Authors: *Lorenzo Rosasco*,

We propose and analyze a variant of the classic Polyak-Ruppert averaging scheme, broadly used in stochastic gradient methods. Rather than a uniform average of the iterates, we consider a weighted average, with weights decaying in a geometric fashion. In the context of linear least squares regression, we show that this averaging scheme has a the same regularizing effect, and indeed is asymptotically equivalent, to ridge regression. In particular, we derive finite-sample bounds for the proposed approach that match the best known results for regularized stochastic gradient methods.

4 - Convergence vs stability: a regularization view on accelerated methods

Speaker: Lorenzo Rosasco, university of genoa-iit-mit, IT, talk 632

First order methods are the preferred solutions in many large scale problems because of their ease of implementation and small computational footprint. Acceleration strategies are often used to reduce the number of iterations needed to achieve a prescribed accuracy level. In many practical situations, however, acceleration methods can be seen to be less stable than their the basic counterparts. This natural raises the question of what is the interplay between convergence speed and stability, and how it can be characterized. In this talk, we study this question considering a regularization perspective, where estimation and computational aspects are considered in a unified framework.

Optimal Control of Variational Inequalities and Complementarity Systems

Continuous Optimization
Control - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Contributed Session 336
Chair: Alexandre Vieira, INRIA Grenoble, FR

1 - Optimal control of Linear Complementarity Systems
Speaker: Alexandre Vieira, INRIA Grenoble, FR, talk 1618
Co-Authors: *Bernard Brogliato*, *Christophe Prieur*,
This presentation will focus on necessary and sufficient conditions for the Optimal Control problem of Linear Complementarity Systems (LCS):

$$\min \int_0^T \langle x, Qx\rangle + \langle u, Uu\rangle$$

$$s.t.\ \dot{x} = Ax + Bv + Fu,$$

$$0 \leq v \perp Cx + Dv + Eu \geq 0$$

where A, B, C, D, E, F, Q, U are matrices of according dimensions. LCS are a class of strongly nonlinear and nonsmooth dynamical systems. This optimal control problem is a generalization of Mathematical Programs with Equilibrium Constraints (MPEC). First, we will sketch how necessary conditions can be put into the form of an LCS, which is numerically tractable. Secondly, we will show two numerical methods for computing an approximate solution for this problem, using algorithms suited for MPEC. One of this method uses the first order condition previously derived. A comparison between the two methods will be carried, and we will show the efficiency of the two methods. The numerical examples will allow us to deduce some properties that the optimal controller have, and also highlight theoretical results. Some results concerning the minimal time problem for LCS will also be presented.
2 - Computing a Subgradient for the Solution Operator of the Obstacle Problem
Speaker: Anne-Therese Rauls, TU Darmstadt, DE, talk 1013
Co-Authors: *Stefan Ulbrich*,
The obstacle problem is an important prototype of an elliptic variational inequality and it appears in the mathematical formulation of applications from physics, finance and other fields. When dealing with constraints of obstacle type in optimization problems, the main difficulty is the nondifferentiability of the corresponding solution operator. In this talk we determine and characterize a specific element of the Bouligand subdifferential respective to the solution operator of the obstacle problem. We construct an abstract sequence of differentiability points whose derivatives converge to a subgradient. In order to show this convergence, a precise analysis of the relevant set-valued mappings connected to the Gâteaux derivatives is necessary. The limit and thus the subgradient itself is determined by the solution of a variational equation, which is independent of the abstract approximating sequence. We suggest how the resulting PDE can be tackled from a numerical point of view and we investigate problems that have to be taken care of when applying discretization or approximation schemes in order to obtain inexact subgradients.
3 - Optimal Control of Thermoviscoplasticity
Speaker: Ailyn Stötzner, TU Chemnitz, DE, talk 1590
Co-Authors: *Roland Herzog*, *Christian Meyer*,
Elastoplastic deformations play a tremendous role in industrial forming. Many of these processes happen at non-isothermal conditions. Therefore, the optimization of such problems is of interest not only mathematically but also for applications. In this talk we will present the analysis of the existence of a global solution of an optimal control problem governed by a thermovisco(elasto)plastic model. We will point out the difficulties arising from the nonlinear coupling of the heat equation with the mechanical part of the model. Finally, we will discuss some numerical results.
4 - Optimal Control of Elastoplasticity Problems with Finite Deformations
Speaker: Anna Walter, TU Darmstadt, DE, talk 1096
Co-Authors: *Stefan Ulbrich*,
We consider the optimal control of elastoplasticity problems with frictional contact. Since the conditions for plasticity as well as for contact with friction are physically described by complementarity conditions the resulting formulation is nonsmooth. Moreover, we deal with large deformations such that common approaches for infinitesimal deformations are not sufficient. Instead we use a hyperelastic material model with a multiplicative split of the deformation gradient into an elastic and a plastic part. On the basis of the physical model we rewrite the system as a quasivariational inequality of mixed kind and apply a time and space discretization. Afterwards we show an engineering application, the deep drawing, and present numerical results for the optimal control of this process. In order to solve the optimization problem we use a bundle trust region method with an adjoint based subgradient computation. Finally we use model order reduction techniques to speed up the simulation and thereby the optimization.

Bin Packing

Discrete Optimization & Integer Programming
APPROX - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4

Contributed Session 344
Chair: Frits Spieksma, TU Eindhoven, NL

1 - Automatically computed bounds for the online bin stretching problem
Speaker: Nadia Brauner, Université Grenoble Alpes, FR, talk 1057
Co-Authors: *Michaël Gabay*, *Vladimir Kotov*, *Valentin Bartier*,
In the online bin stretching problem, we are given a sequence of items defined by their weights $w_i \in [0; 1]$. They all have to be packed into m bins with infinite capacities. An algorithm with stretching factor c for the online bin stretching problem is an online algorithm which successfully packs into m bins

of size c, any sequence of items fitting into m unit sized bins. The aim is to find an algorithm having a stretching factor as small as possible. The online bin stretching problem was introduced by Azar and Regev in 2001. These authors proposed an algorithm with stretching factor 1.625 and proved that 4/3 is the smallest possible stretching factor for 2 bins. Then, this factor was improved to $11/7 \approx 1.5714$, $26/17 \approx 1.5294$ and then 1.5. The best stretching factor for 3 bins is 1.375. The upper bound of the stretching factor was regularly improved while the best lower bound remained the same since recently: 4/3. We use game theory techniques to automatically compute improved lower bounds on the stretching factor for the bin stretching problem: $19/14 \approx 1.3571$. This bound was calculated for 3 and 4 bins which leaves a slack of $1/56 \approx 0.018$ for 3 bins and $1/7 \approx 0.143$ from 4 bins.

2 - Batched bin packing

Speaker: Leah Epstein, University of Haifa, IL, talk 1256

Bin packing is the problem of partitioning a set of items of rational sizes in (0,1] into subsets of total sizes at most 1, called bins. This problem is also called standard or classic bin packing. In the offline scenario, items are all presented at once, as a set. In the online scenario, items are presented and packed one by one, without any knowledge on any properties of future items. Batched bin packing is an intermediate version which has features of both the online problem and the offline scenarios. In batched bin packing, items are presented in k batches, for a fixed integer k>1, such that the items of a batch are presented as a set, and must be packed before the items of the next batch are presented. In the disjoint model, the algorithm must pack the items of each batch into separate bins, and in the augmenting model, it may also use bins of previous batches for packing the current batch. We present tight bounds on the approximation ratio for the disjoint model, thus providing upper bounds for the augmenting model as well. We discuss other variants of batched bin packing and compare them to the classic variant.

3 - Online Packing of Arbitrary Size Items into Designated and Multipurpose Bins

Speaker: Shlomo Karhi, Bar-Ilan Univesity, IL, talk 681

Co-Authors: *Noam Goldberg*,

We consider an online multitype bin packing problem. The problem was introduced by Goldberg and Karhi (2017) who focused on the case of two item types and one and two item sizes. The problem was motivated by different transportation requirements of items that could be shipped in both standard or more costly refrigerated containers and items that must be shipped in the refrigerated containers. They showed a tight (also known as optimal) absolute competitive ratio of approximately 1.618 with up to two item sizes. Here we consider the general problem with arbitrary item sizes and show a lower bound of (approximately) 1.781 on the absolute competitive ratio of any online algorithm. Then we extend the fi rst-fi t algorithm to our problem setting and prove an absolute competitive ratio for this algorithm as a function of the bin costs, which in the worst case is shown to be upper bounded by 1.930. In addition we prove an upper bound on the worst-case asymptotic (as the number of items grows large) competitive ratio of 1.750.

4 - Partitioning Vectors into Quadruples

Speaker: Frits Spieksma, TU Eindhoven, NL, talk 847

Co-Authors: *Annette Ficker*, *Thomas Erlebach*, *Matus Mihalak*,

We consider a clustering problem where 4k given vectors need to be partitioned into k clusters of four vectors each. A cluster of four vectors is called a quad, and the cost of a quad is the sum of the component-wise maxima of the four vectors in the quad. The problem is to partition the given 4k vectors into k quads with minimum total cost. We analyze the worst-case behavior of a straightforward iterative matching-based algorithm, and prove that this algorithm is a 1.5-approximation algorithm for this clustering problem. We also look into the special case that arises when each vector is a binary vector containing exactly two ones – such an instance can be represented by a graph H that has a node for each component of a vector. We show that the resulting problem remains NP-hard, and that, for the special case where H is connected, the algorithm becomes a 1.25 approximation algorithm.

Multi-commodity flows

Specific Models, Algorithms, and Software

Network - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 358

Organizer: Ralf Borndörfer, ZIB, DE

1 - Monotonicity and conformality in multicommodity network-flow problems

Speaker: Daniel Granot, University of British Columbia, CA, talk 178

Our main objective is to develop a monotonicity theory for the important class of minimum convex-cost parametric multicommodity network-flow problems defined over general graphs. Our results allow us to determine when it is possible to predict, without numerical computations, the direction of change of optimal multicommodity flows resulting from changes in arc-commodity parameters. In particular, we provide necessary and sufficient conditions that for every cost function satisfying a submodularity-convexity-compactness hypothesis there exists an optimal multicommodity flow for which the flow of a commodity in a given arc a is nondecreasing (resp., nonincreasing) in the parameter of a distinct commodity in arc b. These conditions are that either (i) there are only two commodities and the underlying graph is series-parallel or (ii) there are three or more commodities and the graph is 2-isomorphic to a suspension graph. A characterization of the precise pairs of arcs for which the above monotonicity result holds is also provided.

2 - An exact method based on adaptive partitions for the Stochastic Fixed-Charge MCF

Speaker: Eduardo Moreno, Universidad Adolfo Ibanez, CL, talk 1428

Co-Authors: *Cristian Ramirez Pico*,

We study the Stochastic Fixed Charge Multicommodity Flow (SFCMF) problem, which is a classical strategic and tactical decision problem studied in supply chain and network design.The main idea of the problem is what given a known graph $G(V, E)$, we want to find the optimal subgraph which minimizes a total cost composed by fixed cost related to build a subset of edges $\hat{E} \subseteq E$ and a variable cost associated to the flow over the open edges, for a certain set of commodities or data. Recent developments in operations research aims to deal classical and new problems where the stochasticity is a key factor into the formulation. Thus, we present the SFCMF as a Two-Stage Stochastic Program including stochasticity on the commodities' demand. We propose an adaptive partition-based resolution method where using a relaxation of the original problem exploits some special features of its solution, yielding an algorithm converging in a finite number of iterations to the optimal solution. Mainly, the method is based on the aggregation of an exponential number of constraints and variables, since a partition includes a subset of added constraints, one per scenario. Also, each is scenario variable is added with the other ones belonging to the same partition. At each iteration, the algorithm refines quality of the partitions, improving the lower bound by solving a "Master problem" and, also, enhances the upper bound by solving the subproblems generated once we fix the first stage solutions. The experimental results and benchmark against classical methods will be shown.

3 - Approximate Wasserstein Distances of order 1 between images

Speaker: Stefano Gualandi, University of Pavia, IT, talk 1450
Co-Authors: *Marco Veneroni*, *Federico Bassetti*,

In this work, we present a method to compute the Wasserstein distance of order one between a pair images having N pixels. The main contribution of our work is to approximate the exact Wasserstein distance by solving an uncapacitated min cost flow problem defined on grid graphs of size O(N), using the network simplex algorithm. More precisely, when the distance among the pixels is measured with the 1-norm or the infinity-norm, our approach provides an optimal solution. When the distance between pixels is measured with the 2-norm: (i) we derive a quantitative estimate on the error between optimal and approximate solution; (ii) given the error, we construct a grid graph of size O(N). We numerically show the benefits of our approach on a large set of benchmark images used in the literature.

4 - Metric Inequalities for Routings on Direct Connections in Line Planning

Speaker: Ralf Borndörfer, ZIB, DE, talk 1461
Co-Authors: *Marika Karbstein*,

The talk considers multi-commodity flow problems in which capacities are installed on paths. In this setting, it is often important to distinguish between flows on direct connection routes, using single paths, and flows that include path switching. A feasibility condition for path capacities supporting such direct connection flows similar to the well-known feasibility condition for arc capacities in ordinary multi-commodity flows is derived. The concept allows to solve large-scale real-world line planning problems in public transport including a passenger routing model that favors direct connections over connections with transfers.

Stackelberg Games

Optimization under Uncertainty
Game - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 374
Chair: Stefano Coniglio, University of Southampton, GB

1 - Tropical geometry applied to bilevel programming

Speaker: Jean-Bernard Eytard, INRIA - Ecole Polytechnique, FR, talk 1375
Co-Authors: *Marianne Akian*, *Mustapha Bouhtou*, *Stephane Gaubert*, *Gleb Koshevoy*,

Tropical geometry allows one to represent the responses of agents to price signals by a polyhedral complex. We use this approach, together with discrete convexity methods, to obtain parametrized complexity results. In particular, we identify a class of bilevel programs that can be solved in polynomial time. We also show that the pricing schemes determined by the bilevel problems in this class are limits of competitive equilibria for indivisible goods. We finally present an application to a large scale bilevel problem arising in the optimal pricing of data traffic in a telecom network.

2 - Bilevel Programming for Combinatorial Exchanges with Budget Constraints

Speaker: Stefan Waldherr, TU Munich, DE, talk 295
Co-Authors: *Martin Bichler*,

Combinatorial exchanges allow buyers and sellers to specify package bids, i.e. a price is defined for a subset of the items for auction. The price is only valid for the entire package and the package is indivisible. Such types of markets have significant potential for the private and the public sector. Examples include day-ahead electricity markets, supply chain coordination and trading fishery access rights. Buyers often face budget constraints that limit their bids, even though they have significantly higher value for packages. However, since these constraints can usually not be expressed in the exchange, this can lead to depressed bidding and inefficiencies even in the presence of non-strategic bidders. We analyze pricing and different notions of stability in combinatorial exchanges where buyers have budget constraints. Our aim is welfare maximization subject to budget constraints and core-constraints in large non-convex markets. The computational complexity analysis yields that the allocation and pricing problems become Σ_2^p-hard with budget constraints by a reduction from the canonical Σ_2^p-complete problem $QSAT_2$. Bilevel mixed integer linear programs (MIBLP) are introduced to compute core prices. Further, we discuss restricted but simpler cases and effective computational techniques for the problem.

3 - Computing Pessimistic Leader-Follower Equilibria with Multiple Followers

Speaker: Stefano Coniglio, University of Southampton, GB, talk 1188

We investigate the problem of computing a Leader-Follower equilibrium in Stackelberg games where two or more followers react to the strategy chosen by the (single) leader by playing a Nash Equilibrium. We consider two natural cases, the optimistic one where the followers select a Nash Equilibrium maximizing the leader's utility and the pessimistic one where they select an equilibrium minimizing the leader's utility. We first illustrate that, in both cases, computing a Leader-Follower Nash equilibrium is NP-hard and not in Poly-APX unless P=NP and that even deciding whether one of the leader's actions would be played with strictly positive probability is NP-hard. We then focus on the pessimistic case with followers restricted to pure strategies, showing that this problem too is NP-hard and not in Poly-APX unless P=NP. After casting it as a pessimistic bilevel programming problem, we propose an exact implicit enumeration algorithm for its solution. In particular, our algorithm is capable of computing the maximum of the problem and, for the general case where the former only admits a supremum, an α-approximate strategy for any $\alpha \geq 0$. Experimental results are presented and illustrated, showing the viability of the proposed approach. This is joint work with Nicola Gatti and Alberto Marchesi

4 - A learning approach for selection of subgame perfect Nash equilibria

Speaker: Francesco Caruso, Univ. of Naples Federico II, IT, talk 361

Co-Authors: *Maria Ceparano*, *Jacqueline Morgan*,

In one-leader one-follower two-stage games, multiplicity of Subgame Perfect Nash Equilibria (henceforth SPNE) arises when the optimal reaction of the follower to any choice of the leader is not always unique, that is when the best reply correspondence of the follower is not a single-valued map. This paper concerns a new method to approach SPNEs which makes use of a sequence of SPNEs of perturbed games where the best reply correspondence of the follower is single-valued, i.e. a sequence of SPNEs of classical Stackelberg games. The sequence is generated by a learning method where the payoff functions of both players are modified subtracting a term that represents a physical and behavioural cost to move and which is linked to the Moreau-Yosida regularization. Firstly the effectiveness of the learning method is illustrated through an example, then existence results of SPNEs approached via this method are provided under mild assumptions on the data, together with connections with other methods to construct SPNEs.

Energy

Invited Talks

INTERFACE - Th 8:30am-10:30am, Format: 4x30 min

Room: SIGALAS Building: C, 2nd floor, Zone: 2

Contributed Session 387

Chair: Kazem Abbaszadeh, UoA, NZ

1 - Optimization Models for Geothermal Energy

Speaker: Rishi Adiga, The University of Auckland, NZ, talk 934

Co-Authors: *Andy Philpott*, *John O'Sullivan*,

Drilling geothermal wells for electricity generation has a very high capital cost. The location of the wells and their operation affects their production, and so it is important to maximize the value from the wells by optimizing these decisions. The economic outcomes from well placement and operational decisions can be determined approximately from large-scale computational models of geothermal reservoirs, which can simulate production under different operating policies and assumptions about environmental conditions. Example reservoir models of this sort are simulated with the AUTOUGH2 geothermal simulator. We combine the results of these simulations with a Mixed Integer Programming model to optimize well locations and start times. Binary decision variables are used to select the combination of wells and start times that would maximize total NPV. This model is extended to a stochastic MIP to account for uncertainty in the results of the numerical simulations, and information that accrues from the outcomes of drilling previous wells.

2 - Static robustness for EDF nuclear long term production planning

Speaker: Rodolphe Griset, EDF-INRIA, FR, talk 1647

Co-Authors: *Boris Detienne*, *Francois Vanderbeck*, *Marc Porcheron*, *Pascale Bendotti*, *Hugo Gevret*,

Long-term production planning for nuclear plans requires to schedule maintenance period about once a year. EDF has to optimize decisions on starting times for maintenance along with the associated refueling levels that prescribe the production capacities over the next year. The stochastic demands are modeled via scenarios and the objective is to minimize expected cost under recourse actions consisting in adjusting non-nuclear production and externalization. Here we further assume that maintenance durations are uncertain and unexpected shutdowns may be required. We report on several approaches to ensure robust satisfaction of scheduling constraints (that are linking the power plans individual schedules) and of the fuel stock constraints. We present preliminary results and we evaluate the robustness of our solutions in terms of feasibility with respect to a set of scenarios on plans' availability. Our output also provides the cost of robustness in this application.

3 - Optimization of district heating production operations

Speaker: Gabriela Maschietto, Veolia, FR, talk 1297

Co-Authors: *Phillipe Sampaio*, *Damien Chenu*, *Stephane Couturier*, *David Mouquet*,

District heating network (DHN) produces thermal energy from various sources at production plants and transports it over a distribution network to the buildings. DHNs are one of the driving forces for the rapid decarbonization and energy efficiency of modern societies. Despite its advantages, its European market share is still low due to the lack of tools to optimize them. We propose a production scheduling optimization tool that considers together heat production and distribution to maximize the DHN revenues. We use a Mixed-Integer Non-Linear Programming (MINLP) model where thermal storage system, several heat-only and cogeneration heat and power production units are handled. It also considers the connection between the production plant and different networks. The network dynamics is addressed through a black-box physical simulation model. In order to solve the problem for a real European case, we employ radial basis function models for the black-box functions and a MINLP solver. The obtained results are compared to DHN historical real planning. Acknowledgments: This work is part of the project E2District which has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant agreements no. 696009.

4 - Demand and reserve co-optimization for a price-making consumer of electricity

Speaker: Mahbubeh Habibian, University of Auckland, NZ, talk 947

Co-Authors: *Golbon Zakeri*, *Anthony Downward*,

We optimize the bidding policy for a major consumer of energy in an energy and reserve co-optimized electricity market. In our model, the major consumer has dispatchable demand, and it is able to offer interruptible load reserve. The large consumer is a strategic player, maximizing its profit, while meeting its required level of consumption over a long-time horizon. By reformulating the equilibrium constraints, we present a multi-stage stochastic dynamic programming. In order to solve our mixed integer program in an adequate time-frame we use heuristics while utilizing the intuition of stochastic dual dynamic programming.

Vehicle Routing I

Specific Models, Algorithms, and Software
Logistics - Th 9:00am-10:30am, Format: 3x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

Contributed Session 411
Chair: Guy Desaulniers, Polytechnique Montreal GERAD, CA

1 - The vehicle routing problem with stochastic and correlated travel times
Speaker: Guy Desaulniers, Polytechnique Montreal GERAD, CA, talk 506
Co-Authors: *Borzou Rostami*, *Fausto Errico*, *Andrea Lodi*,
We consider the capacitated vehicle routing problem with stochastic and correlated travel times where the uncertain travel times are assumed to be correlated and follow a multivariate distribution whose first and second moments are known. To find an efficient routing solution, we use a mean-variance approach where the routes with high travel time variability are penalized. This leads to a parametric binary quadratic program for which we propose two alternative set partitioning reformulations. One of them retains arc-flow variables and a quadratic term in the objective function. The other is an integer linear program where the quadratic costs are included in the cost coefficient of the route variables. For each model, we develop an exact branch-price-and-cut algorithm. In the first, the objective function of the master problem is quadratic. In the second, the column generation subproblem involves a quadratic cost function. The first algorithm can handle a general case where there can exist a correlation between the travel times of any pair of arcs and a simpler case, where such correlation exists only for adjacent arcs. The second algorithm is restricted to the latter case. Our computational results show the efficiency of our algorithms to find solutions with different means and variances. Instances with up to 32 customers can be solved by the first algorithm in the general case. In the adjacent case, the second algorithm outperforms the first and can solve instances with up to 75 customers.

2 - An exact formulation for pickup and delivery problem with divisible split-ups
Speaker: Bolor Jargalsaikhan, University of Groningen, NL, talk 1073
Co-Authors: *Ward Romeijnders*, *Kees Jan Roodbergen*,
In vehicle routing problems, it is well known that splitting up the loads of a delivery may lead to significant cost benefits. In this work, we consider a pickup and delivery problem with divisible split-ups. In offshore helicopter routing problems, several teams may be located at the same platform and need to be transported to different platforms. Teams at the same origin platform with different destinations may split up. Such split-ups can be addressed in a mathematical model by duplicating the platforms into fictitious nodes for each arriving and leaving team. Then the extended network can be solved as if it is a standard pickup and delivery problem without split-ups. However, the number of nodes increases significantly and it becomes numerically inefficient. In this paper, we provide a linear integer programming formulation on the original graph of the platforms without any duplications.

3 - Branch-and-Price for Probabilistic Vehicle Routing
Speaker: Mathias Klapp, PUC, CL, talk 388
Co-Authors: *Felipe Lagos*, *Alejandro Toriello*,
The Vehicle Routing Problem with Probabilistic Customers (VRP-PC) is a fundamental building block within the broad family of *a priori* and dynamic routing models and has two decision stages. In the first stage, the dispatcher determines a set of vehicle routes serving all potential customer locations before the actual requests for service realize. In the second stage, vehicles are dispatched after observing the subset of customers requiring service; a customer not requiring service is skipped from its planned route at execution. The objective is to minimize the expected vehicle travel cost assuming known customer realization probabilities. We propose a column generation framework to solve the VRP-PC to a given optimality tolerance. Compared to Branch and Cut approaches for the VRP-PC, our framework can handle sequence dependent constraints such as time windows. Specifically, we present two novel algorithms, one that underapproximates a solution's expected cost, and another that uses its exact expected cost. Each algorithm is equipped with a route pricing mechanism that iteratively improves the approximation precision of a route's reduced cost; this produces fast route insertions at the start of the algorithm and reaches termination conditions at the end of the execution. We provide a priori and a posteriori performance guarantees for these algorithms and test their performance on VRP-PC instances with time windows.

Graph theory

Discrete Optimization & Integer Programming
COMB - Th 8:30am-10:30am, Format: 4x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Contributed Session 422
Chair: Thomas Bellitto, University of Bordeaux, FR

1 - A Tight Cut Decomposition for Hypergraphs with Perfect Matchings
Speaker: Isabel Beckenbach, Zuse Institute Berlin, DE, talk 623
Co-Authors: *Sebastian Wiederrecht*, *Meike Hatzel*,
We investigate the structure of hypergraphs with perfect matchings using ideas from the theory of matching covered graphs. First, we generalise the notions of a tight cut, a tight cut contraction, and a tight cut decomposition to hypergraphs and examine the properties of tight cuts in general and uniform hypergraphs. Every tight cut decomposition of a hypergraph leads to a decomposition of its perfect matching polytope. As an application we show that the tight cut contractions of uniform balanced hypergraphs, which can be seen as a hypergraphic generalisation of bipartite graphs, remain balanced. A graph might have distinct tight cut decompositions. However, Lovasz showed that the indecomposable graphs, so-called bricks and braces, are always the same (up to multiplicity of edges) independent from the concrete decomposition. We proof that this remarkable result also holds for uniform hypergraphs. Furthermore, we give a counterexample for the general case. Finally, we investigate hypergraphs without non-trivial tight cuts and their properties.

2 - Densities, Matchings, and Fractional Edge-Colorings
Speaker: Xujin Chen, Chinese Academy of Sciences, CN, talk 771

Co-Authors: *Wenan Zang*, *Qiulan Zhao*,

Given a multigraph $G = (V, E)$ with a positive rational weight $w(e)$ on each edge e, the weighted density problem is to find a subset U of V, with $|U| \geq 3$ and odd, that maximizes $\frac{2w(U)}{|U|-1}$, where $w(U)$ is the total weight of all edges with both ends in U, and the weighted fractional edge-coloring problem can be formulated as the linear program

$$\max\{\mathbf{1}^T\mathbf{x} : A\mathbf{x} = \mathbf{w}, \mathbf{x} \geq \mathbf{0}\}$$

where A is the edge-matching incidence matrix of G. These two problems are closely related to the celebrated Goldberg-Seymour conjecture on edge-colorings of multigraphs, and have great interests in their own rights. We present strongly polynomial-time algorithms for solving them exactly, and develop a novel matching removal technique for multigraph edge-coloring.

3 - Making Bipartite Graphs DM-irreducible

Speaker: Yutaro Yamaguchi, Osaka University, JP, talk 566

Co-Authors: *Kristóf Bérczi*, *Satoru Iwata*, *Jun Kato*,

The Dulmage–Mendelsohn decomposition (or the DM-decomposition) gives a unique partition of the vertex set of a bipartite graph reflecting the structure of all the maximum matchings therein. A bipartite graph is said to be DM-irreducible if its DM-decomposition consists of a single component. In this talk, we focus on the problem of making a given bipartite graph DM-irreducible by adding edges. When the input bipartite graph is balanced (i.e., both sides have the same number of vertices) and has a perfect matching, this problem is equivalent to making a directed graph strongly connected by adding edges, for which the minimum number of additional edges was characterized by Eswaran and Tarjan (1976). We give a general solution to this problem in the sense of polynomial-time algorithms for finding a smallest set of additional edges and min-max characterizations of the minimum number, which generalize the result of Eswaran and Tarjan. In general, our problem can be formulated as a special case of a general framework of covering supermodular functions, which was introduced by Frank and Jordán (1995) to investigate the directed connectivity augmentation problem. Furthermore, when the input graph is not balanced, the problem is solved via matroid intersection. For balanced input graphs, we devise a direct combinatorial algorithm, which is much more efficient than solving the problem as supermodular covering. This talk is based on the same-title paper published by SIAM Journal on Discrete Mathematics in 2018.

4 - Optimal weighting to minimize the independence ratio of a graph

Speaker: Thomas Bellitto, University of Bordeaux, FR, talk 1414

Co-Authors: *Arnaud Pecher*,

The independence ratio of a weighted graph is the ratio between the maximum weight of an independent vertex set and the total weight of the graph. In this talk, we present how to find a weighting of the vertices of a graph that minimizes its independence ratio. This problem is motivated by the study of the maximum density of a set of $\mathbb{R}^n$ that does not contain two points at distance exactly one. This problem is closely related to other well-known problems including the Hadwiger-Nelson problem and tiling problems, and has applications in coding theory. In a previous publication with Christine Bachoc and Philippe Moustrou, we solved the Bachoc-Robins conjecture for several families of polytopes including the parallelohedra of dimension 2, but our proof involves a bound on the independence ratio of infinite graphs and does not extend easily in higher dimension. The work we present here allows us to achieve similar results on weighted finite graphs and to improve our bounds in dimension 3.

First Order Methods I

Continuous Optimization

NLP - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle KC7 Building: K, Intermediate 2, Zone: 10

Contributed Session 436

Chair: Sandra Santos, University of Campinas, BR

1 - Accelerating block coordinate descent methods with identification strategies

Speaker: Sandra Santos, University of Campinas, BR, talk 389

Co-Authors: *Ronaldo Lopes*, *Paulo Silva*,

This work is about active set identification strategies aimed at accelerating block-coordinate descent methods (BCDM) applied to large-scale problems. We start by devising an identification function tailored for bound-constrained composite minimization together with an associated version of the BCDM, called Active BCDM, that is also globally convergent. The identification function gives rise to an efficient practical strategy for Lasso and L1-regularized logistic regression. The computational performance of Active BCDM is contextualized using comparative sets of experiments that are based on the solution of problems with data from deterministic instances from the literature. These results have been compared with those of well-established and state-of-the-art methods that are particularly suited for the classes of applications under consideration. Active BCDM has proved useful in achieving fast results due to its identification strategy. Besides that, an extra second-order step was used, with favorable cost-benefit.

2 - On Matching Pursuit and Coordinate Descent

Speaker: Francesco Locatello, MPI - ETH Zurich, CH, talk 1642

Co-Authors: *Anant Raj*, *Sai Praneeth Karimireddy*, *Gunnar Rätsch*, *Bernhard Schölkopf*, *Sebastian Stich*, *Martin Jaggi*,

Two popular examples of first-order optimization methods over linear spaces are coordinate descent and matching pursuit algorithms, with their randomized variants. While the former targets the optimization by moving along coordinates, the latter considers a generalized notion of directions. Exploiting the connection between the two algorithms, we present a unified analysis of both, providing affine invariant sublinear $O(1/t)$ rates on smooth objectives and linear convergence on strongly convex objectives. As a byproduct of our affine invariant analysis of matching pursuit, our rates for steepest coordinate descent are the tightest known (improving the constants in the rates of Stich et al 2017 and Nutini et al 2015). Furthermore, we show the first accelerated convergence rate $O(1/t^2)$ for matching pursuit and steepest coordinate descent on convex objectives. We discuss the convergence guarantees of random pursuit methods which we analyze through the lens of matching pursuit. In particular, we present a unified analysis of both which allows us to carefully trade off the use of (approximate) steepest directions over random ones.

3 - A Unified Scheme to Accelerate Adaptive Cubic Regularization and Gradient Method

Speaker: Tianyi Lin, UC Berkeley, US, talk 198

Co-Authors: *Shuzhong Zhang*, *Bo Jiang*,

In this paper we propose a unified two-phase scheme for convex optimization to accelerate: (1) the adaptive cubic regularization methods with exact/inexact Hessian matrices, and (2) the adaptive gradient method, without any knowledge of the Lipschitz constants for the gradient or the Hessian. This is achieved by tuning the parameters used in the algorithm adaptively in its process of progression, which can be viewed as a relaxation over the existing algorithms in the literature. Under the assumption that the sub-problems can be solved approximately, we establish overall iteration complexity bounds for three newly proposed algorithms to obtain an ϵ-approximate solution. Specifically, we show that the adaptive cubic regularization methods with the exact/inexact Hessian matrix both achieve an iteration complexity in the order of $O(1/\epsilon^{1/3})$, which matches that of the original accelerated cubic regularization method presented in [Nesterov-2008-Accelerating] assuming the availability of the exact Hessian information and the Lipschitz constants, and that the sub-problems are solved to optimality. Under the same two-phase adaptive acceleration framework, the gradient method achieves an iteration complexity in the order $O(1/\epsilon^{1/2})$, which is known to be best possible (cf. Nesterov-2013-Introductory).Our numerical experiment results show a clear effect of acceleration displayed in the adaptive Newton method with cubic regularization on a set of regularized logistic regression instances.

4 - Performance Estimation for Fixed Point Iterations

Speaker: Felix Lieder, Heinrich-Heine University, DE, talk 7

In recent years exact worst-case performance estimation of first-order methods has gained great attention: It is now well established (especially, but not solely, due to the work of de Klerk, Drori, Glineur, Hendrickx, Taylor and Teboulle) that we can find tight convergence rates for smooth (strongly) convex functions via semidefinite programming. Here we attempt to transfer the existing approach to the broader setting of fixed point iterations of non-expansive operators. Specifically we consider two fixed point iterations, first the Halpern-Iteration and second the Krasnoselskii-Mann-Iteration. In both cases we focus on the convergence of the norm of the residuals as our performance criterion of interest. We are able to improve the existing bounds on the convergence rate and, more importantly, show tightness of our second bound. One notable consequence is the following: Since the gradient method with constant step-size, for the case of smooth convex functions, can be regarded as a special type of Krasnoselskii-Mann Iteration we present a new and (interestingly) also tight bound for the convergence rate of the norm of the gradients. Finally we discuss applications and possible future extensions, such as different performance criteria and automated algorithm modeling.

New applications of robust optimizations

Optimization under Uncertainty

Robust - Th 9:00am-10:30am, Format: 3x30 min

Room: Salle 33 Building: B, Ground Floor, Zone: 5

Contributed Session 461

Chair: Mirjam Duer, Augsburg University, DE

1 - Condition and geometric measures for consistency in intertemporal optimization

Speaker: Jorge Vera, Catholic University of Chile, CL, talk 1113

Co-Authors: *Rodrigo Cofre*,

In many applications, decisions are made in various stages or horizons. For instance, aggregate production planning decisions are done in tactical horizons and then the detail is managed in short term planning. Optimization models have been used for long in this area and one typical problem is how to deal with the inconsistencies that arise many times from uncertainties present in the different decisions stages. Stochastic approaches like 2-stage models have been used in this context as well as robust approaches. On the other hand, some optimization problems could be more sensible to data perturbations than others and the more sensible ones will have a higher risk of being affected by uncertainties. Theoretical developments in recent decades have studied condition and geometric measures associated to optimization problems, which can assess the sensitivity of a model to data perturbation and, hence, to the risk of uncertainty exposure. In this work we show how some of those measures con be connected to measures of robustness, illustrating this with application to some real-world models. We also show how a 2-stage decision model can be modified to incorporate condition and geometric measures to reduce the sensitivity of the second stage problem to data perturbation and, hence, to the risk of uncertainty. We illustrate and evaluate the computational solution of these problems in some simulated experiments.

2 - Compositional Stochastic Optimization with Kernels for Robust Online Learning

Speaker: Alec Koppel, U.S. Army Research Laboratory, US, talk 47

Co-Authors: *Amrit Bedi Singh*, *Ketan Rajawat*,

In supervised learning, we learn a statistical model by minimizing some merit of fitness averaged over data. Doing so, however, ignores the model variance which quantifies the gap between the optimal within a hypothesized function class and the Bayes Risk. We propose to account for both the bias and variance by modifying training procedure to incorporate *coherent risk* which quantifies the uncertainty of a given decision. We develop the first online iterative solution to this problem when estimators belong to a reproducing kernel Hilbert space (RKHS), which we call Compositional Online Learning with Kernels (COLK). COLK addresses the fact that (i) minimizing risk functions requires handling objectives which are compositions of expected value problems by generalizing the two time-scale stochastic quasi-gradient method to RKHSs; and (ii) the RKHS-induced parameterization has complexity which is proportional to the iteration index which is mitigated through greedily constructed subspace projections. We establish almost sure convergence of COLK with attenuating step-sizes, and linear convergence in mean to a neighborhood with constant step-sizes, as well as the fact that its worst-case complexity is bounded. Experiments on data with heavy-tailed distributions illustrate that COLK exhibits robustness to outliers, consistent performance across training runs, and thus marks a step towards ameliorating the problem of overfitting.

3 - Robust Approach for Stratified Sampling Allocation Problems

Speaker: Mirjam Duer, Augsburg University, DE, talk 1010

A central problem in survey sampling is the optimal allocation of samples to entities of a population. The primary goal of the allocation is to minimize the variances of estimated totals of the population under the given cost. The optimal solution in stratified sampling relies on the stratum specific variances of the (multiple) variables of interest. However, these stratum specific variances are generally not known precisely. Also, the stratum specific cost is not known precisely and can vary within a given interval. In order to account for these uncertainties we formulate a robust optimization model for this multivariate stratified allocation problem. Using robust optimization, we seek an optimal allocation which is feasible for any realization of the uncertain variances and costs. A sample problem is considered and solved in order to validate the applicability of the model. Joint work with: Jan Pablo Burgard, Ralf Muennich, Mohammad Asim Nomani

Dynamical systems, control and optimization

Specific Models, Algorithms, and Software

Learning - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 16 Building: I, 2nd floor, Zone: 7

Contributed Session 470

Chair: Benjamin Recht, UC Berkeley, US

1 - Tangent Space Regularization for Neural-Networks Models of Dynamical Systems

Speaker: Fredrik Bagge Carlson, Automatic Control, Lund Uni., SE, talk 1303

Co-Authors: *Anders Robertsson*, *Rolf Johansson*,

This work considers the problem of tangent space regularization for neural-network models of dynamical systems. The tangent space to the dynamics function of many physical systems of interest in control applications exhibits useful properties, e.g., smoothness, motivating regularization of the model Jacobian along system trajectories using assumptions on the tangent space of the dynamics. Without assumptions, large amounts of training data are required for a neural network to learn the full non-linear dynamics globally. Previous work has addressed efficient learning of LTV models with an emphasis on their utility in learning the Jacobian along a trajectory. In this work, we demonstrate the effectiveness of Jacobian propagation for tangent-space regularization using Jacobians provided by estimated LTV models. We compare different network architectures on one-step prediction and simulation performance and investigate the propensity of different architectures to learn models with correct input-output Jacobian. Furthermore, the influence of L_2 weight regularization on the learned Jacobian eigenvalue spectrum, and hence system stability, is investigated.

2 - The sample complexity of iteratively learning to control

Speaker: Benjamin Recht, UC Berkeley, US, talk 1217

Given the dramatic successes in machine learning and reinforcement learning over the past half decade, there has been a resurgence of interest in applying these techniques to continuous control problems in robotics, self-driving cars, and unmanned aerial vehicles. Though such control applications appear to be straightforward generalizations of standard reinforcement learning, few fundamental baselines have been established prescribing how well one must know a system in order to control it. In this talk, I will discuss how one might merge techniques from statistical learning theory with robust optimization to derive such baselines for such continuous control. Drawing connections to iterative methods for optimization, I will explore several examples that balance parameter identification against controller design and demonstrate finite sample tradeoffs between estimation fidelity and desired control performance. I will describe how these simple baselines give us insights into benefits and shortcomings of existing methodology in reinforcement learning and iterative learning control. I will close by listing several exciting open problems that must be solved before we can build robust, safe learning systems that interact with an uncertain physical environment.

3 - Optimization-based adaptive control using a system level approach.

Speaker: Nikolai Matni, UC Berkeley, US, talk 1311

In this talk we present an adaptive algorithm for an LQR optimal control problem wherein the underlying dynamics are unknown. The estimation component of our online algorithm relies on recent results on the identification of a linear time invariant system using a single observed trajectory which provide sharp bounds on the quality of our system parameter estimates. Using these bounds and nominal estimates, we then formulate a novel robust controller synthesis problem using the system level approach to controller synthesis, which allows us to quantify the degradation in performance of our system as a function uncertainty size. In this way, we provide, to the best of our knowledge, the first practical algorithm (with polynomial time complexity) that does not require unrealistic or unverifiable assumptions and that achieves sublinear regret. This is joint work with Horia Mania, Stephen Tu, and Benjamin Recht.

4 - Lyapunov arguments in optimization

Speaker: Ashia Wilson, UC Berkeley, US, talk 1622

This talk is about Lyapunov functions and how they are used to obtain upper bounds for most algorithms in optimization. I will discuss the viewpoint of algorithms as discrete-time dynamical systems and show how numerical analysis techniques and Lyapunov functions can be used to obtain novel methods.

New results in chance-constrained optimization

Optimization under Uncertainty

Stoch - Th 8:30am-10:30am, Format: 4x30 min

Room: DENIGES Building: C, Ground Floor, Zone: 5

Contributed Session 489

Chair: Bismark Singh, Sandia National Laboratories, US

1 - Smoothing Methods for Chance Constrained Optimization of Elliptic PDE Systems

Speaker: Abebe Geletu, Technische Univerisität Ilmena, DE, talk 1312

Co-Authors: *Armin Hoffmann*, *Patrick Schmidt*, *Pu Li*,
Partial differential equations (PDEs) are widely used to describe various physical, biological and natural processes. Realistic PDE models commonly contain parameters that vary randomly and spatially, so that such parameters can be considered as random fields. In addition, there are also uncertain influences from the environment, e.g., ambient tem- perature and pressure, which can be modeled as random forcing terms of the PDE system. When a PDE model involves random parameters and/or random forcing terms, the states (or solutions) of the PDE system become random. As a result, constraints on the states of the PDE systems cannot hold deterministically. Hence, in this work, inequality constraints on state variables are formulated as chance (probabilistic) constraints, leading to a chance constrained optimization problem of elliptic PDEs (CCPDE). Under standard assumptions, we verify that CCPDE is a convex optimization problem. Furthermore, since chance constrained optimization problem are generally nonsmooth and difficult to solve directly, we propose a smoothing inner-outer approximation method to generate a sequence of smooth approximate problems for the CCPDE. Thus, the optimal solution of the convex CCPDE is approximable through optimal solutions of the inner-outer approximation problems. A numerical example demonstrates the viability of the proposed approach.

2 - Dynamic chance constraints under random distributiond

Speaker: René Henrion, Weierstrass Institute Berlin, DE, talk 1395

The talk discusses several aspects of modeling, analytical properties and numerical solution approaches for optimization problems with dynamic chance constraints under continuously distributed random parameters. The dynamic character of the constraints takes the analysis into an infinite-dimensional context. This raises new challenging questions when compared to a traditional static setting. The talk will approach questions like existence of solutions, piecewise linear decision rules, spheric-radial decomposition and time consistency.

3 - Differentiabilty of joint chance constraints under weakened LICQ

Speaker: Armin Hoffmann, TU Ilmenau, DE, talk 382

Co-Authors: *Abebe Geletu*, *Pu Li*,

<p align="justify"> In [1] the continuous differentiability of a single chance constraint $p(u) = \Pr(X(u)) \geq \alpha$ with $X(u) = \{\xi \mid g(u,\xi) \leq 0\}$ in some neighbourhood W of u_0 is shown where $g \in C^1(\mathbb{R}^m \times \mathbb{R}^p, \mathbb{R})$ and the probability distribution possesses a density. In [2] it is extended to a joint chance constraint where $g \in C^1\left(\mathbb{R}^m \times \mathbb{R}^p, \mathbb{R}^d\right)$ and $d > 1$. In the contribution the used LICQ for $g(u_0, \cdot)$ on the boundary $\partial X(u_0)$ in [2] is weakened to $\nabla g_i(u_0, \cdot) \neq 0$ on $\partial X(u_0)$ for $i = 1, 2, ...d$. Additionally, the former valid nonlinear metric regularity [3] and the zero measure of $p-2$ dimensional submanifolds of $X(u)$ w.r.t. the $p-1$ dimensional surface measure are assumed. Main tool is as in [1], [2] the lower and upper analytic approximation of p by families of smooth functions converging to p. It is shown that their gradients uniformly converge over W. Hence the limit of the gradients is $\nabla p \in C^1(W, \mathbb{R}^m)$.
 [1] A. Geletu, A. Hoffmann, M. Klöppel, Pu Li: An inner-outer approximation approach to chance constrained optimization. SIAM J. OPTIM. 27(2917) 3, 1834-1857.
 [2] A. Geletu, A. Hoffmann, Pu Li: Analytic approximation and differentiability of joint chance constraints. Optimization (submitted 12/2017).
 [3] A. Y. Kruger: Nonlinear Metric Subregularity. J. Optim. Theory Appl. 171(2016), 820–855. </p>

4 - Approximating Chance Constrained Programs using Classical Inequalities

Speaker: Bismark Singh, Sandia National Laboratories, US, talk 1589

Co-Authors: *Jean-Paul Watson*,

We consider a joint-chance constraint (JCC) as a union of events, and approximate this union using bounds from classical probability theory. When these bounds are used in an optimization model constrained by the JCC, we obtain corresponding upper and lower bounds on the optimal objective function value. We investigate the strength of these bounds under two different sampling schemes, and observe that a larger correlation between the uncertainties results in a more computationally challenging optimization model.

Topics in multistage and integer stochastic optimization

Optimization under Uncertainty

Stoch - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Invited Session 490

Organizer: Jim Luedtke, University of Wisconsin-Madiso, US

1 - Three-Stage Stochastic Airline Scheduling Problem

Speaker: Ozge Safak, Bilkent University, TR, talk 1293

Co-Authors: *Ozlem Cavus*, *Selim Akturk*,

We propose a three-stage stochastic programming model which determines flight timing, fleeting and routing decisions while considering the uncertainties in passenger demand and non-cruise times. Our model differs from the existing two-stage stochastic models by considering not only flight timing and potential passenger demand, but also operational expenses, such as fuel burn and carbon emission costs. We include cruise time controllability to compensate for non-cruise time variability to satisfy the time requirements of the passenger connections. We handle nonlinear functions of fuel and emission costs associated with cruise speed adjustments by utilizing the mixed integer second order cone programming. Because the three-stage stochastic model leads to a large decision tree, we suggest a scenario group-wise decomposition algorithm to obtain lower and upper bounds for the optimal value of the proposed model. The lower and upper bounds are obtained by solving a number of group subproblems, which are similar to proposed multi-stage stochastic model defined over a reduced number of scenarios. We present a cutting plane algorithm to efficiently solve scenario group subproblems. In the numerical experiments, we provide a significant cost savings over two-stage stochastic programming and deterministic approaches. TUBITAK [Grant 116M542]

2 - State space analysis of a stochastic DP to deal with curse of dimensionality

Speaker: Mehdi Karimi-Nasab, Institute for OR, Uni Hamburg, DE, talk 351

Stochastic dynamic programing (SDP) is a powerful tool to optimize multi-period problems, where some kind of randomness should be considered at every stage of decision making because the decisions are chained together in the state space. Curse of dimensionality is a common observed character of an SDP, where it refers to the need of checking an exponentially growing number of decisions as the algorithm goes from one stage to the next stage. Hence, the SDP normally either encounters with memory overflow or will take long because it needs an exponential order of computations. None of these phenomenons is desired for practitioners. Thus, if it becomes possible to skip checking the set of non-optimal decisions for a given set of states at some intermediary stages, the SDP can cope with curse of dimensionality, where it can find the optimal policy in a practically reasonable amount of CPU time. In this talk, a production planning problem is studied under the assumption that the lifespan of a unit of inventory is a random variable which follows a general finite discrete probability distribution function. The production manager wants to minimize the (expected) total cost due to setups, production, inventory holding, shortages and inventory perishability, while taking into account the fact that a random number of product units in the inventory can perish independently in every period. The trade-off between different costs makes it hard to determine the optimal policy, while for every decision about the inventory volume, there are different probabilistic consequences and vice versa.

3 - Partitioned Subgradient Methods for Stochastic Mixed Integer Program duals

Speaker: Cong Han Lim, UW-Madison, US, talk 1196

Co-Authors: *Jeff Linderoth*, *Jim Luedtke*, *Stephen Wright*,

We present our work on improving the subgradient method for handling consensus problems with difficult subproblems, a special case of which includes the Langrangian dual of a stochastic mixed-integer program. In particular, we describe a simple partitioning-based framework for subgradient algorithms that allows them to run more efficiently in a distributed or multi-core setting. We focus on a simple partitioned variant of the standard subgradient method and discuss extensions. Computational results on some larger instances of SIPLIB problems will be shown.

4 - Lagrangian dual decision rules for multistage stochastic integer programs

Speaker: Jim Luedtke, University of Wisconsin-Madiso, US, talk 104

Co-Authors: *Merve Bodur*, *Maryam Daryalal*,

We consider Lagrangian dual decision rules for multi-stage stochastic integer programming problems. We investigate techniques for using these decision rules to obtain bounds on the optimal solution and a primal policy, and compare the strength of the relaxation obtained from different techniques. Preliminary numerical results will be presented.

Convexity and Polytopes

Discrete Optimization & Integer Programming

IPtheory - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 35 Building: B, Intermediate, Zone: 4

Contributed Session 518

Chair: David Warme, Group W, Inc., US

1 - Box-Total Dual Integrality and k-Edge-Connectivity

Speaker: Emiliano Lancini, LIPN - Université Paris 13, FR, talk 1651

Co-Authors: *Roland Grappe*, *Mathieu Lacroix*, *Michele Barbato*, *Roberto Wolfler Calvo*,

The concept of total dual integrality dates back to the works of Edmonds, Giles and Pulleyblank in the late 70's, and is strongly connected to min-max relations in combinatorial optimization. In this work we show a characterization of series-parallel graphs in terms of box-total dual integrality of the k-edge-connected spanning subgraph polyhedron. The system $Ax \geq b$ is totally dual integral (TDI) if, for each integer vector c for which $\min\{cx : Ax \geq b\}$ is finite, there exists an integer optimal solution of $\max\{yb : yA = c, y \geq 0\}$ such that:

$$\min\{cx : Ax \geq b\} = \max\{yb : yA = c, y \geq 0\}.$$

It is known that every integer polyhedron can be described by a TDI system $Ax \geq b$ with A and b integer. The integrality of the TDI system is desirable because, then we have a min-max relation between combinatorial objects. We are interested in the stronger property of box-TDIness. A system $Ax \geq b$ is called box-TDI if the system $Ax \geq b, \ell \leq x \leq u$ is TDI for all rational vectors ℓ and u. A polyhedron that can be described by box-TDI system is called a box-TDI polyhedron. This definition is motivated by the fact that any TDI system describing a box-TDI polyhedron is box-TDI. The past few years, this property has received a renewed interest and several new box-TDI systems were discovered. We prove that, for $k \geq 2$, the k-edge-connected spanning subgraph polyhedron is a box-TDI polyhedron if and only if the graph is series-parallel. Moreover, in this case, we provide a box-TDI system with integer coefficients describing this polyhedron.

2 - On the Circuit Diameter Conjecture

Speaker: Tamon Stephen, Simon Fraser University, CA, talk 1403

A key concept in optimization is the combinatorial diameter of a polyhedron. From the point of view of optimization, we would like to relate it to the number of facets f and dimension d of the polyhedron. In the seminal paper of Klee and Walkup, the Hirsch conjecture, that the bound is $f - d$, was shown to be equivalent to several seemingly simpler statements, and was disproved for unbounded polyhedra through the construction of a particular 4-dimensional polyhedron with 8 facets. The Hirsch bound for polytopes was only recently narrowly exceed by Santos. We consider analogous questions for a variant of the combinatorial diameter called the circuit diameter. In this variant, paths are built from the circuit directions of the polyhedron, and can travel through the interior. We show that many of the Klee-Walkup results and techniques translate to the circuit setting. However, in this setting we are able to verify the 4-dimensional version of a d-step conjecture for unbounded polytopes, which fails in the combinatorial case. This is joint work with Steffen Borgwardt and Timothy Yusun.

3 - The role of extreme points for convex hull operations.

Speaker: Filipe Cabral, UFRJ, BR, talk 1107

Co-Authors: *Bernardo Costa*, *Joari Costa*,

We present a connection between the Lift and Project algorithm of Balas and the SDDiP algorithm of Zou, Ahmed, and Sun. Both algorithms apply convex programming techniques to solve non-convex problems and rely on preserving certain boundary points of non-convex sets under the convex hull operation. Since the preserved points are closely related to the extreme points of particular convex sets, we call this property the blessing of extreme points. In the case of a non-convex feasible set, the convexification does not add points to special affine spaces, and in the case of a non-convex function, the duality gap of the Lagrangian Relaxation is zero at special points. We introduce two versions of the blessing of extreme points: 1) A discrete version that includes Balas's theorem as a particular case of a convex hull for simplexes. Our version covers more general geometries that could lead to further generalizations of the Lift and Project algorithm; and 2) A continuous version that explains the "blessing of binary" of the SDDiP algorithm, and how the dimensionality of the underlying space enables one to obtain zero duality gap at several chosen points. We build our arguments on an extension of the convex hull formula for the union of closed convex sets, which was proposed by Ceria and Soares using stronger hypothesis. We also comment on the relation of this formula with disjunctive programming.

4 - Metrics for Strength of Inequalities with Respect to a Polytope

Speaker: David Warme, Group W, Inc., US, talk 777

"Measure what is measurable, and make measurable what is not so." [Attributed to Galileo] Experience with cutting-planes has taught us that "all inequalities are not created equal." Certain inequalities close major portions of the gap, while thousands of others collectively do little. The former inequalities are said to be "strong" while the latter are "weak." Strength is a very desirable, yet ethereal quality that causes computations to converge quickly. We follow Galileo's advice by proposing several metrics $m(H,P)$ that assign a real number to each pair of linear inequality (hyperplane) H and polytope P. (Note these metrics are independent of any objective function.) There is a compelling intuitive case for each metric, capturing some property that "strong" inequalities should possess. We compute two of these metrics for each of 5 families of facet-defining inequalities from two distinct polytopes (TSP and the spanning tree in hypergraph polytopes). Both metrics confirm all known computational experience with these inequalities on both problems, with both metrics giving remarkably consistent appraisals across each inequality family – good evidence that these metrics are useful surrogates for measuring "strength" of said inequalities. We give two practical applications: (1) Using insight from the metrics, we greatly improve the separation algorithms of GeoSteiner, as shown by computational results. (2) The metrics provide empirical evidence for why the MST in hypergraph problem gets vastly better performance out of its subtour inequalities than the TSP.

Non smooth optimization for lage scale poblems

Continuous Optimization

NonSmooth - Th 8:30am-10:30am, Format: 4x30 min

Room: Salle 9 Building: N, 4th floor, Zone: 12

Invited Session 556

Organizer: Yu Du, University of Colorado Denver, US

1 - Selective Linearization for Multi-block Statistical Learning Problems

Speaker: Yu Du, University of Colorado Denver, US, talk 280

Co-Authors: *Andrzej Ruszczynski*,

We consider the problem of minimizing a sum of several convex non-smooth functions. In this talk, we introduce the selective linearization method, which iteratively linearizes all but one of the functions and employs simple proximal steps. The algorithm is a form of multiple operator splitting in which the order of processing partial functions is not fixed, but rather determined in the course of calculations. It proposes one of the first operator-splitting type methods which are globally convergent for an arbitrary number of operators without artificial duplication of variables. This algorithm is a multi-block extension of the alternating linearization (ALIN) method for solving structured non-smooth convex optimization problems. Global convergence is proved and estimates of the convergence rate are derived. Specifically, under a strong convexity condition, the number of iterations needed to achieve solution accuracy ϵ is of order $O(\ln(1/\epsilon)/\epsilon)$. The convergence rate analysis technique invented by us can also be used to derive the rate of convergence of the classical bundle method and ALIN method, for which no convergence rate estimate has been available so far. We also study the optimal tuning parameters in the improvement test of the algorithm. We report results of extensive comparison experiments in statistical learning problems such as large-scale fused lasso regularization problem, overlapping group lasso problem and regularized support vector machine problem. The numerical results demonstrate the efficacy and accuracy of the method

2 - Randomized Proximal Algorithm with Automatic Dimension Reduction.

Speaker: Dmitry Grishchenko, Univ. Grenoble Alpes, FR, talk 1426

Co-Authors: *Franck Iutzeler*, *Jerome Malick*, *Massih-Reza Amini*,

Optimization problems in machine learning and signal processing applications often involve objective functions made of a smooth data-fidelity term plus nonsmooth convex regularization term. Proximal algorithms are popular methods for solving such composite optimization problems. Most of the popular regularizers have in fact a strong geometric structure, which implies specific identification properties of proximal algorithms; more precisely, the convergence towards an optimal solution is such that after a finite number of iterations, all iterate lies in the low-complexity subspace related to the one of the optimal solution. In this work, we present a random proximal-gradient algorithm that uses this identification property to automatic reduce of the numerical cost of solving special composite problems, for instance when ℓ_1 and TV regularizers are used. Our algorithm naturally extends to a distributed optimization set-up, where a master-machine combines all the results computed in parallel by slave-machines. In this case, our proximal algorithm leverage on identification to gain in both faster gradient computations and lower cost of communications between machines.

3 - Inexact proximal memoryless spectral-scaling MBFGS method

Speaker: Shummin Nakayama, Tokyo University of Science, JP, talk 225

Co-Authors: *Yasushi Narushima*, *Hiroshi Yabe*,

In this talk, we deal with a proximal type method for the minimization of a composite function that is the sum of a smooth convex function and a nonsmooth convex function. Such a problem appears in machine learning and hence it is important to develop an efficient numerical method for solving the problem. Recently, a particular attention is paid to Newton-type proximal methods which make use of proximal mappings weighted by the Hessian matrix or its approximation. Since the calculation of the proximal mapping is much expensive, inexact Newton-type proximal methods, which calculate the proximal mapping inexactly, have been studied. In order to calculate proximal mappings more easily, we propose an inexact proximal method based on the memoryless spectral-scaling MBFGS method. We analyze convergence properties of the proposed method within the framework of an Armijo type line search.

4 - Decomposition methods for computing d-stationary solutions for nonconvex problem

Speaker: Min Tao, Nanjing University, CN, talk 3

Co-Authors: *Jong-Shi Pang*,

Motivated by block partitioned problems arising from group sparsity representation and generalized non-cooperative potential games, this paper presents a basic decomposition method for a broad class of multi-block nonsmooth nonconvex optimization problems. By taking advantage of the structure in the objective with minus max function, the developed algorithm and its convergence result are aimed atthe computation of a blockwise directional stationary solution, which arguably is the sharpest stationary solutions. Furthermore, in order to lessen the potential computational burden, a probabilistic version of the algorithm is presented and its almost sure convergence is established.

Cutting Planes in the Extended Space

INVITED TALKS

KEYNOTE - Th 11:00am-12:00am, Format: 1x60 min

Room: BROCA Building: W, 3rd floor, Zone: 0

INVITED SESSION 543

Organizer: Adam Letchford, Lancaster University, GB

1 - Cutting Planes in the Extended Space

Speaker: Oktay Gunluk, IBM Research, US, talk 1629

For a given formulation of an optimization problem, an extended formulation is one which uses additional variables to represent the same problem in an extended space. In integer programming literature there is a significant body of work that focuses on constructing compact polyhedral descriptions of integer programs in this framework. In this talk, we take a different approach and study the effect of adding cutting planes in the extended space for mixed-integer programs. We show that for 0-1 problems, even when the initial extended formulation is not stronger than the original LP formulation, it is possible to obtain the convex hull of integer solutions after adding one round of split cuts. This idea also leads to an lift-and-project operator with better theoretical properties than other similar operators. We also consider what we call binarization schemes that produce extended formulations by expressing each bounded integer variable with a collection of auxiliary binary variables. We present a hierarchy of such binarization schemes and present numerical experiments.

Effective Scenarios and Scenario Reduction for Risk-Averse Stochastic Programs

INVITED TALKS

KEYNOTE - Th 11:00am-12:00am, Format: 1x60 min

Room: DENIGES Building: C, Ground Floor, Zone: 5

INVITED SESSION 544

Organizer: Jim Luedtke, University of Wisconsin-Madiso, US

1 - Effective Scenarios and Scenario Reduction for Risk-Averse Stochastic Programs

Speaker: Tito Homem-de-Mello, Universidad Adolfo Ibanez, CL, talk 1598

Co-Authors: *Sebastian Arpon*, *Bernardo Pagnoncelli*, *Hamed Rahimian*, *Guzin Bayraksan*,

In this talk we discuss some scenario reduction methods for risk-averse stochastic optimization problems. Scenario reduction techniques have received some attention in the literature and are used by practitioners, as such methods allow for an approximation of the random variables in the problem with a moderate number of scenarios, which in turn makes the optimization problem easier to solve. The majority of works for scenario reduction are designed for classical risk-neutral stochastic optimization problems; however, it is intuitive that in the risk-averse case one is more concerned with critical scenarios that correspond to high cost. The identification of such critical scenarios can be accomplished using the notion of effective scenarios recently introduced in the literature in the context of distributionally robust optimization problems. According to that notion, a scenario is effective if the removal of that scenario — defined in a precise way — causes a change in the optimal objetive function value; in some cases, it is posible to identify the effective scenarios analytically. By building upon these tools, we propose a scenario reduction technique for stochastic optimization problems where the objective function is a Conditional Value-at-Risk. The numerical results presented with problems from the literature illustrate the performance of the method and indicate the general cases where we expect it to perform well.

The BARON software for MINLP

INVITED TALKS

SEMI - Th 11:00am-12:00am, Format: 1x60 min

Room: Auditorium Building: Symph H, Gambetta, Zone: 0

INVITED SESSION 547

Organizer: Claudia D Ambrosio, LIX, FR

1 - The BARON software for MINLP

Speaker: Nikolaos Sahinidis, Carnegie Mellon University, US, talk 1558

The BARON project for the global optimization of NLPs and MINLPs began in the early 1990s. The project has led to the introduction of a number of methodologies to the forefront of global optimization, including domain reduction techniques, finite branching schemes for continuous problems, polyhedral relaxations, dynamic convexity detection, and the use of multi-term relaxations, multi-constraint relaxations, integer programming relaxations, and portfolios of relaxations in branch-and-bound algorithms. In this talk, we review key developments in the history of BARON, and present computational results on benchmarks and an application in symbolic regression.

Randomness, risk and electricity prices

Invited Talks
PLENARY - Th 1:30pm-2:30pm, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 554
Organizer: Michael Ferris, University of Wisconsin, US

1 - Randomness, risk and electricity prices
Speaker: Andy Philpott, University of Auckland, NZ, talk 1605
Co-Authors: *Michael Ferris*,
Competitive markets for electricity supply have been around for over twenty years. They were introduced to support commercial investment in conventional generation plants with known costs and capacities, under predictable operating conditions. The design of these markets was therefore based primarily on deterministic optimization paradigms. Improvements in stochastic programming models and algorithms allied with the growth of intermittent and distributed generation and energy storage prompts a re-examination of these market designs. We examine the formation of electricity prices and incentives through a stochastic programming lens, where optimization models are used to yield efficient solutions and stochastic equilibrium models are used to study incentives. Differences between solutions to these models occur when agents are risk averse and markets for risk are incomplete. We illustrate using two case studies: stochastic optimization of ramping generation in markets with wind power and hydroelectric reservoir optimization with uncertain inflows.

Noncommutative polynomial optimization: semidefinite relaxations, free convexity and applications to quantum information II

Continuous Optimization
SDP - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

Invited Session 18
Organizer: Monique Laurent, CWI and Tilburg University, NL

1 - Quantifying entanglement of a quantum correlation using polynomial optimization
Speaker: Sander Gribling, CWI, NL, talk 57
Co-Authors: *David de Laat*, *Monique Laurent*,
In this talk we study bipartite quantum correlations. In particular we investigate the minimal entanglement dimension: the size of the physical system needed to generate the correlation. This can be modeled as the smallest integer d for which there exist two families of d-by-d positive semidefinite matrices satisfying certain properties. Using techniques from tracial polynomial optimization we construct a hierarchy of semidefinite programming lower bounds on d. This hierarchy converges to a new parameter: the minimal average entanglement dimension, which measures the amount of entanglement needed to reproduce a quantum correlation when access to shared randomness is free. For synchronous correlations, we show a correspondence between the minimal entanglement dimension and the completely positive semidefinite rank of an associated matrix.

2 - Graph isomorphism: conic relaxations and physical interpretation
Speaker: Antonios Varvitsiotis, National University of Singapo, SG, talk 60
Co-Authors: *Laura Mancinska*, *David Roberson*, *Albert Atserias*, *Robert Samal*, *Simone Severini*,
We introduce the (G,H)-isomorphism game where classical players win with certainty if and only if G and H are isomorphic. We then define the notions of quantum and non-signalling isomorphism, by considering perfect quantum and non-signalling strategies for the (G,H)-isomorphism game, respectively. First, we prove that non-signalling isomorphism coincides with fractional graph isomorphism. Second, we show there exist graphs that are quantum isomorphic but not isomorphic. Lastly, we show that both classical and quantum isomorphism can be reformulated as feasibility programs over the completely positive and completely positive semidefinite cones respectively, and give a combinatorial interpretation of the relaxation obtained using the doubly nonnegative cone.

3 - Optimization over univariate polynomials: Algorithms and applications
Speaker: Farid Alizadeh, Rutgers University, US, talk 1679
Co-Authors: *Mohammad Ranjbar*,
We apply the self-dual, homogeneous interior point method to the optimization problems over univariate polynomials and related problems. We use several tools, including the Fast Fourier Transform, the Chebyshev orthogonal basis, and predictor-corrector methods to design a numerically stable and efficient algorithm. Some numerical computations and applications in time-variant network flows,and shape-constrained regression will be presented.

Methods of Optimization in Riemannian Manifolds

Continuous Optimization
NLP - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 21
Organizer: Orizon Ferreira, Universidade Federal de Goias, BR

1 - A two-phase proximal-like algorithm in domains of positivity
Speaker: Paulo Oliveira, Federal University R J, BR, talk 34
Co-Authors: *Ronaldo Gregorio*, *Charlan Alves*,
This paper improves and extends a proximal-like algorithm,

developed for computing minimuns for convex functions within the framework of symmetric positive semidefinite matrices, to domains of positivity of reducible type, in a nonlinear sense and in a Riemannian setting.

2 - Proximal point method in multiobjective optimization on Hadamard manifolds

Speaker: Glaydston Bento, Universidade Federal de Goias, BR, talk 42

Co-Authors: *João Cruz Neto*, *Lucas Meireles*,

In this talk, will be presented a proximal point method for nonsmooth multiobjective program in the Riemannian context. In our approach it is explored an optimality condition, for multiobjective problems, which does not use scalarization and, consequently, allowed us to consider the method without any assumption of convexity over the constraint sets that determine the vectorial improvement steps. Our main result of convergence assures that each cluster point (if any) of any sequence generated from the method is a Pareto critical point. Moreover, when the problem is convex on Hadamard manifold it follows the full convergence of the method for a weak Pareto optimal.

3 - Newton's Method for Locally Lipschitz vector Fields on Riemannian Manifolds

Speaker: Orizon Ferreira, Universidade Federal de Goias, BR, talk 28

Co-Authors: *Fabiana de Oliveira*,

The goal of this paper is twofold. First, we generalize some results of nonsmooth analysis, from Euclidean context to the Riemannian setting. In particular, we discusses the concepts and main properties of the locally Lipschitz continuous vector fields defined on complete Riemannian manifolds, such as directional derivative, Clarke's generalized covariant derivative, Rademacher's theorem, mean value theorem and semismoothness. Next, we present Newton's method for finding a singularity of a locally Lipschitz continuous vector field and its convergence properties. Under the assumptions of semismoothness and regularity at the singularity we establish the well-definedness of generated sequence by the method in a neighborhood of this singularity. We also show that this sequence can locally converge for the solution with superlinear or quadratic rate, under suitable conditions. Furthermore, under Kantorovich's-type assumptions the convergence of the sequence to a solution is proved and its uniqueness in a suitable neighborhood of the starting point is verified. Keywords: Riemannian manifold, locally Lipschitz continuous vector fields, Clarke's generalized covariant derivative, semismoothness, Newton's method.

Approximation Algorithms for Clustering.

Discrete Optimization & Integer Programming

APPROX - Th 3:15pm-4:45pm, Format: 3x30 min

Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 32

Organizer: Deeparnab Chakrabarty, Dartmouth College, US

1 - Constant-Factor Approximation for Ordered k-Median

Speaker: Jaroslaw Byrka, University of Wroclaw, PL, talk 464

Co-Authors: *Krzysztof Sornat*, *Joachim Spoerhase*,

We study the Ordered k-Median problem, in which the solution is evaluated by first sorting the client connection costs and then multiplying them with a predefined non-increasing weight vector (higher connection costs are taken with larger weights). Since the 1990s, this problem has been studied extensively in the discrete optimization and operations research communities and has emerged as a framework unifying many fundamental clustering and location problems such as k-Median and k-Center. Recently, Aouad and Segev obtained an O(log n) approximation algorithm for Ordered k-Median using a sophisticated local-search approach and the concept of surrogate models thereby extending the result by Tamir (2001) for the case of a rectangular weight vector, also known as k-Facility p-Centrum. In this work we provide an LP-rounding constant-factor approximation algorithm for the Ordered k-Median problem. It is based on adapting the rounding process by Charikar and Li (2012) for k-Median.

2 - Sampling-based algorithms and clustering with outliers

Speaker: Amit Jayant Deshpande, Microsoft Research, IN, talk 454

Sampling-based algorithms have many interesting and related applications in clustering using points or subspaces. Sampling leads to provably good seeding or initialization such as k-means++. Sampling also provides small coresets and PTAS. Many of these non-uniform sampling schemes are not robust and fail in the presence of outliers, especially when the outliers can be arbitrarily far and constitute a small, constant fraction of the input. In this talk, we will discuss simple fixes to rectify this problem. First, we will show a simple modification of k-means++ that is robust to outliers. Second, we will show how sampling-based algorithms for subspace approximation can be made resilient to outliers.

3 - Generalized Center Problems with Outliers

Speaker: Deeparnab Chakrabarty, Dartmouth College, US, talk 891

Co-Authors: *Maryam Negahbani*,

We study the F-center problem with outliers: given a metric space (X, d), a general downclosed family F of subsets of X, and a parameter m, we need to locate a subset S in F of centers such that the maximum distance among the closest m points in X to S is minimized. Our main result is a dichotomy theorem. Colloquially, we prove that there is an efficient 3-approximation for theF-center problem with outliers if and only if we can efficiently optimize a poly-bounded linear function over F subject to a partition constraint. One concrete upshot of our result is a polynomial time 3-approximation for the knapsack center problem with outliers for which no (true) approximation algorithm was known.

Convexification and more (I)

Discrete Optimization & Integer Programming

MINLP - Th 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 39 Building: E, 3rd floor, Zone: 1

Invited Session 62

Organizer: Jon Lee, University of Michigan, US

1 - Treating indefinite quadratic and bilinear forms in MINLP
Speaker: Marcia Fampa, UFRJ, BR, talk 620
Co-Authors: *Jon Lee*,
We investigate different ways of treating indefinite quadratic and bilinear forms in the context of MINLP, by applying DC decomposition, McCormick convexification, and disjunctive programming. Our approach aims at exploiting as much as possible the convexity that can be extracted from indefinite quadratics, both algebraically and structurally.

2 - Valid inequalities for QCQPs
Speaker: Amélie Lambert, Cedric-Cnam, FR, talk 745
We consider the solution of mixed-integer quadratically constrained programs (QCQP). In our algorithm, we introduce valid inequalities, that we separate during a convexification process. This convex formulation is then used within a spatial B and B. As expected, the valid inequalities improve the gap at the root node of the spatial B and B, and by construction, they favorably impact the behavior of the whole algorithm.

3 - More Virtuous Smoothing
Speaker: Luze Xu, University of Michigan, US, talk 772
Co-Authors: *Jon Lee*, *Daphne Skipper*,
In the context of global optimization of mixed-integer nonlinear optimization formulations, we consider smoothing univariate functions f that satisfy $f(0) = 0$, f is increasing and concave on $[0, +\infty)$, f is twice differentiable on all of $(0, +\infty)$, but $f'(0)$ is undefined or intolerably large. The canonical examples are root functions $f(w) := w^p$, for $0 < p < 1$. We consider the earlier approach of defining a smoothing function g that is identical with f on $(\delta, +\infty)$, for some chosen $\delta > 0$, then replacing the part of f on $[0, \delta]$ with a homogeneous cubic, matching f, f' and f'' at δ. The parameter δ is used to control the derivative at 0 (which controls it on all of $[0, +\infty)$ when g is concave). Our main results: (i) we weaken an earlier sufficient condition to give a necessary and sufficient condition for the piecewise function g to be increasing and concave; (ii) we give a general sufficient condition for $g'(0)$ to be decreasing in the smoothing parameter δ; (iii) we give a general sufficient condition for g to underestimate f; (iv) we give a general sufficient condition for g to dominate the simple 'shift smoothing' $h(w) := f(w + \lambda) - f(\lambda)$ $(\lambda > 0)$, when the parameters δ and λ are chosen "fairly" – i.e., so that $g'(0) = h'(0)$. In doing so, we solve two natural open problems of Lee and Skipper (2016), concerning (iii) and (iv) for root functions.

Optimization Models for Renewable Energy Integration 1

Specific Models, Algorithms, and Software
Energy - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 120
Organizer: Luis Zuluaga, Lehigh University, US

1 - Optimal Grid Operation and DER Dispatch in Active Distribution Networks
Speaker: Panagiotis Andrianesis, Boston University, US, talk 1658
Co-Authors: *Michael Caramanis*,
Rapidly growing Distributed Energy Resources (DERs) present a major challenge together with a still unexploited opportunity for a radical transformation of the distribution grid, which is becoming increasingly active, distributed, dynamic, and challenging to plan and operate. The value of DERs over time and location is the key driver of optimal DER scheduling that promises fundamental changes in distribution planning, operation, and markets. We propose a tractable and robust hierarchical, massively distributed, yet coordinated, computation, communication and control framework for optimal distribution grid operation and DER dispatch. We employ a distribution grid representation that captures the salient features and costs of distribution assets (e.g., service transformer overloading), as well as the complex DER preferences and capabilities, and enables the discovery of short-term dynamic locational marginal costs. We discuss the inherent difficulties of the underlying optimization problem (e.g., non-convexities, mobile resources that couple multiple networks), and provide insights that leverage advances in state-of-the-art technology and distributed algorithms.

2 - Bilevel Optimization for Flexible Electricity Supply Tariff Design
Speaker: Galina Orlinskaya, FAU Erlangen-Nuernberg, DE, talk 1425
Co-Authors: *Veronika Grimm*, *Martin Schmidt*, *Gregor Zöttl*, *Lars Schewe*,
We consider an electricity retailer buying electrical power on the energy exchange at current auction prices and then selling it to a private customer. This customer is a "prosumer" who has independent energy storage and generation facilities and can also export electrical energy from own generation to the main grid. The goal of the retailer is to design new tariffs that are flexible due to critical peak pricing or partial supply interruptions, and thus more profitable. The prosumer strives for cost optimal control of his facilities with respect to current weather conditions as well as electrical and heat power demand, managing his electricity imports according to a particular energy supply tariff structure. With a discretization of the time horizon we compare different tariff designs that lead to bilevel optimization models with retailer as leader and prosumer as follower. We obtain single level formulations by applying strong duality for follower models, solve the resulting mixed-integer non-linear problems, and discuss the results.

3 - Competitive equilibrium and revenue adequate prices for robust energy markets
Speaker: Luis Zuluaga, Lehigh University, US, talk 941
Co-Authors: *Xin Chi*, *Alberto Lamadrid*,
We consider a uncertain electricity market in which the uncertainty arises from the presence of renewable energy sources. A common way to obtain revenue adequate energy prices in this type of market is by solving an appropriate sample average stochastic program from which the desired prices can be obtained in each sample scenario. This approach however has the drawback of not producing an a priori pricing scheme, complicating settlements. Here we consider a robust model for the market using chance constraints together with a proportional control law for power generation. We prove that in this framework, market clearing prices yielding a robust competitive market equilibrium, as well as revenue adequate prices, can be computed and used for uncertain market settlements by risk-aware system operators. We illustrate our

results by computing settlement prices in different instances of energy markets.

Nonlinear Optimization and Variational Inequalities II

Continuous Optimization
Variat - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 141
Organizer: Cong Sun, Beijing Univ. Post. Telecomm., CN

1 - On the Lojasiewicz Exponent of Quadratic Minimization with Sphere Constraint
Speaker: Xin Liu, Chinese Academy of Sciences, CN, talk 96
Co-Authors: *Bin Gao*, *Xiaojun Chen*, *Yaxiang Yuan*,
In this paper, we prove that the global version of the Lojasiewicz gradient inequality holds for the quadratic optimization problem with sphere constraint with exponent $\theta = \frac{3}{4}$. The tightness of $\theta = \frac{3}{4}$ can be illustrated by an instance. This is the first Lojasiewicz gradient inequality established for the general quadratic optimization problem with sphere constraint.
2 - A Parallelizable Algorithm for Orthogonally Constrained Optimization Problems
Speaker: Bin Gao, Chinese Academy of Sciences, CN, talk 85
Co-Authors: *Xin Liu*, *Yaxiang Yuan*,
To construct a parallel approach for solving orthogonally constrained optimization problems is usually regarded as an extremely difficult mission, due to the low scalability of orthogonalization procedure. In this talk, we propose an infeasible algorithm for solving optimization problems with orthogonality constraints, in which orthogonalization is no longer needed at each iteration, and hence the algorithm can be parallelized. We also establish a global subsequence convergence and a worst-case complexity for our proposed algorithm. Numerical experiments illustrate that the new algorithm attains a good performance and a high scalability in solving discretized Kohn-Sham total energy minimization problems.
3 - A Joint Matrix Minimization Approach for Seismic Wavefield Recovery
Speaker: Yanfei Wang, Chinese Academy of Sciences, CN, talk 1559
Co-Authors: *Liping Wang*,
Recently, multi-trace seismic wavefield recovery has attracted extensive attention in geophysical community. Representation coding pattern among the group of samples is observed in seismic signals, hence can be used for seismic wavefield reconstruction. To take account of the collective correlation from a given set of testing samples as well as each individual, a matrix minimization model is presented to jointly representing all the testing samples over the coding bases simultaneously. A generalized matrix norm $l_{2,p}(0 < p \leq 1)$ is employed to measure the interrelation of the multiple samples and the entries of each one. For solving the involved matrix optimization problem, a unified algorithm is developed and the convergence analysis is accordingly demonstrated for the range of parameters $p \in (0, 1]$. Extensive experiments on real-world seismic waves exhibit the efficient performance of the joint technique over the state-of-the-art methods.

Asynchronous Parallel and Distributed Optimization

Continuous Optimization
RandomM - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 200
Organizer: Wotao Yin, UCLA, US

1 - Improved asynchronous parallel optimization analysis for incremental methods
Speaker: Rémi Leblond, INRIA, FR, talk 741
Co-Authors: *Fabian Pedregosa*, *Simon Lacoste-Julien*,
As datasets continue to increase in size and multi-core computer architectures are developed, asynchronous parallel optimization algorithms become more and more essential to Machine Learning. Unfortunately, conducting the theoretical analysis of asynchronous methods is difficult, notably due to the introduction of delay and inconsistency in inherently sequential algorithms. Handling these issues often requires resorting to simplifying but unrealistic assumptions. Through a novel perspective, we revisit and clarify a subtle but important technical issue present in a large fraction of the recent convergence rate proofs for asynchronous parallel optimization algorithms, and propose a simplification of the recently introduced "perturbed iterate" framework that resolves it. We demonstrate the usefulness of our new framework by analyzing three distinct algorithms: Hogwild (asynchronous SGD), KROMAGNON (asynchronous SVRG) and ASAGA, a novel asynchronous parallel version of the incremental gradient algorithm SAGA that enjoys fast linear convergence rates. We are able to both remove problematic assumptions and obtain better theoretical results. Notably, we prove that ASAGA and KROMAGNON can obtain a theoretical linear speedup on multi-core systems even without sparsity assumptions. We present results of an implementation on a 40-core architecture illustrating the practical speedups as well as the hardware overhead.
2 - Why Asynchronous Algorithms may Drastically Outperform Traditional Ones
Speaker: Robert Hannah, UCLA, US, talk 339
Co-Authors: *Wotao Yin*,
In this talk, we present a series of results that comprise the first strong theoretical evidence that asynchronous-parallel algorithms may drastically outperform traditional ones. Asynchronous algorithms overcome costly synchronization penalty by having nodes compute updates with the most recent data available, rather than waiting for all nodes to complete their computation. However, this means that the solution vector is updated with outdated information. Until recently, how many additional iterations that asynchronous algorithms need to compensate for this outdatedness has been an open question. We prove our claim with a series of results. We first use renewal theory to show how many factors cause asynchronous algorithms to complete "faster iterations". We then prove the first sharp iteration complexity results for a variety of synchronous algorithms (including randomized block gradient descent, block proximal gradient, etc.) so that we can make a fair comparison to asynchronous algorithms. Finally,

we prove that the iteration complexity of the asynchronous counterparts of these algorithms is only negligibly higher, meaning asynchronous iterations are of the "same quality". Taking these factors together, we can conclude that many asynchronous algorithms may drastically outperform traditional ones. Similar results are presented for accelerated algorithms: We also prove that an accelerated block coordinate descent algorithm (NU-ACDM) has optimal complexity, and propose an asynchronous variant that also has optimal complexity.

3 - Complexity of a quadratic penalty accelerated inexact proximal point method

Speaker: Renato Monteiro, Georgia Tech, US, talk 938

Co-Authors: *Weiwei Kong*, *Jefferson Melo*,

This talk discusses the iteration-complexity of a quadratic penalty accelerated inexact proximal point method for solving linearly constrained nonconvex composite programs. More specifically, the objective function is of the form $f+h$ where f is a differentiable function whose gradient is Lipschitz continuous and h is a closed convex function with bounded domain. The method, basically, consists of applying an accelerated inexact proximal point method for solving approximately a sequence of quadratic penalized subproblems associated to the linearly constrained problem. Each subproblem of the proximal point method is in turn approximately solved by an accelerated composite gradient method. It is shown that the proposed scheme generates a rho - approximate stationary point in at most O(1/rho power 3). Finally, numerical results showing the efficiency of the proposed method are also given.

Algorithms for TSP

Discrete Optimization & Integer Programming

COMB - Th 3:15pm-4:45pm, Format: 3x30 min

Room: SIGALAS Building: C, 2nd floor, Zone: 2

Invited Session 239

Organizer: Ola Svensson, EPFL, CH

1 - Approaching 3/2 for the s-t-path TSP

Speaker: Vera Traub, University of Bonn, DE, talk 571

Co-Authors: *Jens Vygen*,

The s-t-path TSP is a variant of the traveling salesman problem in which the endpoints of the tour are given and distinct. The integrality ratio of the natural linear programming relaxation is believed to be 3/2, but all approximation algorithms known so far have worse performance ratio. We show that there is a polynomial-time algorithm with approximation guarantee $\frac{3}{2} + \epsilon$, for any fixed $\epsilon > 0$. It is well known that Wolsey's analysis of Christofides' algorithm also works for the s-t-path TSP except for the narrow cuts (in which the LP solution has value less than two). A fixed optimum tour has either a single edge in a narrow cut (then call the edge and the cut lonely) or at least three (then call the cut busy). Our algorithm "guesses" (by dynamic programming) lonely cuts and edges. Then we partition the instance into smaller instances and strengthen the LP, requiring value at least three for busy cuts. By setting up a k-stage recursive dynamic program, we can compute a spanning tree (V, S) and an LP solution y such that $(\frac{1}{2} + O(2^{-k}))y$ is in the T-join polyhedron, where T is the set of vertices whose degree in S has the wrong parity.

2 - Cut-Covering Decompositions for Connectivity Problems

Speaker: Ramamoorthi Ravi, CMU, US, talk 585

Co-Authors: *Arash Haddadan*, *Alantha Newman*,

We study decompositions of graphs that cover small-cardinality cuts an even number of times, and we use these decompositions to design algorithms with improved approximation guarantees for the traveling salesman problem (TSP) and the 2-edge-connected spanning multigraph problem (2EC) on (restricted classes of) weighted graphs. We present several applications of the algorithms of Boyd, Iwata and Takaza to connectivity problems on node-weighted graphs, which has been suggested as an intermediate step for TSP between graph and general metrics. Specifically, on 3-edge-connected, cubic, node-weighted graphs, we present a 7/5-approximation algorithm for TSP and a 13/10-approximation algorithm for 2EC. To extend this approach to graphs that are 2-edge connected, we present a procedure to decompose an optimal solution for the subtour linear program into spanning, connected subgraphs that cover each 2-edge cut an even number of times. We use this decomposition to design a simple 4/3-approximation algorithm for 2EC on subcubic, node-weighted graphs. Finally, motivated by the well known "four-thirds conjecture", we apply these decomposition tools to the problem of uniform covers. For a cubic, 3-edge-connected graph, we show that the everywhere 18/19 vector can be efficiently written as a convex combination of tours, answering a question of Sebo. Additionally, for such graphs, we show that the everywhere 15/17 can be efficiently written as a convex combination of 2-edge-connected spanning multigraphs. (Paper at `arxiv.org/abs/1707.05387`)

3 - A Constant-factor Approximation Algorithm for the Asymmetric Traveling Salesman

Speaker: Ola Svensson, EPFL, CH, talk 550

Co-Authors: *Jakub Tarnawski*, *Laszlo Vegh*,

We give a constant-factor approximation algorithm for the asymmetric traveling salesman problem. Our approximation guarantee is analyzed with respect to the standard LP relaxation, and thus our result confirms the conjectured constant integrality gap of that relaxation. Our techniques build upon the constant-factor approximation algorithm for the special case of node-weighted metrics. Specifically, we give a generic reduction to structured instances that resemble but are more general than those arising from node-weighted metrics. For those instances, we then solve Local-Connectivity ATSP, a problem known to be equivalent (in terms of constant-factor approximation) to the asymmetric traveling salesman problem.

Theoreticals and practicals aspects of decomposition algorithms for multi-stage stochastic problems: 1

Optimization under Uncertainty

Stoch - Th 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Invited Session 246

Organizer: Vincent Leclère, ENPC, FR

1 - Computing parameter sensitivities for discrete time Markov decision processes

Speaker: David Wozabal, Technical University of Munich, DE, talk 1002

Co-Authors: *Goncalo Terca*,

We propose a method to calculate the sensitivities of the optimal value of a multi-stage stochastic optimization problem with respect to changes in the model's parameters. More specifically, we prove an envelope theorem suited for SDDP type algorithms and demonstrate how the derivative of the value function of a Markov decision problem can be approximated to an arbitrary precision by sampling. We test our ideas on a discrete time version of the standard replication problem for a European option with known derivatives and show that the algorithm convergences reasonably fast. We proceed by showing that parameter sensitivities may be calculated for more complicated problems in energy trading for which there exist no analytical solutions for the optimal value.

2 - Modeling time-dependent randomness in stochastic dual dynamic programming

Speaker: Nils Löhndorf, University of Luxembourg, LU, talk 849

Co-Authors: *Alexander Shapiro*,

We consider the multistage stochastic programming problem where uncertainty enters the right-hand sides of the problem. Stochastic Dual Dynamic Programming (SDDP) is a popular method to solve such problems under the assumption that the random data process is stagewise independent. There exist two approaches to incorporate dependence into SDDP. One approach is to model the data process as an autoregressive time series and to reformulate the problem in stagewise independent terms by adding state variables to the model (TS-SDDP). The other approach is to use Markov Chain discretization of the random data process (MC-SDDP). While MC-SDDP can handle any Markovian data process, some advantages of statistical analysis of the policy under the true process are lost. In this work, we compare both approaches based on a computational study using the long-term operational planning problem of the Brazilian interconnected power systems. We find that the optimality bounds computed by the MC-SDDP method close faster than its TS-SDDP counterpart, and the MC-SDDP policy dominates the TS-SDDP policy. When implementing the optimized policies on real data, we observe that not only the method but also the quality of the stochastic model has an impact on policy performance and that using an AVaR formulation is effective in making the policy robust against a misspecified stochastic model.

3 - Computing ellipsoidal controlled invariant sets for stochastic programming

Speaker: Benoît Legat, UCLouvain, BE, talk 1243

Co-Authors: *Raphaël Jungers*,

In a multistage program without complete recourse, a solution, which is feasible at a particular stage, may lead to an infeasible program for a subsequent stage. When solving the multistage program, infeasibility cuts are usually added to forbid such a solution. However, the number of infeasibility cuts needed to ensure relatively complete recourse can grow rapidly as the number of stages considered increase. We show how to reduce the computation of feasible sets ensuring relatively complete recourse to the computation of controlled invariant sets of an hybrid system. Recent work in the theory of control of cyber-physical systems shows how to compute ellipsoidal controlled invariant sets for these system by using semidefinite programming. The containment of the solution to an ellipsoid only requires second order cone programming and it certifies relatively complete recourse. This allows to precompute new constraints to add to the programs at each stage and scenario to remove the need for infeasibility cuts without significantly increasing the complexity of solving each program.

Generation and Representation Algorithms in Multiobjective Optimization

Optimization under Uncertainty

Game - Th 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 30 Building: B, Ground Floor, Zone: 5

Invited Session 267

Organizer: Michael Stiglmayr, University of Wuppertal, DE

1 - On a Polynomial Bound in Multiobjective Unconstrained Combinatorial Optimization

Speaker: Britta Schulze, University of Wuppertal, DE, talk 1061

Co-Authors: *Kathrin Klamroth*, *Michael Stiglmayr*,

The multiobjective unconstrained combinatorial optimization problem (MUCO) can be considered as an archetype of a discrete linear multiobjective optimization problem. It can be interpreted as a specific relaxation of any multiobjective combinatorial optimization problem with linear sum objective function. While its single criteria analogon is analytically solvable, MUCO shares the computational complexity issues of most multiobjective combinatorial optimization problems: intractability and NP-hardness of the ε-constraint scalarizations. We present interrelations between the supported nondominated points of a MUCO problem, arrangements of hyperplanes, a weight space decomposition, and zonotopes. Based on these interrelations, a polynomial bound on the number of extreme supported solutions can be derived.

2 - Efficient Representation of the Search Region and Generic Algorithms in MOCO

Speaker: Kathrin Klamroth, University of Wuppertal, DE, talk 1232

Co-Authors: *Kerstin Daechert*, *Renaud Lacour*, *Daniel Vanderpooten*,

Given some (partial) knowledge on the nondominated set of a multiobjective optimization problem, the search region corresponds to that part of the objective space that potentially contains additional nondominated points. We consider a representation of the search region by a set of tight local upper bounds (in the minimization case). While the search region can be easily determined in the bi-objective case, its computation in higher dimensions is considerably more difficult and gives rise to interesting relations to computational geometry and to tropical algebra. We discuss the usefulness of local upper bounds in generic scalarization based solution methods, aiming at concise representations of the nondominated set.

3 - Representation of the non-dominated set of multiobjective optimization problems

Speaker: Michael Stiglmayr, University of Wuppertal, DE, talk 1127

Since the cardinality of the non-dominated set of multiobjective discrete optimization problems is often too large to present it to a decision maker, the selection of a representative subset is of particular interest. This talk focuses on the computation of good represenations with respect to quality measures like: uniformity, coverage, epsilon-indicator or hypervolume. In most cases the exact solution of representation problems is a two stage process, since it requires the knowledge of the complete non-dominated set. The hypervolume, on the other side, can be evaluated point-wise and can thus be directly integrated in the optimization process by choosing an appropriate scalarization. This can be utilized particularly for linear biobjective optimization problems where the corresponding hypervolume maximiation problem can be solved a-priori.

Heuristics in MINLP

Discrete Optimization & Integer Programming
MINLP - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3
Contributed Session 276
Chair: Bertrand Travacca, UC Berkeley, US

1 - MINLP solutions using a Generalized-GRASP solver
Speaker: João Lauro Faco', Federal University of RJ, BR, talk 1368
Co-Authors: *Ricardo Silva*, *Mauricio Resende*,
The method Continuous-GRASP solves efficiently general constrained global continuous optimization problems (Facó, Resende and Silva) by adapting the greedy randomized adaptive search metaheuristic procedure (GRASP) for discrete optimization to the case of constrained continuous variables. A new version that also considers discrete variables is presented as Generalized-GRASP. Small and medium scale MINLPs are currently addressed using continuous relaxations and solved by a branch and bound procedure. Large scale instances however cannot be solved this way due to the curse of dimensionality. Generalized-GRASP doesn't do any relaxation for the discrete variables. GRASP random search and local improvement phases use independently a discrete and a continuous set. Linear and/or nonlinear constraints are incorporated in the objective function by quadratic penalty terms as in C-GRASP. Numerical solutions to difficult MINLP problems are discussed.

2 - Feasible rounding ideas for mixed-integer optimization problems
Speaker: Christoph Neumann, Cont. Opt. IOR KIT, DE, talk 494
Co-Authors: *Nathan Sudermann-Merx*, *Oliver Stein*,
We initially introduce granularity as a sufficient condition for the consistency of a mixed-integer linear optimization problem and show how to exploit it for the computation of good feasible points. For optimization problems which are granular, solving a certain linear problem and rounding its optimal point always leads to a feasible point of the original problem. The resulting feasible rounding approach is deterministic and efficient, i.e., it computes feasible points in polynomial time. Secondly, we extend central ideas of this approach to mixed-integer convex optimization problems and introduce a feasible cutting plane algorithm (FCPA). In contrast to other methods from the literature, the FCPA only needs to solve an LP-relaxation in each iteration. We prove convergence of the algorithm. Finally, we provide computational results on optimization problems from standard libraries. These demonstrate that granularity may be expected in many real world applications and that our algorithms can improve the CPU time needed to solve problems from practice.

3 - Dual Hopfield Models for Large Scale Mixed Integer Programming
Speaker: Bertrand Travacca, UC Berkeley, US, talk 796
Co-Authors: *Scott Moura*,
We present a novel heuristic method to propose candidate solutions to large scale mixed-integer programs. Our method builds on a combination of Lagrangian relaxation and Hopfield models. We focus on a subclass of mixed-integer programs, consisting of binary variables, box constraints, quadratic constraints and objectives. We apply our method to an economic load dispatch problem and compare it with a semidefinite relaxation technique.

MINLP with quadratic terms

Discrete Optimization & Integer Programming
MINLP - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4
Contributed Session 282
Chair: Enrico Bettiol, LIPN - Université Paris 13, FR

1 - The p-Lagrangian method for MIQCQPs
Speaker: Fabricio Oliveira, Aalto University, FI, talk 201
Co-Authors: *Tiago Andrade*, *Silvio Hamacher*,
Mixed-integer quadratically constrained quadratic programming (MIQCQP) is a general class related to several important problems such as polynomial, semidefinite, and conic programming. Moreover, MIQCQP is a natural way to model many important problems in chemical engineering applications. Our motivation is the refinery operational planning problem (ROPP) under uncertainty, which has a large-scale deterministic equivalent MIQCQP. We tackle this problem proposing a primal-dual decomposition algorithm named the p-Lagrangian method, which combines a bundle-method inspired Lagrangian decomposition with MIP-based relaxations. These relaxations are obtained using the normalised multiparametric desegregation technique (NMDT) and can be made arbitrarily precise by means of a precision parameter p. We present enhancements for the NMDT-based relaxation and how to effectively employ them in the decomposition algorithm. The proposed method was tested on a real-world ROPP and compared with the commercial solver BARON in terms of performance. The numerical results obtained illustrate the efficiency of the method for several instances.

2 - A dedicated version of BiqCrunch for solving the Max-Stable Set problem exactly
Speaker: Etienne Leclercq, LIPN, University Paris XIII, FR, talk 1489
Co-Authors: *Frederic Roupin*,
BiqCrunch is a semidefinite-based branch-and-bound solver for binary quadratic problems.We present here a specific version to solve the max-stable-set problem. In particular, this version uses valid additional inequalities (built from quadratized rank inequalities) and new branching strategies (instead of standard binary).

3 - Simplicial Decomposition for quadratic convex 0-1

problems
Speaker: Enrico Bettiol, LIPN - Université Paris 13, FR, talk 716
Co-Authors: *Lucas Letocart*, *Emiliano Traversi*, *Francesco Rinaldi*,
We propose an algorithm to solve problems of this form: minimization of a quadratic convex objective function, with mixed binary variables and linear constraints. It integrates the Branch and Bound method with Simplicial Decomposition (SD), a column generation method, which is suited for solving specific classes of continuous convex problems. The Simplicial Decomposition algorithm makes an inner approximation of the original domain, by a sequence of simplices: a master program finds the optimum in a simplex, the pricing program provides a new extreme point or assures the optimality. We use an ad hoc algorithm for solving the master problem, which is an adaptation of the Conjugate Directions method. We use SD to solve the continuous relaxation at each node of the branch and bound. We nest the SD algorithm in this structure for three reasons. Firstly, we noticed that, for specific continuous problems, this algorithm outperforms the solver CPLEX. Secondly, the pricing problem of SD, at each cycle, gives a valid lower bound on the solution and this gives remarkable improvements in our branch and bound. Finally, we can do a warmstart in many nodes by an efficient reuse of a lot of extreme points from the father-node to the children. Preliminary results, obtained on two sets of quadratic shortest path instances, are very promising: we solve the integer problem to optimality faster than CPLEX. In conclusion, we show how the SD algorithm, originally designed for convex continuous problems, can be profitably adapted for mixed binary quadratic problems.

Applications of CP

Discrete Optimization & Integer Programming
CP - Th 3:15pm-4:45pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 284
Organizer: Louis-Martin Rousseau, Polytechnique Montreal, CA

1 - A Constraint Programming approach to a meal delivery problem
Speaker: Olivier Bachollet, IMT Atlantique - CIRRELT, FR, talk 1604
Co-Authors: *Michel Gendreau*, *Fabien Lehuédé*, *Louis-Martin Rousseau*,
We investigate the distribution of meals from several depots in a city. The problem is dynamic, in the sense that meal orders continuously arrive from the company website and should be addressed within very short delays. The goal is to design multi-trip routes for several vehicles (mainly bikes and scooters), which may differ in capacity, cost of use and speed. We propose a Constraint Programming model to solve the problem based on a pickup an delivery problem formulation. The model is solved at regular time intervals in a framework which implements various dynamic policies.

2 - A Decomposition Approach for the Home Health Care Routing and Scheduling Problem
Speaker: Florian Grenouilleau, Polytechnique Montréal, CA, talk 1053
Co-Authors: *Nadia Lahrichi*, *Louis-Martin Rousseau*,
The home health care routing and scheduling problem comprises the assignment and routing of a set of home care visits over the duration of a week. These services allow patients to remain in their own homes, thereby reducing governmental costs by decentralizing the care. In this project, we developed a Benders decomposition approach to solve the problem. We present here different formulations of the problem, using a MILP to solve the assignments of the patients to the nurses (Master) and a constraint programming method to check the feasibility of the created routes (Subproblem). According to our computational results, the benefits and the weaknesses of each formulation are studied. Finally, some constraint programming enhancements allowing computation time reductions are presented.

3 - A CP Approach to the Traveling Salesman Problem in the Postal Services
Speaker: Louis-Martin Rousseau, Polytechnique Montreal, CA, talk 1333
Co-Authors: *Alexis Bretin*, *Guy Desaulniers*,
Tackling vehicle routing problem with time windows in postal services is a complex issue, as it deals with large instances, and often low time windows density, as commercial recipients usually have time windows whereas private customers do not. Our industrial partner uses a cluster first route second procedure to solve these instances, where each territory may count up to almost 500 deliveries. To do so, many TSPTW may be solved in at most a minute. First, we suggest two different constraints programing (CP) oriented models to solve bi-objective TSPTW. Indeed, the route duration is a key factor in route quality for postal services. We also introduce a node clustering procedure to solve the large scale with low time windows density instances for the TSPTW to generate smaller instances. We investigate reinforcing CP disaggregation approaches with MIP models to find good quality solution in the restricted available computation time.

Extending the Reach of First-Order Methods, Part II

Continuous Optimization
NonSmooth - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 286
Organizer: Robert Freund, MIT, US

1 - Risk and parameter convergence of logistic regression
Speaker: Matus Telgarsky, UIUC, US, talk 1557
Co-Authors: *Ziwei Ji*,
The logistic loss is strictly convex and does not attain its infimum; consequently the solutions of logistic regression are in general off at infinity. This work provides a convergence analysis of gradient descent applied to logistic regression under no assumptions on the problem instance. Firstly, the risk is shown to converge at a rate $O(\ln(t)^2/t)$. Secondly, the parameter convergence is characterized along a unique pair of complementary subspaces defined by the problem instance: one subspace along which strong convexity induces

parameters to converge at rate $O(\ln(t)/\sqrt{t})$, and its orthogonal complement along which separability induces parameters to converge in direction at rate $O(\ln\ln(t)/\ln(t))$.

2 - A conditional gradient framework for composite convex minimization

Speaker: Alp Yurtsever, EPFL, CH, talk 254

Co-Authors: *Olivier Fercoq*, *Francesco Locatello*, *Volkan Cevher*,

We propose a conditional gradient framework for a composite convex minimization template with broad applications. Our approach combines the notions of smoothing and homotopy under the CGM framework, and provably achieves the optimal convergence rate. We demonstrate that the same rate holds if the linear subproblems are solved approximately with additive or multiplicative error. Specific applications of the framework include the non-smooth minimization, semidefinite programming, minimization with linear inclusion constraints over a compact domain. We provide numerical evidence to demonstrate the scalability benefits of the new framework.

3 - Accelerating Greedy Coordinate Descent Methods

Speaker: Robert Freund, MIT, US, talk 260

Co-Authors: *Haihao Lu*, *Vahab Mirrokni*,

We study ways to accelerate greedy coordinate descent in theory and in practice, where "accelerate" refers either to $O(1/k^2)$ convergence in theory, in practice, or both. We introduce and study two algorithms: Accelerated Semi-Greedy Coordinate Descent (ASCD) and Accelerated Greedy Coordinate Descent (AGCD). While ASCD takes greedy steps in the x-updates and randomized steps in the z-updates, AGCD is a straightforward extension of standard greedy coordinate descent that only takes greedy steps. On the theory side, our main results are for ASCD: we show that ASCD achieves $O(1/k^2)$ convergence, and it also achieves accelerated linear convergence for strongly convex functions. On the empirical side, we observe that both AGCD and ASCD outperform Accelerated Randomized Coordinate Descent on a variety of instances. In particular, we note that AGCD significantly outperforms the other accelerated coordinate descent methods in numerical tests, in spite of a lack of theoretical guarantees for this method. To complement the empirical study of AGCD, we present a Lyapunov energy function argument that points to an explanation for why a direct extension of the acceleration proof for AGCD does not work; and we also introduce a technical condition under which AGCD is guaranteed to have accelerated convergence. Last of all, we confirm that this technical condition holds in our empirical study.

Computational Issues in Integer Programming

Discrete Optimization & Integer Programming

IPpractice - Th 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 44 Building: C, 3rd floor, Zone: 1

Invited Session 289

Organizer: Ricardo Fukasawa, Ricardo, CA

1 - Implementation and performance of the simplex method

Speaker: Laurent Poirrier, University of Waterloo, CA, talk 1124

Co-Authors: *Ricardo Fukasawa*,

Despite the fact that its theoretical complexity is not settled, the simplex method remains a primary computational tool for solving linear programming problems. It is even the best available option in contexts such as branch-and-bound and column generation. While the number of iterations of the method has deservedly attracted much interest from our community, little is known about the cost of individual iterations in practice. In this talk, we present a high-level breakdown of this computational cost. An iteration of the simplex method consists in different steps, each involving specific linear algebra operations. We discuss various implementations choices for each of these steps, and their impact on performance.

2 - Learning MILP resolution outcomes before reaching time-limit

Speaker: Giulia Zarpellon, Polytechnique Montreal, CA, talk 1341

Co-Authors: *Martina Fischetti*, *Andrea Lodi*,

The resolution of some Mixed-Integer Linear Programming problems still presents challenges for solvers and may require hours of computations, so that a time-limit to the resolution process is typically provided by the user. Nevertheless, it could be useful to get a sense of the optimization trends after only a fraction of the specified total time has passed, and ideally be able to tailor the use of the remaining resolution time in a more strategic and flexible way. Looking at the evolution of a partial branch-and-bound tree for a MILP instance, developed up to a certain fraction of the time-limit, we aim to predict whether the problem will be solved to proven optimality before timing out. We exploit machine learning statistical tools, and summarize the development and progress of a MILP resolution process to cast a prediction within a classification framework.

3 - Computational Results with V-Polyhedral Cuts and Strengthening Approaches

Speaker: Aleksandr Kazachkov, Carnegie Mellon University, US, talk 356

Co-Authors: *Egon Balas*,

We approach the problem of generating disjunctive cuts for mixed-integer linear programs from a V-polyhedral perspective, by collecting a properly selected set of points and rays from which we generate cuts. This has computational advantages over existing approaches for obtaining disjunctive cuts and enables us to test the viability of using large disjunctions. We build these disjunctions by constructing a partial branch-and-bound tree, which is a step towards a tighter integration of the cutting and branching components of an integer programming solver. The cuts are evaluated both on their strength (in terms of integrality gap closed) and their effectiveness within branch-and-cut (by measuring impact on solving time). We present computational and theoretical results with V-polyhedral cuts and discuss methods for applying strengthening techniques to V-polyhedral cuts.

Accelerating Learning

Specific Models, Algorithms, and Software

Learning - Th 3:15pm-4:45pm, Format: 3x30 min

Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 322

Organizer: Martin Takac, Lehigh University, US

1 - Nonlinear Acceleration of Stochastic Algorithms
Speaker: Damien Scieur, INRIA - ENS, FR, talk 468
Co-Authors: *Francis Bach*, *Alexandre d Aspremont*,
Extrapolation methods use the last few iterates of an optimization algorithm to produce a better estimate of the optimum. They were shown to achieve optimal convergence rates in a deterministic setting using simple gradient iterates. Here, we study extrapolation methods in a stochastic setting, where the iterates are produced by either a simple or an accelerated stochastic gradient algorithm. We first derive convergence bounds for arbitrary, potentially biased perturbations, then produce asymptotic bounds using the ratio between the variance of the noise and the accuracy of the current point. Finally, we apply this acceleration technique to stochastic algorithms such as SGD, SAGA, SVRG and Katyusha in different settings, and show significant performance gains.

2 - Accelerated First Order Methods with Approximate Subproblems
Speaker: Sai Praneeth Karimireddy, EPFL, CH, talk 1543
Co-Authors: *Sebastian Stich*, *Martin Jaggi*,
First order methods broadly involve two steps: i) formulating a subproblem using gradient information and ii) computing the update by solving the subproblem. We devise a robust accelerated scheme which provably converges to the minima even if the subproblems are only solved to a multiplicative accuracy at each step. We further show that this framework can be used to obtain an accelerated greedy coordinate method.

3 - Optimal Algorithms for Distributed Optimization
Speaker: Angelia Nedich, ASU, US, talk 307
Co-Authors: *Cesar Uribe*, *Soomin Lee*, *Alexander Gasnikov*,
We present the optimal convergence rates for distributed convex optimization problems in networks, where the objective is to minimize the sum of convex cost functions, each known locally by an agent. We model the communication restrictions imposed by the network as a set of affine constraints and provide optimal complexity bounds for different cases, including the case when each agent cost function is strongly convex and smooth, when it is either strongly convex or smooth, and when it is convex but neither strongly convex nor smooth. Our approach is based on the dual of an appropriately formulated primal problem which includes the underlying static graph that models the communication restrictions. Our results show that Nesterov's accelerated gradient method for the dual problem can be executed in a distributed manner and that it enjoys the same optimal rates as in the centralized version of the problem (up to a constant or logarithmic factors), with an additional cost related to the spectral gap of the interaction matrix.

Robust first order methods

Specific Models, Algorithms, and Software
Learning - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 16 Building: I, 2nd floor, Zone: 7
Invited Session 332
Organizer: Fatma Kilinc-Karzan, Carnegie Mellon University, US

1 - Robust distributed learning in the face of adversity
Speaker: Dimitris Papailiopoulos, UW-Madison, US, talk 783
Co-Authors: *Lingjiao Chen*, *Zachary Charles*, *Hongyi Wang*,
Distributed model training is vulnerable to adversarial compute nodes, i.e., nodes that use malicious updates to corrupt the global model stored at a parameter server (PS). To defend against such attacks, recent work suggests using variants of the geometric median to aggregate distributed updates at the PS, in place of bulk averaging. Although median-based update rules are robust to adversarial nodes, their computational cost can be prohibitive in large-scale settings and their convergence guarantees often require relatively strong assumptions. In this work, we present DRACO, a scalable framework for robust distributed training that uses ideas from coding theory. In DRACO, each compute node evaluates redundant gradients that are then used by the parameter server to eliminate the effects of adversarial updates. We present problem-independent robustness guarantees for DRACO and show that the model it produces is always identical to one trained with no adversaries. We provide extensive experiments on real datasets in a distributed environment which show that DRACO is several times to orders of magnitude faster than median-based approaches.

2 - Characterizing implicit bias of optimization and its role in generalization
Speaker: Suriya Gunasekar, TTI Chicago, US, talk 1519
Co-Authors: *Jason Lee*, *Daniel Soudry*, *Nathan Srebro*,
In leaning high capacity deep neural networks, the optimization objective of minimizing the training error has many global minima, all of which minimize the training error, but most generalize poorly to held out test data. In spite of this, optimizing using variants of gradient descent or other local search methods implicitly biases the solutions to "special" global minima that generalize well. Such implicit bias introduced by optimization algorithms plays a crucial role in the generalization ability of learned models as it provides effective regularization not directly specified in the objective. In this talk, we will look at learning linear models from ill-posed objectives and study how and when we can succinctly characterize the specific global minimum (among the many possible global minima) reached by common optimization algorithms including, mirror descent and steepest descent with respect to different potentials and norms, and matrix factorization. We will see how this characterization, and thus the implicit bias, differ for two families of ill-posed optimization problems (a) learning linear regression from underdetermined number of observations, and (b) learning linear classification over separable data.

3 - First-order Framework for Robust Convex Optimization
Speaker: Nam Ho-Nguyen, Carnegie Mellon University, US, talk 1077
Co-Authors: *Fatma Kilinc-Karzan*,
Robust optimization (RO) has emerged as one of the leading paradigms to efficiently model parameter uncertainty. However, traditional solution approaches based on building and solving robust counterparts or the iterative approaches utilizing nominal oracles can be prohibitively expensive and thus significantly hinder the scalability of RO. In this paper, we present a general and flexible iterative framework to approximately solve robust convex optimization problems that is built on a fully online first-order paradigm. In comparison

to the existing literature, a key distinguishing feature of our approach is that it only requires access to first-order oracles that are remarkably cheaper than pessimization or nominal feasibility oracles, while maintaining the same convergence rates. We also provide new interpretations of existing iterative approaches in our framework and illustrate our framework on robust quadratic programming.

Theory and Methods for ODE- and PDE-Constrained Optimization 2

Continuous Optimization
Control - Th 3:15pm-4:15pm, Format: 2x30 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Contributed Session 333
Chair: Johann Schmitt, TU Darmstadt, DE

1 - Optimal boundary control of hyperbolic balance laws with state constraints
Speaker: Johann Schmitt, TU Darmstadt, DE, talk 751
Co-Authors: *Stefan Ulbrich*,
This talk deals with the treatment of pointwise state constraints in the context of optimal boundary control of nonlinear hyperbolic scalar balance laws. We study an optimal control problem governed by balance laws with initial and boundary conditions, where we suppose that the boundary data switch between smooth functions at certain switching points. The smooth functions and the switching points are hereby considered as the control. The appearance of state constraints presents a special challenge, since solutions of nonlinear hyperbolic balance laws develop discontinuities after finite time, which prohibits the use of standard methods. In this talk, we will build upon the recently developed sensitivity- and adjoint calculus by Pfaff and Ulbrich to derive necessary optimality conditions. In addition, we will use Moreau-Yosida regularization for the algorithmic treatment of the pointwise state constraints. Hereby, we will prove convergence of the optimal controls and weak convergence of the corresponding Lagrange multiplier estimates of the regularized problems.

2 - Numerical approximation of optimal control problems for conservation laws
Speaker: Paloma Schäfer Aguilar, TU Darmstadt, DE, talk 1076
Co-Authors: *Stefan Ulbrich*,
Many physical problems, for example models for traffic or inviscid fluid flows, are described by hyperbolic conservation laws. We study boundary control problems where the initial and the boundary data are given by piecewise C^1-functions, where the smooth parts as well as the switching times between the smooth parts serve as controls. In this talk we discuss the consistent numerical approximation of these optimal boundary control problems for scalar hyperbolic conservation laws. It was shown by Pfaff and Ulbrich that under weak assumptions tracking-type objective functionals are differentiable with respect to the initial and boundary control and that the reduced gradient can be represented by the reversible solution of a suitable adjoint equation. We analyze the convergence of discrete adjoint schemes corresponding to monotone schemes in conservation form. To this end we present (based on the work of Bouchut and James for the initial value problem) a convenient characterization of reversible solutions for the adjoint equation in the case of boundary control which is suitable to show that the limit of discrete adjoints is in fact the correct reversible solution of the adjoint equation.

Routing and Inventory

Discrete Optimization & Integer Programming
APPROX - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4

Invited Session 343
Organizer: Dorit Hochbaum, UC Berkeley, US

1 - Improved upper bound for online Dial-a-Ride on the line
Speaker: Alexander Birx, TU Darmstadt, DE, talk 544
Co-Authors: *Yann Disser*,
The online Dial-a-Ride problem is a fundamental online problem in a metric space, where transportation requests appear over time and may be served in any order by a single server with unit speed. Restricted to the real line, online Dial-a-Ride captures natural problems like controlling a personal elevator. Tight results in terms of competitive ratio are known for the general setting and for online TSP on the line (where source and target of each request coincide). In contrast, online Dial-a-Ride on the line has resisted tight analysis so far, even though it is a very natural online problem. We improve the best known upper bound of 3.41 [Krumke 2000] for open, non-preemptive online Dial-a-Ride on the line to 2.94, thus ruling out a competitive ratio of 3. The best known lower bound remains 2.04 [SODA 2017]. We obtain our result by tight analysis of the SmartStart algorithm [STACS 2000] that gives a tight result for the general, metric case.

2 - A 4/5 - Approximation Algorithm for the Maximum Traveling Salesman Problem
Speaker: Jan Marcinkowski, University of Wroclaw, PL, talk 1464
Co-Authors: *Szymon Dudycz*, *Katarzyna Paluch*, *Bartosz Rybicki*,
In the Maximum Traveling Salesman Problem (Max–TSP) we are given a complete undirected graph with non-negative weights on the edges, and we are asked to compute a Traveling Salesman tour of maximum weight. We present a fast, combinatorial $\frac{4}{5}$—approximation algorithm for Max–TSP. The previously best approximation ratio for this problem was $\frac{7}{9}$. Our algorithm builds on a technique of eliminating difficult subgraphs via gadgets with half-edges, a new method of edge colouring and a technique of exchanging edges. The result was presented at IPCO 2017.

3 - The gap between the continuous and discrete Replenishment Schedule problem
Speaker: Dorit Hochbaum, UC Berkeley, US, talk 284
Co-Authors: *Xu Rao*,
The Replenishment Storage problem (RSP) is to minimize the storage capacity requirement for a multi-item inventory system where each item has a given demand, reorder size and cycle length. In the discrete-RSP reorders can only take place at an integer time unit within the cycle. Discrete-RSP was shown to be NP-hard for constant joint cycle length (the least common multiple of the length of all individual cycles). We

show that discrete-RSP is weakly NP-hard for constant joint cycle length and strongly NP-hard for non-constant joint cycle length. For , We further present a pseudo-polynomial time algorithm that solves the constant joint cycle length discrete-RSP optimally, and the first known Fully Polynomial Time Approximation Scheme (FPTAS) for the single-cycle RSP. The scheme is utilizing a new integer programming formulation of the problem. For the continuous-RSP reorders can take place at any time within a cycle. We narrow the previously known complexity gap between the continuous and the discrete versions of RSP for the multi-cycle RSP (with either constant or non-constant cycle length) and the single-cycle RSP with constant cycle length, and widen the gap for single-cycle RSP with non-constant cycle length. For the multi-cycle case, and constant joint cycle length, the complexity status of continuous-RSP is open, whereas it is proved here that the discrete-RSP is weakly NP-hard. Under our conjecture that the continuous-RSP is easier than the discrete one, this implies that continuous-RSP on multi-cycles and constant joint cycle length, is at most weakly NP-hard.

Distributionally Robust Optimization With Marginals and Cones

Optimization under Uncertainty
Robust - Th 3:15pm-4:45pm, Format: 3x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 354
Organizer: Divya Padmanabhan, SUTD, SG

1 - Distributionally Robust Linear and Discrete Optimization with Marginals
Speaker: Louis Chen, MIT, US, talk 762
Co-Authors: *Karthik Natarajan*, *Will Ma*, *David Simchi-Levi*, *Zhenzhen Yan*,
We study the class of linear and discrete optimization problems in which the objective coefficients are chosen randomly from a distribution, and the goal is to evaluate robust bounds on the expected optimal value as well as the marginal distribution of the optimal solution. The set of joint distributions is assumed to be specified up to only the marginal distributions. We generalize the primal-dual formulations for this problem from the set of joint distributions with absolutely continuous marginal distributions to arbitrary marginal distributions using techniques from optimal transport theory. While the robust bound is shown to be NP-hard to compute for linear optimization problems, we identify a sufficient condition for polynomial time solvability using extended formulations. This generalizes the known tractability results under marginal information from 0-1 polytopes to a class of integral polytopes and has implications on the solvability of distributionally robust optimization problems in areas such as scheduling which we discuss.
2 - A Copositive Approach for Decision Rule Approximations of Multi-Stage RO
Speaker: Guanglin Xu, University of Iowa, US, talk 696
Co-Authors: *Grani Hanasusanto*,
In this talk, we study a multi-stage adaptive robust linear optimization problem. We consider the linear decision rule approximation in the case where the objective coefficients, the recourse matrices, and the right-hand sides are uncertain and consider the quadratic decision rule approximation in the case where only the right-hand sides are uncertain. As the resulting problems are non-convex, we propose copositive programming reformulations for them. We then show that the copositive approach motivates tight conservative approximations. We provide both theoretical and numerical results to demonstrate the effectiveness of our approach.
3 - Tractable Solutions to Distributionally Robust Optimisation
Speaker: Divya Padmanabhan, SUTD, SG, talk 1239
Co-Authors: *Karthik Natarajan*, *Karthyek Murthy*,
Robust optimization is being used to make decisions in several scenarios where uncertainty is involved in the underlying optimisation problem. In particular, distributionally robust solutions look at making decisions when some distributional information (such as moments) of the uncertain parameters is available. We look at distributionally robust linear programs under moment constraints. Solution approaches for the same involve the completely positive cone of matrices, for which tractable solutions do not exist in general. However there are special instances where, under partial knowledge of the moments, tractable solutions have been proposed. For example, in appointment scheduling, if the marginal moments are known, the problem is solvable in polynomial time. In this work, we analyse and identify other instances where the distributionally robust linear programming problem could be solved efficiently.

Inverse Problems in Physics

Specific Models, Algorithms, and Software
Sciences - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle LA4 Building: L, Basement, Zone: 8

Contributed Session 391
Chair: Leo Liberti, CNRS and Ecole Polytechnique, FR

1 - On the reconstruction of lattices from diffraction data
Speaker: Andreas Alpers, Technical University of Munich, DE, talk 1442
The task of reconstructing the structure and orientations of crystal lattices from diffraction data is instrumental in modern materials science for understanding and optimizing materials properties. After a brief introduction to the application, we establishing links to the geometry of numbers. This allows us to characterize the crystals that can be reconstructed from such data. Along with algorithmic aspects we discuss the ill-posedness of the underlying problem.
2 - Grain map reconstruction by means of generalized Voronoi Diagrams
Speaker: Fabian Klemm, Technical University of Munich, DE, talk 1003
Co-Authors: *Peter Gritzmann*,
We consider the task of the reconstruction of grain maps by leanly parameterized tessellation models in the form of generalizations of Voronoi Diagrams. Such grain maps appear among others in the microscopic analysis of polycrystalline materials. Generalizations of Voronoi Diagrams can been shown to have a strong connection to constrained clustering problems. Such generalized diagrams may, for example, additively weight the diagram's sites and use non-Euclidean

norms that may even be individually chosen for each of the sites. In a constrained clustering problem, weighted points are to be grouped to clusters subject to constraints expressed as integrals over the resulting clusters. Up to some mild relaxations, any clustering that is optimal w.r.t. a linear objective function over all feasible clusterings, it may be embedded into a generalized Voronoi Diagram of type determined by the objective and the choice of constraints. As an important particular example, if points in $\mathbb{R}^d$ are to be grouped to clusters of prescribed weight and centroids, there always exists a so-called Anisotropic Power Diagram that embeds such a clustering. The considered diagrams turn out to yield very well-fitting reconstructions of grain maps while using only very few parameters. Although finding the optimal diagram (w.r.t. voxel errors) turns out to be NP-hard, we are able to propose different computational methods that provide exceeding results.

3 - Scientific applications of distance geometry
Speaker: Leo Liberti, CNRS and Ecole Polytechnique, FR, talk 399
The Distance Geometry Problem is the inverse problem of "computing some pairwise distances in a given set of points", and aims at retrieving the points given some pairwise distances (with their adjacencies) and the dimension of the embedding space. It is well known for its engineering applications to time-synchronization network protocols, sensor network localization, statics, and unmanned submarine vehicle control. In this talk we discuss some of the scientific applications: to protein conformation, spherical geometry, and machine learning.

Path Problems

Specific Models, Algorithms, and Software
Logistics - Th 3:15pm-4:15pm, Format: 2x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8
Contributed Session 453
Chair: Yanchao Liu, Wayne State University, US

1 - Dynamic Discretization Discovery Algorithms for Time-Dependent Path Problems
Speaker: Edward He, GIT, US, talk 1615
Co-Authors: *Natashia Boland*, *George Nemhauser*, *Martin Savelsbergh*,
In many transportation applications, the travel time on an arc depends on the time at which traversal of the arc begins. The problem of finding a path of minimum duration, which minimizes the difference between the time of arrival at the destination and the departure time at the origin, has attracted recent interest. In the case of arc travel times that are continuous piecewise linear functions of the traversal start time, Foschini (2014) showed that the problem can be solved in time polynomial in the total number of breakpoints in these functions. However, the algorithm they propose requires solution of a shortest path problem for every one of these breakpoints. Here, we use a (possibly coarse) discretization of time to construct a time-expanded network, with arc lengths taken to be lower bounds on the arc travel time over the subsequent time interval. A shortest path in this time-expanded network yields a lower bound on the minimum duration of any path. Inspection of breakpoints associated with such a shortest path can be used to derive an upper bound. We propose an algorithm that iteratively refines the discretization, and permits time intervals to be eliminated, improving the lower (and upper) bound, until - in a finite number of iterations - optimality is proved. The lower bounds and interval elimination features enable optimal solutions to be found without exploring all breakpoints. This is supported by computational experiments where we explore less than 6 percent of the total breakpoints. The algorithm can also be extended to the more general minimum travel time problem.

2 - Drone Path Planning and Aerial Traffic Flow
Speaker: Yanchao Liu, Wayne State University, US, talk 1632
Cargo delivery using unmanned aerial systems (UAS) is a promising new mode of transportation. While control, navigation and communication technologies are becoming ready on the single-unit level, system-level air traffic management for a dense UAS traffic in the low-altitude airspace remains an open question. We present a path-planning model that centrally coordinates the flight paths for all vehicles traversing a shared airspace. The model respects kinematic laws in the Euclidean space and hence results in a nonlinear, nonconvex optimization problem. We provide theoretical bounds on the loss of separation due to time discretization, and show that the model induces shortest-path and minimum-delay paths. We analyze the phenomenon of path deadlock associated with local optimum and propose an efficient, near optimal algorithm that guarantees a feasible dispatch of all vehicles regardless of traffic density. Using this path-planning algorithm, we then quantify the capacity and efficiency of an open space at various traffic settings, and fit an empirical traffic flow model for the two-dimensional transit space.

Non-linear robust optimization

Optimization under Uncertainty
Robust - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 37 Building: B, Intermediate, Zone: 4
Contributed Session 460
Chair: Laurent Alfandari, ESSEC Business School, FR

1 - Graph learning with the Wasserstein metric
Speaker: Daniel de Roux, Universidad de los Andes, CO, talk 1191
Co-Authors: *Mauricio Velasco*,
We study the question of finding the best deterministic summary (i.e. adjacency matrix A with entries in $\{0, 1\}$ of a random graph G from an i.i.d. sample $B_1, \ldots, B_n$ of its adjacency matrix. Ideally we would like A to be the matrix for which the risk $E[\|G - A\|_1]$ is minimized. The difficulty lies on the fact that, as in the usual machine learning setup, we know G only through the information contained in the sample $B_1, \ldots, B_n$ which is not sufficient to compute this risk. Instead, we minimize the upper bound $R_\epsilon(A) := \sup_{\mu\in D} E[\|B - A\|1]$ where μ ranges in the Wasserstein ball D of radius ϵ centered at the empirical measure and $B \sim \mu$. We prove that for some choices of metric this problem leads to a tractable, consistent, convex optimization problem (LP, SOCP or SDP). We further discuss some concrete applications. In particular, the proposed approach allows us to recover the underlying cluster structure of G if sufficiently many observations are given.

2 - Robust optimization for non-linear impact of data variation

Speaker: Laurent Alfandari, ESSEC Business School, FR, talk 1610

Co-Authors: *Juan-Carlos Espinoza-Garcia*,

We extend the Gamma-robustness approach of Bertsimas and Sim to the case of non-linear impact of parameter variation. The seminal work considered protection from infeasibility over the worst-case variation of coefficients in a constraint, this variation being controlled by an uncertainty budget called Gamma. Several papers in the literature deal with non-linear robust optimization, but they usually study the robust counterpart of a non-linear problem. Our nominal problem is truly linear however. Coefficients in a constraint are non-linear functions fj(aj), where parameter aj is subject to uncertainty. For example in a Capital Budgeting problem, the NPV of a project is a non-linear function of the discount rate, which may vary. We study a piece-wise linear approximation of the non-linear function, and show that the subproblem of determining the worst-case variation can still be dualized despite the discrete structure of the piece-wise linear function. We conduct numerical experiments on three different problems: Capital Budgeting, Generalized Assignment and Knapsack problems to analyze the trade-off between feasibility and objective value for the robust solution of the piece-wise linear approximation compared to the nominal solution, and to a simpler binary approximation. We also taylor the number of pieces to the degree of concavity of the function. Despite the piece-wise approximation, the robust solution reveals to remain feasible over the 6800 runs performed in our experiments, with an average deterioration of the objective value of only a few percents.

3 - A mathematical program for signal control with equilibrium constraints

Speaker: Suh-Wen Chiou, National Dong Hwa Univ, TW, talk 183

For urban road networks with signal-controlled junctions, the reliability of a road network is heavily dependent on its vulnerability to a dangerous mix of probabilistic threats such as uncertain travel demand and link capacity loss. In this paper, a mathematical program with equilibrium constraints on randomized sets of uncertainty (MPEC) is proposed to solve a data-driven time-dependent signal control to uncertain origin-destination (OD) demand and transportation risk. Due to non-linearity and non-convexity of MPEC, a smoothed model is considered. Effective bounds are presented for smoothed MPEC via randomized sets of uncertain OD demand and uncertain link risk. A new solution scheme is proposed to solve a single level model of smoothed MPEC with global convergence. To investigate solution stability of proposed scheme, numerical computations and comparisons using example road networks are empirically made with the existing time-dependent signal control. These results reported obviously indicate that proposed smoothed model can achieve good solutions with near zero gradients as smoothing factor vanishes. The results also indicate that proposed data-driven time-dependent signal control achieved reliably better performance than did existing ones for area traffic against high consequence of uncertainty. Moreover, as compared to robust models of signal control, the proposed data-driven signal control attenuates relatively high optimality with success and exhibits better flexibility in controlling the level of conservatism of uncertainty.

High-Performance Computing in Optimization II

Specific Models, Algorithms, and Software

Algo - Th 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 22 Building: G, 2nd floor, Zone: 6

Contributed Session 466

Chair: Joaquim Dias Garcia, PSR and PUC-Rio, BR

1 - High-Performance Solver for Binary Quadratic Problems

Speaker: Timotej Hrga, University of Ljubljana, SI, talk 969

Co-Authors: *Janez Povh*, *Angelika Wiegele*,

Many problems in combinatorial optimization can be formulated as constrained binary quadratic problems (BQPs), which are in general NP hard. We present a method for finding exact solutions of large-scale linearly constrained binary quadratic programming problems. Our exact solution method combines parallelization techniques and exact penalty method approach to obtain optimal solutions of problems of sizes that are due to their size unsolvable by existing methods and tools. We use exact penalty method to first efficiently transform constrained BQP into an instance of max-cut. The obtained problem is then solved by parallel branch-and-bound algorithm that uses SDP based relaxations and is implemented using MPI (distributed memory parallel model) on supercomputer HPC located at Faculty of Mechanical Engineering of the University of Ljubljana. We will present numerical results and demonstrate how to submit a graph instance to new open-source parallel solver BiqBin for (BQPs) which is available as an online service.

2 - Bilevel optimization approaches for power system security

Speaker: Brian Dandurand, Argonne National Laboratory, US, talk 1413

Co-Authors: *Kibaek Kim*, *Sven Leyffer*,

We are interested in identifying critical contingency events that disrupts electric power system operations within an AC power network. In our approach, we formulate a bilevel optimization model. The upper level problem models an adversarial disruption to the system, such as cutting or impairing lines, transformers, etc. We note the different approaches to modeling the adversarial subproblem. Given the disruption passed from the upper level problem, the lower level problem models the restoration of stability to the system while maintaining power dispatch as close to the baseline dispatch as possible. In the solution approach, we implement the Karush Kuhn Tucker conditions to a second-order cone convex relaxation to the lower level problem and embed the resulting constraints into the adversarial upper level problem. We use SCIP for solver interfaced with Julia and apply the implementation to IEEE test instances. We discuss the issues specific to the problem structure of preprocessing, primal heuristics, tuning of branch-and-bound parameters, and parallelization of the branch-and-bound process using the UG library of SCIP. We discuss results and observations related to the robustness and susceptibility of different baseline solutions to adversarial attacks.

3 - Genesys: Simulating Power Systems by Solving Mil-

lions of MIPs
Speaker: Joaquim Dias Garcia, PSR and PUC-Rio, BR, talk 1091
Co-Authors: *André Pinto*, *Raphael Chabar*, *Julio Dias*, *Luiz Carlos da Costa Junior*, *John Fazio*, *John Ollis*, *Dan Hua*,
The Genesys software was created to compute reliability and adequacy indices of power systems with elevated level of details. This model is designed in a hierarchical fashion to closely replicate real life system operation: the simulation starts with yearly planning, goes through day ahead scheduling and finishes with hourly realizations. This is an extremely large problem and requires the solution of hundreds of millions of mixed integer programming problems (MIP) of different sizes and difficulty degree. This includes efficient construction and solution of MIPs, parallel processing and communication with other software layers. We will demonstrate how Julia and JuMP were applied to solve this extremely demanding computational task and describe how we plan to use Julia and JuMP in other steps of the process. Julia is a high-level scientific computing language and JuMP is a Mathematical Modelling library for Julia. The application will be exemplified with a case study of the Pacific Northwest System, USA.

Progress in Algorithms for Optimal Power Flow Problems II

Specific Models, Algorithms, and Software
Energy - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 23 Building: G, 3rd floor, Zone: 6

Contributed Session 509
Chair: Miguel Anjos, Polytechnique Montreal, CA

1 - Robust Optimization for the Alternating Current Optimal Power Flow Problem
Speaker: Alvaro Lorca, PUC-Chile, CL, talk 2
Co-Authors: *Andy Sun*,
We present a two-stage adaptive robust optimization model for the alternating current optimal power flow problem (ACOPF), considering uncertainty in renewable power availability and the active and reactive power injections at demand nodes. The key of the proposed approach is to employ strong SOCP-based convex relaxations of ACOPF combined with an alternating direction method to identify worst-case uncertainty realizations. We also discuss solution methods and extensive computational experiments that show advantages as compared to a deterministic ACOPF model.
2 - Global Optimization for Alternating Current Optimal Power Flow
Speaker: Ksenia Bestuzheva, ANU, Data61-CSIRO, AU, talk 1169
Co-Authors: *Hassan Hijazi*,
The Alternating Current Optimal Power Flow (ACOPF) is a non-convex optimization problem that lies at the core of many energy-related applications. Due to the high impact of the quality and validity of solutions on power systems, there is demand for reliable optimization methods that can provide feasibility and global optimality guarantees on ACOPF. In our work, we first study a subclass of non-convex problems whose every Karush-Kuhn-Tucker point is the global optimum, referred to as Kuhn-Tucker-invex (KT-invex) problems. A new property is defined and proven to be necessary for KT-invexity in n dimensions and sufficient in the case of problems with two degrees of freedom. Under mild assumptions, it is shown to hold for ACOPF problems with two degrees of freedom. For the general non-invex case an algorithm for efficiently computing the Semidefinite Programming relaxation of ACOPF is proposed based on decomposition of the network and dynamic generation of linearized cuts.
3 - Optimal Power Flow solver based on HELM
Speaker: Andreas Grothey, Uni Edinburgh, GB, talk 335
Co-Authors: *Ian Wallace*, *Ken McKinnon*,
Optimal Power Flow is known as a difficult global optimization problem. Due to its importance in its own right and as a subproblem in other power systems optimization problems it has attracted a lot of attention eg by SDP relaxations. If solved by a standard NLP solver to local optimality the resulting solution may not just be suboptimal but also non-physical, in that it violates bus stability criteria. The Holomorphic Embedded Load Flow (HELM) method has been suggested recently by Antonio Trias as an alternative (and efficient) method of solving the related load flow problem. The claim (observed in practice, but not formally proven) is that HELM will never return unstable solutions. We present a novel method to wrap the HELM method in an SQP framework to arrive at a OPF solver that avoids unstable solutions. This does not avoid all local solutions, but a significant number depending on the problem in question. HELM-OPF is shown to be competetive with other local OPF solvers, but has a higher chance of finding the global solution.

Electricity Generation Scheduling and Dispatch

Specific Models, Algorithms, and Software
Energy - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6

Contributed Session 511
Chair: Christophe Duhamel, Université Clermont Auvergne, FR

1 - Data-Driven Generator Maintenance and Operations Scheduling under Uncertainty
Speaker: Beste Basciftci, Georgia Tech, US, talk 1292
Co-Authors: *Shabbir Ahmed*, *Nagi Gebraeel*,
In this study, our aim is to effectively model and solve the integrated condition-based maintenance and operations scheduling problem of a fleet of generators from two perspectives. Firstly, we optimize maintenance and operations schedules of generators by explicitly considering the unexpected failure possibilities. We formulate this problem as a two-stage stochastic mixed-integer program and propose a chance constraint along with its safe approximation to ensure a reliable maintenance plan. We introduce a data-driven approach by considering the degradation levels of the generators within the optimization model through their estimated remaining life time distributions. To solve the resulting large-scale and challenging problem, we propose a combination of a sample average approximation and an enhanced scenario decomposition

algorithm in a distributed framework. We introduce various algorithmic improvements specific to our problem. We also develop an optimization framework that explicitly considers the effect of the operations decisions on the generators‘ degradation levels. Since this problem involves decision-dependent uncertainties, we not only extend our prior results into this setting, but also propose a stochastic formulation that captures the resulting endogeneity. Finally, we present computational experiments demonstrating the significant cost savings and computational benefits of the proposed approaches.

2 - A Network Flow–Based MILP Formulation for the Thermal Unit Commitment Problem

Speaker: Diego Jimenez, UTFSM, CL, talk 1492

Co-Authors: *Alejandro Angulo*,

This work proposes a reformulation for the thermal unit commitment (UC) problem using a network flow–based monolithic mixed–integer linear programming (MILP) scheme. Most current approaches to solve the UC problem use tight and compact MILP formulations, making the use of network flow impractical since network flows do not feature compact representations. We experimentally show in this work that a compact representation is not necessary because preprocessing techniques available in state–of–the–art commercial solvers reduce the formulation size. Therefore, network flows may be utilized for the UC problem formulation. In contrast with compact formulations available in the literature, network flows allow for straightforward inclusion of additional/new constraints, making the problem formulation much more flexible. We evaluate the computational performance of the proposed reformulation against the best compact formulation found in the literature for several instances, including new constraints and features. Results shows 23**3 - solving the Short-term Hydrothermal Scheduling problem with linearizations**

Speaker: Christophe Duhamel, Université Clermont Auvergne, FR, talk 1305

Co-Authors: *Gabriela Migliorini*, *Pedro Palermo*,

Short-term hydrothermal scheduling is a daily operation in power systems. It consists in setting the production level for hydroelectric and thermal plants in order to meet the power demand and to minimize the total thermal cost. Several sets of constraints are considered: the hydraulic flow on cascading reservoirs, the power generation limits, the given hourly power demand. Optional constraints can also be added: ramp-rate limits, prohibited hydroelectric production zones, power loss (PL) and valve point (VP) effect in the thermal plants. This leads to a non-linear, non-convex problem. Due to its huge economical impact on power systems, it has been been deeply investigated, especially using approximate methods (heuristics and metaheuristics). We propose an iterative approach, based on local linearization and MILP, to compute a feasible approximate solution. Each non-linear part of the model is analyzed and a specific way to set linear approximation is defined. While this is straightforward for the hydraulic power and the thermal cost computation, this is more complex for the power loss and the valve point effect. An overestimation is performed for the former while several techniques are combined for the latter. Decision variables are used to handle the prohibited zones. Our scheme converges towards the optimal value when PL and VP are not considered. A classic instance is used to assess the performance of our approach. In particular, the impact of each optional component is analyzed. The results are compared with the literature, showing the efficiency of our method.

Non-Standard IP Methods

Discrete Optimization & Integer Programming

IPtheory - Th 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 42 Building: C, 3rd floor, Zone: 1

Contributed Session 513

Chair: Ulf Friedrich, TU Munich, DE

1 - Algebraic Geometry and Integer Programmings in Cooperative Game Theory

Speaker: Tri-Dung Nguyen, University of Southampton, GB, talk 629

Algebraic geometry has recently been emerged as an alternative approach for solving integer (non)-linear programs by exploiting the algebraic structure of the underlying lattice and generating sets. Although algebraic geometry is, in general, still not as competitive as mainstream IP solvers such as CPLEX, there are certain classes of problems where using algebraic geometry is more effective. This includes the problem of finding the Shapley value of a class of integer maximization games where an exponentially large number of IPs must be solved. A major obstacle in using algebraic geometry for integer programming is the computational bottleneck of finding the Groebner and the Graver bases. In the second part, we present a recent progress in refining the project-and-lift method, which is the current state-of-the-art algorithm for finding the Graver basis, such that the algebraic geometry method can handle larger IPs.

2 - A hierarchy of cutting plane operators based on lineality spaces

Speaker: Wolfgang Keller, Otto-von-Guericke University, DE, talk 854

To derive cutting planes for a rational polyhedron $P \subseteq R^m \times R^n$ (m: number of integer variables, n: number of continuous variables) we consider inequalities for $P \cap ((Z^m \times R^n) + V)$ or $(P + V) \cap (Z^m \times R^n)$, where V is a subspace of codimension $k \in \{0, \ldots, m + n\}$. For now let V be a rational subspace, though we also consider the case that V is generated by vectors from $Q^m \times R^n$. We call the first construction $L_{k,Q}$ cuts and the second one $L_{k-\frac{1}{2},Q\times Q}$ cuts. $L_{k,Q}$ cuts are closely related to the k-dimensional lattice cuts that were recently studied by Dash, Günlük and Morán Ramirez. For a given rational polyhedron P these hierarchies of closures can be merged into a unified hierarchy: $P = cl_{L_{0,Q}}(P) \supseteq cl_{L_{1-\frac{1}{2},Q\times Q}}(P) \supseteq cl_{L_{1,Q}}(P) \supseteq \ldots \supseteq cl_{L_{m-1,Q}}(P) \supseteq cl_{L_{m-\frac{1}{2},Q\times Q}}(P) \supseteq cl_{L_{m,Q}}(P) = cl_{L_{(m+1)-\frac{1}{2},Q\times Q}}(P) = cl_I(P)$. This hierarchy includes multiple well-known cutting plane closures: $cl_{L_{1-\frac{1}{2},Q\times Q}}(P)$, $cl_{L_{1,Q}}(P)$ and $cl_{L_{2,Q}}(P)$ correspond to the (projected) Chátal-Gomory closure, split closure and crooked cross closure of P. We could show that for any inclusion in this hierarchy strict inclusion can occur. Additionally the closures regarding $L_{k-\frac{1}{2}}$ cuts with respect to vector spaces generated by vectors from $Q^m \times R^n$ can also be embedded neatly into this hierarchy.

3 - A power series algorithm for non-negative IP

Speaker: Ulf Friedrich, TU Munich, DE, talk 1021

We present a perspective on IP with non-negative input which combines generating function techniques with a multipath version of Cauchy's integral formula. Based on a power series representation for its input data, the optimization problem is linked to the evaluation of a complex path integral. This approach allows the formulation of algorithms which rely on numerical quadrature. Besides the theoretical background of the method, we discuss challenges in practical implementations. In particular, it is demonstrated how preprocessing with so-called path adaption algorithms can help to improve the condition number of the quadrature problem, whose efficient solution is essential for the algorithm. An especially promising variant of the path adaption idea solves a shortest path problem on a predefined grid graph inside the unit disc. This leads to a refined version of the algorithm with better numerical stability and overall performance.

Polynomial Time Solvable Problems and Complete Descriptions

Discrete Optimization & Integer Programming
IPtheory - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Contributed Session 520
Chair: Andreas Bärmann, FAU Erlangen-Nürnberg, DE

1 - Extreme points for scheduling around a common due date
Speaker: A-E Falq, LIP6, FR, talk 870
Co-Authors: *Pierre Fouilhoux*, *Safia Kedad-Sidhoum*,
We study a single machine just-in-time scheduling problem with a polyhedral approach. The aim is to minimize the weighted sum of earliness and tardiness penalties around a common due date. An instance is considered unrestrictive if all the tasks can be scheduled before the due date. In this case, some dominance properties allows to efficiently solve some particular instances. In the general case, some of these dominance properties are not still valid. For the unrestrictive case, we provide both compact and non-compact formulations. The latter one is extended to the general case. For the non-compact formulations, a vector satisfying all the constraints can correspond to an unfeasible schedule. However, we ensure that the extreme points of the associated polyhedra correspond to feasible schedules satisfying dominance properties. We prove that the separation problem of these two formulations reduces to min-cut problem, leading to a polynomial time algorithm. Some experimental results will illustrate the effectiveness of these formulations.

2 - On Integer Programming and Convolution
Speaker: Lars Rohwedder, University of Kiel, DE, talk 846
Co-Authors: *Klaus Jansen*,
Integer programs with a fixed number of constraints can be solved in pseudo-polynomial time. We present a surprisingly simple algorithm and matching conditional lower bounds. Consider an IP in standard form $\max\{c^T x : Ax = b, x \in \mathbb{Z}^n_{\geq 0}\}$, where $A \in \mathbb{Z}^{m\times n}$, $b \in \mathbb{Z}^m$ and $c \in \mathbb{Z}^n$. Let Δ be an upper bound on the absolute values in A. We show that this IP can be solved in time $O(m\Delta)^{2m} \cdot \log(\|b\|_\infty)$. The previous best algorithm has a running time of $n \cdot O(m\Delta)^{2m} \cdot \|b\|_1^2$. The hardness of (min, +)-convolution has been used to prove conditional lower bounds on a number of polynomially solvable problems. We show that improving our algorithm for IPs of any fixed number of constraints is equivalent to improving (min, +)-convolution. More precisely, for any fixed m there exists an algorithm for solving IPs with m constraints in time $O(m(\Delta + \|b\|_\infty))^{2m-\delta}$ for some $\delta > 0$, if and only if there is a truly sub-quadratic algorithm for (min, +)-convolution. For the feasibility problem, where the IP has no objective function, we improve the running time to $O(m\Delta)^m \log(\Delta) \log(\Delta + \|b\|_\infty)$. We also give a matching lower bound here: For every fixed m and $\delta > 0$ there is no algorithm for testing feasibility of IPs with m constraints in time $n^{O(1)} \cdot O(m(\Delta + \|b\|_\infty))^{m-\delta}$ unless the SETH is false.

3 - The Clique Problem with Multiple-Choice Constraints and Two Polynomial Subcases
Speaker: Andreas Bärmann, FAU Erlangen-Nürnberg, DE, talk 1176
Co-Authors: *Patrick Gemander*, *Maximilian Merkert*, *Oskar Schneider*,
We introduce the Clique Problem with Multiple-Choice Constraints, a combinatorial optimization problem that is found as a substructure in various applications. It can be posed as follows: Given an undirected graph and a partition of its nodes into subsets, the task is to select exactly one node from each subset such that any two chosen nodes are connected in the graph. Although the general problem is NP-complete, we are able to present two relevant special cases where the problem is solvable in polynomial time. In the first case, called staircase compatibility, we can give a totally unimodular formulation of linear size. In the second case, called forest dependencies, we show that the underlying compatibility graph is perfect. In both cases, we have derived efficient reformulations of the problem whose significant benefit we demonstrate in real-world case studies.

Production Planning

Specific Models, Algorithms, and Software
Scheduling - Th 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 531
Chair: Michel Siemon, RWTH Aachen, DE

1 - ISO-PESP - A PESP Variant for Minimizing the Cycle Time of Production Lines
Speaker: Tobias Hofmann, TU Chemnitz, DE, talk 576
Co-Authors: *Christoph Helmberg*,
Modern production systems rely more and more on fully automated production lines. The increasing complexity of robot interactions makes automated development tools indispensable. Given the sequences of robot operations, a decisive step is minimizing the cycle time of the entire line while respecting collision restrictions. We investigate the applicability of the Periodic Event Scheduling Problem (PESP) in order to tackle this scheduling problem. We establish a variant of the classical formulation, the so-called ISO-PESP in order to cover the special characteristics of the application. We consider modeling aspects, prove the NP-hardness of this new problem and provide good bounds on the integer offset variables of the problems' Cycle Periodicity Formulation. Finally, we present a computational study based on real-world as well as designed data sets that confirms the practical usability of the model proposed.

2 - A matheuristic for the blocking job shop problem with a tardiness objective
Speaker: Julia Lange, OvG-Universität Magdeburg, DE, talk 1331
Co-Authors: *Reinhard Bürgy*,
We consider the blocking job shop scheduling problem with a tardiness objective (BJS-T). This problem is an extension of the classical job shop characterized by blocking constraints that model a lack of buffers in the production or logistics system. This process feature typically occurs in flexible manufacturing systems, in the production of huge items and in single-track railway scheduling. The tardiness objective considered here is especially suitable when modeling economic purposes such as contract compliance and customer due date targets. The BJS-T is not only NP-hard but also particularly challenging due to feasibility issues caused by the absence of buffers. Current state-of-the-art solvers struggle in finding good feasible solutions even for medium-sized instances when using standard mixed-integer linear programming formulations of the BJS-T. Therefore, we propose a variable neighborhood search heuristic where the neighborhoods are explored using mixed-integer programs. We develop various neighboring concepts and discuss their performance. The computational results support the validity of the approach.
3 - Value-based End-to-End Production Planning in Non-Ferrous Metal Industry
Speaker: Michel Siemon, RWTH Aachen, DE, talk 1568
Co-Authors: *Max Schiffer*, *Grit Walther*,
Production planers in the non-ferrous metal industry face an inherent combinatorical complexity of the metal production process. Additionally, the supply chains complexity is increasing in a fast changing market environment. Herein, mathematical optimization helps to cope with the resulting challenges. However, a value-based operational planning approach that covers the entire production process is missing so far. High economic and technical benefits could result by implementing such an approach into the daily processes of a production plant. Against this background, we present a mixed integer linear program for non-ferrous metal operational production planning that is able to cover the complexity of the material flows and the entire production process.

Polynomial and tensor optimization II

Continuous Optimization
NLP - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 6
Organizer: Jiawang Nie, Univ. of California San Diego, US

1 - Computing invariant measures with the Lasserre hierarchy
Speaker: Didier Henrion, LAAS-CNRS Univ. Toulouse, FR, talk 227
When a dynamical system admits an invariant measure, we show that the Lasserre hierarchy of polynomial moment-sum-of-square semidefinite relaxations can be adapted to approximate the absolutely continuous part (with respect to the Lebesgue measure) of the invariant measure with guarantees of strong convergence. We also show how the support of the singular part (continuous and discrete) of the invariant measure can be approximated arbitrary well in the Hausdorff metric. Joint work with Marcelo Forets, Milan Korda, Igor Mezic and Victor Magron.
2 - Completely positive tensor recovery with minimal nuclear value
Speaker: Anwa Zhou, Shanghai University, CN, talk 9
Co-Authors: *Jinyan Fan*,
In this talk, we introduce the CP-nuclear value of a completely positive (CP) tensor and study its properties. A semidefinite relaxation algorithm is proposed for solving the minimal CP-nuclear-value tensor recovery. If a partial tensor is CP-recoverable, the algorithm can give a CP tensor recovery with the minimal CP-nuclear value, as well as a CP-nuclear decomposition of the recovered CP tensor. If it is not CP-recoverable, the algorithm can always give a certificate for that, when it is regular. Some numerical experiments are also presented.
3 - Phaseless rank of a matrix
Speaker: João Gouveia, University of Coimbra, PT, talk 297
Co-Authors: *António Goucha*,
In this talk we present some results on the problem of minimizing the rank of a complex matrix under phase uncertainty but prescribed magnitudes for the entries. The minimum value of this optimization problems is what we define to be the phaseless rank of the matrix. This problem, motivated by questions on semidefinite representations of polytopes, turns out to have strong connections to amoeba theory, that can be explored to derive some interesting results. We will show some of the geometrical and algebraic results obtained concerning this new notion and present some open conjectures.
4 - A Complete Semidefinite Algorithm for Detecting Copositive Matrices and Tensors
Speaker: Xinzhen Zhang, Tianjin University, CN, talk 10
A real symmetric matrix (resp., tensor) is said to be copositive if the associated quadratic (resp., homogeneous) form is greater than or equal to zero over the nonnegative orthant. The problem of detecting their copositivity is NP-hard. This paper proposes a complete semidefinite relaxation algorithm for detecting the copositivity of a matrix or tensor. If it is copositive, the algorithm can get a certificate for the copositivity. If it is not, the algorithm can get a point that refutes the copositivity. We show that the detection can be done by solving a finite number of semidefinite relaxations, for all matrices and tensors.

Recent Advances in Conic Programming III

Continuous Optimization
SDP - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Invited Session 84
Organizer: Masakazu Muramatsu, UEC, JP

1 - A path-following method for semidefinite programming without Slater condition
Speaker: Makoto Yamashita, Tokyo Institute of Technology, JP, talk 166

Co-Authors: *Kei Takemura*,
In this talk, we propose an augmented Lagrangian method for semidefinite programming (SDP) problems that do not meet the Slater condition. Standard path-following interior-point methods follow the central path to approach an optimal solution. The existence of the central path requires the Slater condition, that is, both primal and dual SDP problems have interior-points. In contrast, the duality gap can be zero under a weaker condition that the dual SDP has an interior-point and the primal SDP is feasible. The proposed method is designed for SDPs whose primal problem does not have interior-points. Instead of the central path, we construct alternative paths that approach an optimal solution. In particular, we show that the center of alternative paths is the central path when the central path exists, and that the alternative paths exist even when the central path does not exist. To construct the alternative paths, we combine an augmented Lagrangian method for primal SDP and a log-det penalty term for variable matrix. We give a convergence of the proposed method in two different ways: (i) using an augmented Lagrangian method in primal side and (ii) using a proximal method in dual side.

2 - A Majorized Newton-CG ALM for Linearly Constrained Convex Programming
Speaker: Tang Peipei, Zhejiang University City Colle, CN, talk 122
Co-Authors: *Chengjing Wang*,
In this paper, we propose a primal majorized semismooth Newton-CG augmented Lagrangian method for large-scale linearly constrained convex programming problems, especially for some difficult problems which are nearly degenerate. The basic idea of this method is to apply the majorized semismooth Newton-CG augmented Lagrangian method to the primal convex problem. And we take two special nonlinear semidefinite programming problems as examples to illustrate the algorithm. Numerical experiments demonstrate that our method works very well for the testing problems, especially for many ill-conditioned ones.

3 - Analysis of Positive Systems by Semidefinite and Copositive Programming
Speaker: Yoshio Ebihara, Kyoto University, JP, talk 441
In the field of control system theory, analysis and synthesis of positive systems have attracted growing attention recently. A dynamical system is said to be positive if its state and output are nonnegative for any nonnegative initial state and nonnegative input. The theory of positive systems is deeply rooted in the theory of nonnegative matrices, but it has gained renewed interest from the viewpoint of convex optimization. In this talk we will provide recent results on the analysis and synthesis of positive systems by means of linear, semidefinite, and copositive programming.

4 - Acceleration of the Lagrangian-DNN method for a class of QOPs
Speaker: Yuzhu Wang, University of Tsukuba, JP, talk 443
Co-Authors: *Akiko Yoshise*,
Recently, a robust Lagrangian-DNN method has been shown efficient to provide lower bounds for a class of quadratic optimization problems (QOPs) by Arima, Kim, Kojima and Toh in 2017. The bisection method combined with accelerated proximal gradient method they use guarantees valid lower bounds for QOPs and computational efficiency. However, the two parameters which the algorithm uses need to be chosen wisely for an efficient result. To accelerate the bisection method, we introduce a 'deciding region'. Precisely, when the midpoint of the bisection method enters our 'deciding region', it can be determined to be the lower bound or the upper bound directly rather than using iterative method: FISTA. Using our 'deciding region', the bisection method can be accelerated for some random QOPs. Moreover, using our 'deciding region', method's dependency on parameters can be reduced theoretically. Keywords: Non-convex quadratic optimization problems, the Lagrangian-DNN relaxation, accelerated bisection method.

Approximation Algorithms for Optimization under Uncertainty

Discrete Optimization & Integer Programming
APPROX - Th 5:00pm-6:30pm, Format: 3x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 95
Organizer: Marc Uetz, University of Twente, NL

1 - Prophet Inequalities Made Easy: Stochastic Opt. by Pricing Non-Stochastic Inputs
Speaker: Thomas Kesselheim, University of Bonn, DE, talk 816
Co-Authors: *Paul Dütting*, *Michal Feldman*, *Brendan Lucier*,
We present a general framework for stochastic online maximization problems with combinatorial feasibility constraints. The framework establishes prophet inequalities by constructing price-based online approximation algorithms, a natural extension of threshold algorithms for settings beyond binary selection. Our analysis takes the form of an extension theorem: we derive sufficient conditions on prices when all weights are known in advance, then prove that the resulting approximation guarantees extend directly to stochastic settings. Our framework unifies and simplifies much of the existing literature on prophet inequalities and posted price mechanisms, and is used to derive new and improved results for combinatorial markets (with and without complements), multi-dimensional matroids, and sparse packing problems. Finally, we highlight a surprising connection between the smoothness framework for bounding the price of anarchy of mechanisms and our framework, and show that many smooth mechanisms can be recast as posted price mechanisms with comparable performance guarantees.

2 - Hiring Secretaries over Time: The Benefit of Concurrent Employment
Speaker: Max Klimm, HU Berlin, DE, talk 909
Co-Authors: *Yann Disser*, *John Fearnley*, *Martin Gairing*, *Oliver Göbel*, *Daniel Schmand*, *Alexander Skopalik*, *Andreas Tönnis*,
We consider a variant of the stochastic secretary problem where applicants need to be hired over time. Upon arrival of each applicant their cost per time step is revealed, and we have to fix the duration of employment, starting immediately. This decision is irrevocable, i.e., we can neither extend a contract nor dismiss a candidate once hired. In every time step, at least one candidate needs to be under contract, and our goal is to minimize the total hiring cost, which is the sum of the applicants' costs multiplied with their respective employment durations. We provide a competitive online algorithm for the

case that the applicants' costs are drawn independently from a known distribution. Specifically, the algorithm achieves a competitive ratio of 2.98 for the case of uniform distributions. For this case we give an analytical lower bound of 2 and a computational lower bound of 2.14. We then adapt our algorithm to stay competitive in settings where at most two applicants can be hired concurrently and/or the distribution of the applicants' costs is unknown and/or the total number n of time steps is unknown. On the other hand, we show that concurrent employment is a necessary feature of competitive algorithms by showing that no algorithm has a competitive ratio better than $\Omega(\sqrt{n}/\log n)$ if concurrent employment is forbidden, even for uniform distributions and when the total number of time steps is known.

3 - Greed is Good - Online Algorithms for Stochastic Unrelated Machine Scheduling
Speaker: Marc Uetz, University of Twente, NL, talk 837
Co-Authors: *Varun Gupta*, *Benjamin Moseley*, *Qiaomin Xie*,
The talk addresses a classical problem in the area of scheduling, namely minimizing the total weighted completion time of non-preemptive jobs on a set of unrelated machines. Uncertainty enters the model by assuming that job processing times are stochastic. In order to obtain constant factor approximation algorithms for that problem, prior work required sophisticated linear or convex programming relaxations for the assignment of jobs to machines. In contrast, we analyze a purely combinatorial online algorithm. Maybe surprisingly, we show how to derive performance bounds for that algorithm that are of the same order of magnitude as those of earlier work, while our results are the first for an online setting. Specifically, when Δ is an upper bound on the (squared) coefficient of variation of all processing times, our performance bounds are $4+2\Delta$ when there are no release times, and $12 + 6\Delta$ when jobs are released over time. The bound for the model without release times is tight. The analysis is based on dual fitting techniques.

Large-scale combinatorial optimization implementations

Specific Models, Algorithms, and Software
Algo - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 9 Building: N, 4th floor, Zone: 12

Invited Session 96
Organizer: Aaron Archer, Google, US

1 - Lost in Translation: Production Code Efficiency
Speaker: Andrew Goldberg, Amazon.com, US, talk 641
When software engineers re-implement a high-performance research prototype code, one often observes one to two orders of magnitude drop in performance. This holds even if both implementations use the same language. The gap is even wider when one goes from a simple language (e.g., C++) to a more sophisticated language (e.g., Java). The main cause of this phenomenon is the misinterpretation by software engineers of what they learn in school. Theoretical computer scientists ignore constant factors for the sake of machine-independent analysis. Programming language researchers often focus on compilers that automatically handle low-level OS and architectural issues such as memory management. Software engineering professors emphasize specification and re-usability. Many software engineers learn to ignore constant factors, to rely on compilers for low-level efficiency, and to use general-purpose primitives for re-usability. This is tempting to do as one has to worry about fewer issues when coding and to learn fewer primitives. However, in practice constant factors do matter, compilers do not always take advantage of computer architecture features, and general-purpose primitives may be less efficient than the ones that are sufficient for the task. Ignoring these issues leads to significant loss of computational efficiency and increased memory consumption. Power consumption also increases significantly. In this talk we give several examples of inefficient program fragments and discuss them. These examples show that software engineers need to pay attention to low-level detail.

2 - Distributed Balanced Partitioning via Linear Embedding
Speaker: Kevin Aydin, Google Inc, US, talk 908
Co-Authors: *Hossein Bateni*, *Vahab Mirrokni*,
Balanced partitioning is often a crucial first step in solving large-scale graph optimization problems, e.g., in some cases, a big graph can be chopped into pieces that fit on one machine to be processed independently before stitching the results together, leading to certain suboptimality from the interaction among different pieces. In other cases, links between different parts may show up in the running time and/or network communications cost, hence the desire to have small cut size. We study a distributed balanced partitioning problem where the goal is to partition the vertices of a given graph into k pieces so as to minimize the total cut size. Our algorithm is composed of a few steps that are easily implementable in distributed computation frameworks, e.g., MapReduce. The algorithm first embeds nodes of the graph onto a line, and then processes nodes in a distributed manner guided by the linear embedding order. We examine various ways to find the first embedding, e.g., via a hierarchical clustering or Hilbert curves. Then we apply four different techniques including local swaps, minimum cuts on the boundaries of partitions, as well as contraction and dynamic programming. As our empirical study, we compare the above techniques with each other, and also to previous work in distributed graph algorithms. We report our results both on a private map graph and several public social networks, and show that our results beat previous distributed algorithms. We also observe that our algorithms allow for scalable distributed implementation for any number of partitions.

3 - High Quality Graph and Hypergraph Partitioning
Speaker: Christian Schulz, University Vienna, AT, talk 545
Co-Authors: *Sebastian Schlag*, *Peter Sanders*,
In computer science, engineering, and related fields graph partitioning (GP) is a common technique for processing very large graphs, e.g. networks stemming from finite element methods, route planning, or social networks. Hypergraphs are a generalization of graphs, where each (hyper)edge can connect more than two vertices. The hypergraph partitioning (HGP) problem is the generalization of the graph partitioning problem. HGP has a wide range of applications. Two prominent areas are VLSI design and scientific computing. We briefly introduce the partitioning problems and present the KaHIP (Karlsruhe High Quality Partitioning) family of graph par- titioning programs as well as the hypergraph partitioning framework KaHyPar (Karlsruhe Hypergraph Partitioning).

Both systems provide world class solution quality. For example, KaHIP has been able to improve most of the entries reported in the broadly accepted Walshaw benchmark, while KaHyPar is the method of choice for a wide range of hypergraph partitioning tasks, computing better solutions than the widely used general purpose tools hMetis and PaToH.

4 - Solving Coverage Problems on Massive Data

Speaker: Hossein Bateni, Google Inc., US, talk 779

Co-Authors: *Hossein Esfandiari*, *Vahab Mirrokni*,

We study three coverage problems—minimum set cover, maximum k-cover, and minimum set cover with outliers—in large-scale settings. Our main contribution is a simple yet powerful sketch for these problems that leads to almost optimal algorithms in streaming, MapReduce and RAM models. The optimality is measured in terms of the running time, approximation guarantee, space complexity, as well as number of rounds/passes of computation. These results are complemented by demonstrating why natural sketches are not sufficient to solve these problems. We further study extending the algorithms to several weighted variants of set cover, as well as facility location, dominating set, and a large class of submodular maximization problems. Our extensive empirical study illustrates the effectiveness of the new algorithms. Here we consider a variety of set-cover instances (bag-of-word document summarization, collaboration networks, dominating set) as well as a real application for feature selection. We observe that using sketches 30–600 times smaller than the input, one can solve the coverage maximization problem with quality very close to that of the state-of-the-art single-machine algorithm.

Robust Optimization under Data Uncertainty

Optimization under Uncertainty

Robust - Th 5:00pm-6:30pm, Format: 3x30 min

Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 98

Organizer: Omid Nohadani, Northwestern University, US

1 - Uncertain Data Envelopment Analysis

Speaker: Matthias Ehrgott, Lancaster University, GB, talk 299

Co-Authors: *Allen Holder*, *Omid Nohadani*,

Data Envelopment Analysis (DEA) is a nonparametric, data driven method to conduct relative performance measurements among a set of decision making units (DMUs). Efficiency scores are computed based on assessing input and output data for each DMU by means of linear programming. Traditionally, these data are assumed to be known precisely. We instead consider the situation in which data is uncertain, and in this case, we demonstrate that efficiency scores increase monotonically with uncertainty. This enables inefficient DMUs to leverage uncertainty to counter their assessment of being inefficient. Using the framework of robust optimization, we propose an uncertain DEA (uDEA) model for which an optimal solution determines (1) the maximum possible efficiency score of a DMU over all permissible uncertainties, and (2) the minimal amount of uncertainty that is required to achieve this efficiency score. We show that the uDEA model is a proper generalization of traditional DEA and provide a first-order algorithm to solve the uDEA model with ellipsoidal uncertainty sets. Finally, we present a case study applying uDEA to the problem of deciding efficiency of radiotherapy treatments.

2 - Wasserstein Distributionally Robust Kalman Filtering

Speaker: Soroosh Shafieezadeh, EPFL, CH, talk 1449

Co-Authors: *Viet Anh Nguyen*, *Peyman Mohajerin Esfaha*, *Daniel Kuhn*,

We study a distributionally robust mean square error estimation problem over a nonconvex Wasserstein ambiguity set containing only normal distributions. We show that the optimal estimator and the least-favorable distribution form a Nash equilibrium. Despite the non-convex nature of the ambiguity set, we prove that the estimation problem is equivalent to a tractable convex program. We further devise a Frank-Wolfe algorithm for this convex program whose direction-searching subproblem can be solved in a quasi-closed form. Using these ingredients, we introduce a minimax Kalman filter that hedges effectively against model risk.

3 - Appointment Scheduling Under Time-Dependent Patient No-Show Behavior

Speaker: Zhenzhen Yan, Nanyang Technological Universi, SG, talk 928

Co-Authors: *Qingxia Kong*, *Shan Li*, *Nan Liu*, *Chung Piaw Teo*,

This paper studies how to schedule medical appointments with time-dependent patient no-show behavior and random service times. The problem is motivated by our studies of independent datasets from countries in two continents which unanimously identify a significant time-of-day effect on patient show-up probabilities. We deploy a distributionally robust model, which minimizes the worst case total expected costs of patient waiting and service provider's idle and overtime, by optimizing the scheduled arrival times of patients. This model is quite challenging because it involves a linear program with uncertainties present in both the objective function and the right-hand side of the constraint sets. In addition, there exist complementary functional relationships among these uncertainties (namely, patient no-shows and service durations). Via a new technique developed in this paper, we represent this challenging linear program as a completely positive program, which can be reformulated as a copositive program and then be approximated by semidefinite programs. To tackle the case when patient no-shows are endogenous on the schedule, we construct a set of dual prices to guide the search for a good schedule and use the technique iteratively to obtain a near optimal solution. Our computational studies reveal a significant reduction in total expected cost by taking into account the time-of-day variation in patient show-up probabilities as opposed to ignoring it.

Convexification and more (II)

Discrete Optimization & Integer Programming

MINLP - Th 5:00pm-6:30pm, Format: 3x30 min

Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 106

Organizer: Akshay Gupte, Clemson University, US

1 - Binary Programming with Semilinear Elliptic PDE-constraints

Speaker: Christoph Buchheim, TU Dortmund, DE, talk 374
Co-Authors: *Renke Kuhlmann*, *Christian Meyer*,
We present an outer approximation algorithm for binary programming problems where the constraints arise implicitely from semilinear elliptic PDEs and bounds on the states. A typical example is the heating of a metallic workpiece by a given finite set of heat sources which may be switched on or off, with the objective of using as few sources as possible in order to achieve a given minimum temperature everywhere in the workpiece. In the case of linear PDEs, many such problems can be rewritten as (finite-dimensional) linear or convex quadratic integer programs over the controls, and hence solved by state- of-the-art integer programming software. For the non-linear case, the standard solution approach is to directly discretize the entire problem, resulting however in huge non-convex mixed-integer optimization problems that can be solved to proven optimality only in very small dimensions. For PDEs with a convex nonlinear part, which appear in the application mentioned above, we show that the solution operator is pointwise concave and submodular. This allows to over- and underestimate it by linear expressions, leading to linear cutting planes that can be used to cut off any infeasbile solution. By a suitable combination of such over- and underestimators, our approach can also handle linear constraints on both control and state variables as well as L^p-tracking-type objective functions for all $p \in [1, \infty]$.

2 - Using algebraic structure to accelerate polyhedral approximation
Speaker: Christopher Coey, MIT, US, talk 692
Co-Authors: *Juan Pablo Vielma*,
For MINLP problems involving common multivariate functions, we describe extended formulations that are "symmetric" and "effectively univariate" in the input variables. In our new convex MINLP algorithm, we improve upon gradient cuts by utilizing more information from the LP solves and the simple algebraic structure of the extended formulation constraints. In our new nonconvex MINLP algorithm, we build and refine univariate piecewise-convex approximations, which may be more efficient than discretizing in the multivariate space. We show some preliminary computational results.

3 - Quadratic optimization with M-matrices and semi-continuous variables
Speaker: Andres Gomez, University of Pittsburgh, US, talk 220
Co-Authors: *Alper Atamturk*,
We study quadratic optimization with semi-continuous variables and an M-matrix, i.e., PSD with non-positive off-diagonal entries. This structure arises in image segmentation, portfolio optimization, as well as a substructure of general quadratic optimization problems. We prove, under mild assumptions, that the minimization problem is solvable in polynomial time by showing its equivalence to a submodular minimization problem. To strengthen the formulation, we decompose the quadratic function into a sum of simple quadratic functions with at most two semi-continuous variables and provide the convex hull descriptions of these sets. We also describe strong conic quadratic valid inequalities. Preliminary computational experiments indicate that the proposed inequalities can substantially improve the strength of the continuous relaxations with respect to the standard perspective reformulation.

Efficient Semismooth Newton Methods for Large Scale Statistical Optimization Problems

Continuous Optimization
NonSmooth - Th 5:00pm-6:30pm, Format: 3x30 min
Room: Salle LC4 Building: L, Intermediate 1, Zone: 9
Invited Session 123
Organizer: Defeng Sun, Hong Kong Polytechnic Univ, HK

1 - Efficient sparse Hessian based algorithms for the clustered lasso problem
Speaker: Meixia Lin, NUS, SG, talk 497
Co-Authors: *Defeng Sun*, *Kim-Chuan Toh*, *Yong-Jin Liu*,
We focus on solving the clustered lasso problem, which is a least square problem with the ℓ_1-type penalties imposed on both the coefficients and their pairwise differences to learn the group structure of the regression parameters. Here we first reformulate the clustered lasso regularizer as a weighted ordered-lasso regularizer, which is essential in reducing the computational cost from $O(n^2)$ to $O(n \log(n))$. We then propose an inexact semismooth Newton augmented Lagrangian (Ssnal) algorithm to solve this equivalent formulation or its dual depending on whether the sample size is larger than the dimension of the features. An essential component of the Ssnal algorithm is the computation of the generalized Jacobians of the proximal mapping of the clustered lasso regularizer. Based on the new formulation, we derive an efficient procedure for its computation. Comprehensive results on the global convergence and local linear convergence rate of the Ssnal algorithm are established. For the purpose of exposition and comparison, we also summarize/design several first-order methods that can be used to solve the problem under consideration, but with the key improvement from the new formulation of the clustered lasso regularizer. As a demonstration of the applicability of our algorithms, numerical experiments on the clustered lasso problems are performed. The experiments show that the Ssnal algorithm substantially outperforms the best alternative algorithm for the clustered lasso problems.

2 - An efficient algorithm for solving large scale sparse group Lasso problems
Speaker: Yangjing Zhang, NUS, SG, talk 449
Co-Authors: *Ning Zhang*, *Defeng Sun*, *Kim-Chuan Toh*,
The sparse group Lasso is a widely used statistical model which encourages the sparsity both on a group and within the group level. In this paper, we develop an efficient augmented Lagrangian method for large-scale sparse group Lasso problems with each subproblem being solved by a superlinearly convergent inexact semismooth Newton method. Theoretically, we prove that, if the penalty parameter is chosen sufficiently large, the augmented Lagrangian method converges globally at an arbitrarily fast linear rate for the primal iterative sequence, the dual infeasibility, and the duality gap of the primal and dual objective functions. Computationally, we derive explicitly the generalized Jacobian of the proximal mapping associated with the sparse group Lasso regularizer and exploit fully the underlying second order sparsity through the semismooth Newton method. The efficiency and robustness of our proposed algorithm are demonstrated by numerical experiments on both the synthetic and real data sets.

3 - On the efficient computation of the projector over the

Birkhoff polytope
Speaker: Defeng Sun, Hong Kong Polytechnic Univ, HK, talk 959
Co-Authors: *Xudong Li*, *Kim-Chuan Toh*,
We derive an explicit formula, as well as an efficient procedure, for constructing a generalized Jacobian for the projector of a given square matrix onto the Birkhoff polytope, i.e., the set of doubly stochastic matrices. To guarantee the high efficiency of our procedure, a semismooth Newton method for solving the dual of the projection problem is proposed and efficiently implemented. Extensive numerical experiments are presented to demonstrate the merits and effectiveness of our method by comparing its performance against other powerful solvers such as the commercial software Gurobi and the academic code PPROJ [Hager and Zhang, SIAM Journal on Optimization, 26 (2016), pp. 1773–1798]. In particular, our algorithm is able to solve the projection problem with over one billion variables and nonnegative constraints to a very high accuracy in less than 15 minutes on a modest desktop computer. In order to further demonstrate the importance of our procedure, we also propose a highly efficient augmented Lagrangian method (ALM) for solving a class of convex quadratic programming (QP) problems constrained by the Birkhoff polytope. The resulted ALM is demonstrated to be much more efficient than Gurobi in solving a collection of QP problems arising from the relaxation of quadratic assignment problems.

Equilibrium and Optimization in Energy Markets

Specific Models, Algorithms, and Software
Energy - Th 5:00pm-6:30pm, Format: 3x30 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 151
Organizer: Asgeir Tomasgard, NTNU, NO

1 - Bilevel Linear Programming Investment Problems Lower-Level Primal and Dual Variables
Speaker: Steven Gabriel, University of Maryland and NTNU, US, talk 1223
Co-Authors: *Henrik Bylling*, *Trine Boomsma*,
This talk examines bilevel linear programming investment problems in which the upper level objective function depends on both the lower-level primal and dual variables. This sort of problem occurs in energy markets. We show that the upper-level objective function is non-convex and even discontinuous but piece-wise linear with regard to the upper-level variables. We exploit this piece-wise linearity to design a global solution method based on parametric programming and with the advantage that it allows for decomposition of separable lower-level problems. If the upper-level objective function is a bilinear function of the lower-level primal and dual variables, we also provide an exact linearization method that produces a mixed-integer linear programming formulation of the bilevel problem. Numerical experiments demonstrate that our decomposition method has signi cant computational advantages for bilevel investment problems with a high number of lower-level market clearing problems. Furthermore, the parametric programming approach automatically allows for post-optimal sensitivity analysis of the bilevel programming problem.

2 - The Flow-Based Market Coupling Model and the Bidding Zone Configuration
Speaker: Endre Bjorndal, Norwegian School of Economics, NO, talk 1457
Co-Authors: *Mette Bjorndal*, *Hong Cai*,
In May 2015, the Flow-Based Market Coupling (FBMC) model replaced the Available Transfer Capacity (ATC) model in Central Western Europe to determine the power transfer among bidding zones in the day-ahead market. It might be easier to change the bidding zone configuration in the FBMC model than in the ATC model as the FBMC model does not need to determine the maximum trading volume between two bidding zones. In our study, we run a simulation in the IEEE RTS 24-bus test system and examine how the bidding zone configurations affect the performance of both the FBMC and ATC models. We show that by improving the zone configuration, the FBMC model outperforms the ATC model in terms of reducing the re-dispatching cost only when the systems operators have a higher level of cooperation in the real-time market. Our results also indicate that better cooperation among the system operators would help to reduce the need for load shedding.

3 - A European power market model with short- and long-term uncertainty
Speaker: Asgeir Tomasgard, NTNU, NO, talk 1391
Co-Authors: *Hector Marañón-Ledesma*,
In capacity expansion planning, managing long-term uncertainty together with short-term uncertainty has been a computational challenge.We address this by using a multi-horizon approach Our capacity expansion model for the European power system considers several sources of long-term uncertainty. It also include short-term uncertainty for wind power, solar power and load. The analysis shows that an adequate modeling of the uncertainty is crucial to assess the right long term investments. In particular we analyse the effects of fuel-cost uncertainty, demand uncertainty and policy uncertainty. The model is a multi-stage linear stochastic programming with recourse. The solution approach is parallel implementation of the Progressive Hedging algorithm utilizing special structure in the multi-horizon scenario trees.

VU-decomposition techniques for nonsmooth optimization

Continuous Optimization
Variat - Th 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 158
Organizer: Claudia Sagastizabal, Unicamp, BR

1 - An epsilon-VU algorithm with superlinear convergence
Speaker: Shuai Liu, University of Campinas, BR, talk 481
Co-Authors: *Claudia Sagastizabal*, *Mikhail Solodov*,
The theories of $\mathcal{VU}$-space decomposition and $\mathcal{U}$-Lagrangian have been applied to develop algorithms for solving problems with structural properties. We introduce an algorithm based

on the ε-$\mathcal{VU}$-space decomposition, where the $\mathcal{V}_\varepsilon$-subspace is defined by the span of some enlargement of the subdifferential. The algorithm has two steps: the $\mathcal{V}$-step, which we show can be replaced by an exact prox-step, and the $\mathcal{U}$-step, a quasi-Newton step in the $\mathcal{U}_\varepsilon$-subspace. The $\mathcal{U}$-step requires a basis matrix of the $\mathcal{U}_\varepsilon$-subspace and a matrix containing second order information of the objective function in the $\mathcal{U}_\varepsilon$-subspace. If ε is suitably driven to zero, the superlinear convergence of the algorithm can be proven if the Dennis-More condition holds in our context. We give an application of our algorithm on minimizing a function whose proximal point can be easily calculated.

2 - A derivative-free $\mathcal{VU}$-algorithm for convex finite-max problems

Speaker: Claudia Sagastizabal, Unicamp, BR, talk 30

Co-Authors: *Warren Hare*, *Chayne Planiden*,

The $\mathcal{VU}$-algorithm is a superlinearly convergent method for minimizing nonsmooth convex functions. At each iteration, the algorithm separates the space into the $\mathcal{V}$-space and the $\mathcal{U}$-space, such that the nonsmoothness of the objective function is concentrated on its projection onto the $\mathcal{V}$-space, and on the $\mathcal{U}$-space the projection is smooth. This structure allows for an alternation between a Newton-like step where the function is smooth, and a proximal-point step that is used to seek iterates with promising $\mathcal{VU}$-decompositions. We establish a derivative-free variant of the $\mathcal{VU}$-algorithm for convex finite-max objective functions. We show global convergence and provide numerical results from a proof-of-concept implementation that demonstrates the feasibility and practical value of the approach.

3 - A Fast Gradient Sampling-like Method for Solving Nonsmooth Optimization Problems

Speaker: Lucas Simões, University of Campinas, BR, talk 477

Co-Authors: *Elias Helou*, *Sandra Santos*,

The task of minimizing a nonsmooth function appears in many real-world problems. In case the objective function is convex, Bundle Methods have shown to be effective tools for obtaining the desired optimal solution. However, when convexity cannot be assumed, algorithms based on bundle techniques present some difficulties to minimize this kind of function. As an alternative, an algorithm known as Gradient Sampling has shown good numerical results for the nonconvex case. Our study combines sampling and bundle techniques, developed over the years, for obtaining a practical method that converges superlinearly to the solution of a special class of nonsmooth, and possibly nonconvex optimization problems. To achieve this goal, $\mathcal{VU}$-space decomposition together with a quasi-Newton approach have been used.

Combinatorial robust optimization I

Optimization under Uncertainty

Robust - Th 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 37 Building: B, Intermediate, Zone: 4

Invited Session 167

Organizer: Marc Goerigk, Lancaster University, GB

1 - Solving the Robust Capacitated Vehicle Routing Problem Under Demand Uncertainty

Speaker: Artur Pessoa, Univ. Federal Fluminense, BR, talk 302

Co-Authors: *Michael Poss*, *Ruslan Sadykov*, *Francois Vanderbeck*,

In this paper, we propose a Branch-Cut-and-price algorithm for the robust counterpart of the Capacitated Vehicle Routing Problem (CVRP). The deterministic version of this problem consists of finding a set of vehicle routes to serve a given set of customers with associated demands such that the sum of demands served by each vehicle does not exceed its capacity, and each customer is served exactly once. The total travel cost, given by the sum of distances traversed by all vehicles must be minimized. Here, only customer demands are assumed to be uncertain. We consider two types of uncertainty sets: the classical budget polytope introduced by Bertsimas and Sim (2003), and a partitioned budget polytope, proposed by Gounaris et al (2013) for the CVRP with uncertain demands. The method proposed in this paper uses a set partitioning formulation to solve the problem, where each binary variable determines whether a given route is included or not in the solution. It considers only the routes that satisfy the capacity constraints for all possible demand vectors allowed by the uncertainty polytope. The linear relaxation for this formulation is solved by column generation, where the pricing subproblem is decomposed into a small number of deterministic subproblems with modified demand vectors. This reformulation allows the use of state-of-the-art techniques such as ng-routes, rank-1 cuts, specialized labeling algorithms, fixing by reduced costs and route enumeration. As a result, we solve all 47 open instances proposed by Gounaris et al (2013), the largest one having 150 customers.

2 - Approximating combinatorial optimization problems with the OWA criterion

Speaker: Marc Goerigk, Lancaster University, GB, talk 987

Co-Authors: *Adam Kasperski*, *Pawel Zielinski*, *Andre Chassein*,

This talk deals with multiobjective combinatorial optimization problems with K linear cost functions. As a generalization of min-max robustness, the OWA criterion is used to aggregate the cost functions. It is well known that minimizing OWA for most basic combinatorial problems is weakly NP-hard, even if the number of objectives K equals two, and strongly NP-hard, when K is a part of the input. We consider the problem with nonincreasing weights in the OWA criterion and a large K. A method of reducing the number of objectives by appropriately aggregating the objective costs is proposed. It is shown that an optimal solution to the reduced problem has a guaranteed worst-case approximation ratio, which generalizes the current best bound. In computational experiments, we demonstrate that the aggregation approach produces solutions that give a good trade-off between computation time and objective value in practice.

3 - Reformulations for Robust Lot-Sizing Problem with Remanufacturing

Speaker: Oyku Naz Attila, University of Strathclyde, GB, talk 1103

Co-Authors: *Agostinho Agra*, *Kerem Akartunali*, *Ashwin Arulselvan*,

Remanufacturing is an alternative method of production that involves reworking unusable items that have been returned to the manufacturer. This often implies a reduction in production costs and waste, making it a favorable option for satisfying demand. Despite these benefits, determining the exact number of returns is rather difficult, which may lead to inaccuracies in problem parameters, risking feasibility and optimality. Our study aims to address this issue through the framework of robust optimization, where both demands and returns are modeled as parts of predetermined uncertainty sets. More specifically, we implement the min-max approach for the lot sizing problem with remanufacturing, where uncertainty sets are defined as budgeted polytopes. Following the work of Attila et al. (2017), we provide a thorough computational analysis on various reformulations, including their limitations and strengths. Through this analysis, we aim to contribute to the literature on LSR problems with uncertainty, where studies with parameter uncertainty are very scarce.

4 - ast robust shortest path computations

Speaker: Christoph Hansknecht, TU Braunschweig, DE, talk 1020

Co-Authors: *Sebastian Stiller*, *Alexander Richter*,

We develop a fast method to compute an optimal robust shortest path in large networks like road networks. In the robust shortest path problem we are given an s-t-graph $D(V, A)$ and for each arc a nominal length $c(a)$ and a maximal increase to its length $d(a)$. We consider all scenarios in which at most Γ of the arcs have increased length $c(a)+d(a)$. Each path is measured by the length in its worst-case scenario. A classic result by Bertsimas and Sim solves this by $|\Theta|$-many shortest path problems, where Θ is the set of all d-values of D. For large graphs this is impractical. Using monotonicity of a part of the objective we devise a Divide and Conquer method to evaluate significantly less values of Θ. This methods generalizes to binary linear robust problems. Specifically for shortest paths we develop a lower bound to speed-up the Divide and Conquer of Θ. The bound is based on carefully using previous shortest path computations. Combining this with non-preprocessing based acceleration techniques for Dijkstra adapted to the robust case we can reduce the computation time by a factor of up to 45. In the computational results we document the value of different accelerations tried in the algorithm engineering process. We also give an approximation scheme for the robust shortest path problem which computes a $(1 + \epsilon)$-approximate solution requiring $O(\log(1 + \epsilon)^{-1})$ computations of the nominal problem.

Matching Problems

Discrete Optimization & Integer Programming

IPpractice - Th 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 36 Building: B, Intermediate, Zone: 4

Invited Session 175

Organizer: Sergio García Quiles, University of Edinburgh, GB

1 - Stable Matching with Proportionality Constraints

Speaker: Thanh Nguyen, Purdue University, US, talk 509

Co-Authors: *Rakesh Vohra*,

The problem of finding stable matches that meet distributional concerns is usually formulated by imposing various side constraints. Prior work has focused on constraints whose “right hand sides” are absolute numbers specified before the preferences or number of agents on the “proposing” side are known. In many cases it is more natural to express the relevant constraints as proportions. We treat such constraints as soft, but provide ex-post guarantees on how well the constraints are satisfied while preserving stability. Our technique requires an extension of Scarf’s lemma, which is of independent interest.

2 - Mathematical models for stable marriage problems with ties

Speaker: Maxence Delorme, University of Edinburgh, GB, talk 866

Co-Authors: *Sergio García Quiles*, *David Manlove*, *Jacek Gondzio*, *Joerg Kalcsics*, *William Pettersson*,

In the stable marriage problem, we are given two disjoint sets of agents, traditionally called “men” and “women”, together with a set of lists where each agent has ranked the members of the other set in order of preference. A solution of the problem has the particularity that no couple forms a blocking pair, i.e., prefers to be matched together more than the mate they are currently assigned to. When the list of preferences is strictly ordered, the problem can be solved in polynomial time by using the Gale-Shapley algorithm. However, in real world cases, we often have the presence of ties, and the problem of finding a maximum stable matching becomes NP-hard. In this talk, we are interested in two real world application: first, we study a classical stable marriage problem with ties, where the aim is to assign children to families in a children’s charity. Then, we study a stable marriage problem with ties and capacities (also called the hospital/residents problem with ties). For both problems, we review the integer linear programming (ILP) formulations that have been proposed in the literature and we show their limits when the number of agents grow. We then introduce two new ILP models that use alternative constraints to ensure stability and measure their efficiency with respect to the classical models on both real world and randomly generated instances.

3 - Improvements in Kidney Exchange Programme Models for Large-Scale Programmes

Speaker: William Pettersson, University of Glasgow, GB, talk 1095

Co-Authors: *David Manlove*, *Maxence Delorme*, *Sergio García Quiles*, *Joerg Kalcsics*,

A kidney exchange programme facilitates the donation of kidneys amongst a group of donors and patients. A pool involving these donor-patient pairs can be modelled as a graph, with arcs representing compatible donations, and the problem is then reduced to that of finding a largest cardinality cycle packing in this graph. Integer programming is often used to maximise the number of successful transplants in such a programme, and many different models have been investigated in the literature. We examine a number of these models in the context of transnational kidney exchange programmes, scaling the instance sizes upwards to account for larger pool sizes. In this context we discuss various options and parameters for modelling which improve the efficiency of these algorithms at larger scales, as well as experimental data presenting how these options impact upon existing models.

4 - Stable project allocation under distributional constraints

Speaker: Peter Biro, Hungarian Academy of Sciences, HU, talk 1369

Co-Authors: *Kolos Goston*, *Richárd Szántó*,

In a two-sided matching market when agents on both sides have preferences the stability of the solution is typically the most important requirement. However, we may also face some distributional constraints with regard to the minimum number of assignees or the distribution of the assignees according to their types. These two requirements can be challenging to reconcile in practice. In this paper we describe two real applications, a project allocation problem and a workshop assignment problem, both involving some distributional constraints. We used integer programming techniques to find reasonably good solutions with regard to the stability and the distributional constraints. Our approach can be useful in a variety of different applications, such as resident allocation with lower quotas, controlled school choice or college admissions with affirmative action.

Different faces of nonsmoothness in optimization

Continuous Optimization
NonSmooth - Th 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 8 Building: N, 4th floor, Zone: 12
Invited Session 212
Organizer: Tim Hoheisel, McGill, CA

1 - Global optimization of GSIPs using disjunctive programming
Speaker: Oliver Stein, KIT, DE, talk 203
Co-Authors: *Peter Kirst*,
We propose a new branch-and-bound algorithm for global minimization of generalized semi-infinite programs. It treats the inherent disjunctive structure of these problems by tailored lower bounding procedures. Three different possibilities are examined. The first one relies on standard lower bounding procedures from conjunctive global optimization. The second and the third alternative are based on linearization techniques by which we derive linear disjunctive relaxations of the considered sub-problems. Solving these by either mixed-integer linear reformulations or, alternatively, by disjunctive linear programming techniques yields two additional possibilities. Our numerical results on standard test problems with these three lower bounding procedures show the merits of our approach.
2 - Superlinear Convergence of QN Methods for PLQ Convex-Composite Optimization
Speaker: Abraham Engle, University of Washington, US, talk 1638
Co-Authors: *James Burke*,
We consider Newton and Quasi-Newton methods for the minimization of functions of the form $f = h \circ c$, where h is an infinite-valued piecewise linear-quadratic convex function and c is C^2-smooth. Such problems include nonlinear programming, mini-max optimization, estimation of nonlinear dynamics with non-Gaussian noise as well as many modern frameworks for large-scale data analysis and machine learning. Our approach embeds the optimality conditions for convex-composite optimization problems into a generalized equation. We establish conditions for strong metric subregularity and strong metric regularity of the corresponding set-valued mappings. This allows us to extend classical convergence of Newton and quasi-Newton methods to the broader class of non-finite valued piecewise linear-quadratic convex-composite optimization problems. In particular we establish local quadratic convergence of the Newton method under conditions that parallel those in nonlinear programming when h is non-finite valued piecewise linear.
3 - Applications of the generalized matrix-fractional function
Speaker: Tim Hoheisel, McGill, CA, talk 1109
Co-Authors: *James Burke*,
The generalized matrix-fractional function (GMF) is (shown to be) a support function of the graph of the function mapping a matrix to the product with its transpose intersected with an affine manifold. It establishes connections between optimal value functions for quadratic optimization problems, covariance estimation, and the nuclear norm. We present a detailed study of the convex-analytical properties of the GMF, in particular, we give a full description of its subdifferential and characterize the points of differentiability. We will show that many powerful results on Ky-Fan norms and variational Gram functions arise from infimal projections of the sum of the GMF and a closed, proper, convex function.

Advances in Integer Programming

Discrete Optimization & Integer Programming
IPtheory - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1
Invited Session 227
Organizer: Robert Hildebrand, Virginia Tech, US

1 - On the diameter of the fractional matching polytope
Speaker: Laura Sanità, University of Waterloo, CA, talk 929
The diameter of a polytope P is the maximum value of a shortest path between a pair of vertices on the 1-skeleton of P, which is the graph where the vertices correspond to the 0-dimensional faces of P, and the edges are given by the 1-dimensional faces of P. In this talk we characterize the diameter of the fractional matching polytope, which is the polytope given by the standard linear programming relaxation of the matching problem. As a byproduct of our characterization, we get new hardness results on the complexity of computing the diameter of a polytope.
2 - Treewidth-based Extension Complexity Lower Bounds
Speaker: Gonzalo Muñoz, Polytechnique Montreal, CA, talk 208
Co-Authors: *Yuri Faenza*, *Sebastian Pokutta*,
In this work, we study the extension complexity of 0-1 sets parametrized by treewidth: a graph-theoretical parameter that measures structured sparsity. If a 0-1 set can be formulated as the set of binary vectors that satisfy some set of constraints, and those constraints present a sparsity pattern whose treewidth is k, then it is known that the extension complexity of the convex hull of the set is $O(n2^k)$. The goal of this work is to prove the existence of 0-1 sets that (nearly) meet this bound, for any arbitrary treewidth level k. To the best of our knowledge, this is the first work to provide parametric lower bounds on extension complexity based on treewidth.
3 - On valid inequalities for knapsack polytopes
Speaker: Igor Malinovic, EPFL, CH, talk 1502
Co-Authors: *Yuri Faenza*, *Monaldo Mastrolilli*, *Ola Svensson*,
Since the work of Balas in the 70s, knapsack problems have been the subject of extensive polyhedral studies. In this talk, we consider two knapsack problems. The first, IIK, is a generalization of the classical maximum knapsack to a discrete multi-period setting. We give a disjunctive formulation and we use it to deduce a PTAS for the problem. The sec-

ond is min-knapsack, for which we investigate properties of bounded pitch inequalities.

4 - Polynomial Integer Programming in Fixed Dimension and Applications in FPT

Speaker: Robert Hildebrand, Virginia Tech, US, talk 587

I will survey some recent results on integer programming in fixed dimension and discuss their importance in showing that some fixed parameter tractable (FPT).

Computational OR in Julia/JuMP

Specific Models, Algorithms, and Software

Algo - Th 5:00pm-6:30pm, Format: 3x30 min

Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 238

Organizer: Miles Lubin, Google, US

1 - JuMP 0.19 and MathOptInterface: new abstractions for mathematical optimization

Speaker: Miles Lubin, Google, US, talk 1175

The 0.19 release of JuMP, an open-source algebraic modeling language, is one of its most significant ever. Most of the changes, however, are under the hood. Over the past year, we have completely replaced the old solver abstraction layer (MathProgBase) with a new publicly documented solver-independent API called MathOptInterface. We will discuss the motivations and design of the new interface and will highlight the next generation of JuMP applications and extensions that it will enable.

2 - Optimizing Public Policy: School Transportation and Start Times in Boston.

Speaker: Sebastien Martin, MIT, US, talk 1376

Co-Authors: *Dimitris Bertsimas*, *Arthur Delarue*,

Many problems faced by US school districts present interesting challenges for operations research practitioners. In this talk, we focus on the two major problems of school transportation and bell time choice, as part of a collaboration with Boston Public Schools (BPS), the oldest and one of the largest school districts in the nation (with 126 public schools and over 56,000 students). For the problem of school transportation, which involves delivering students to school every morning and back home every afternoon using a fleet of specialized vehicles (around 700 hundred school buses for Boston), we identify a natural multistage decomposition of the problem and propose integer programming formulations and efficient heuristics for each stage to compute school bus routes at the scale of the district. For the problem of bell time choice, we develop an integer optimization model with multiple objectives that provides both the versatility and simplicity that is required to facilitate public policy decision-making . Above all, the talk highlights interesting aspects of a collaboration with a public organization and describes the process of implementing OR solutions at the scale of a major city. Visualizations and computations were built using Julia and the optimization package JuMP.

3 - Capstan: Next-Generation Automatic Differentiation for Julia

Speaker: Jarrett Revels, MIT, US, talk 553

Automatic differentiation (AD) is crucial to modern nonlinear optimization software, where it is used by modeling languages such as JuMP to construct efficient derivative oracles from user-provided models. This talk presents Capstan, a new Julia package for performing AD on native Julia programs. Capstan not only provides forward-mode and reverse-mode operation, but also enables the "mixture" of the two modes where appropriate, allowing certain computation subgraphs to be differentiated in forward-mode and others in reverse-mode in order to achieve greater overall performance and flexibility. By leveraging a new dispatch mechanism built on top of recent Julia compiler advancements, Capstan can propagate derivative information through concrete type constraints without requiring manual source annotation, restriction to a DSL, or refactoring of the target code. In addition, Capstan offers many desirable features such as dynamic graph support, user-extensible derivative definitions, operator fusion, nested differentiation, and GPU support. We discuss Capstan's design and implementation, as well our plans to utilize Capstan within JuMP.

Theoreticals and practicals aspects of decomposition algorithms for multistage stochastic problems: 2

Optimization under Uncertainty

Stoch - Th 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Invited Session 247

Organizer: Vincent Leclère, ENPC, FR

1 - The practitioners guide to SDDP: lessons from SDDP.jl

Speaker: Oscar Dowson, University of Auckland, NZ, talk 439

SDDP.jl is a generic implementation of the SDDP algorithm in the Julia programming language. It has a convenient user-interface which facilitates the rapid prototyping of new models. Despite the generality, the computational performance of the library is similar to problem-specific implementations in languages such as C++. In this talk, we describe a number of issues that we encountered developing SDDP.jl, ranging from easily overcome numerical stability problems, to seemingly incorrect solutions as a result of dual-degeneracy. These findings will be of interest to all practitioners implementing, and using, SDDP and related cutting plane algorithms.

2 - Decomposing Dynamic Programming equations: from global to nodal value functions

Speaker: François Pacaud, CERMICS, FR, talk 615

Co-Authors: *Carpentier Pierre*, *Michel De Lara*,

We consider a stochastic optimization problem where multiple units are interacting together via a network. Each unit is represented as a (small) controlled stochastic dynamic system, located at a node. Each unit state evolution is affected by uncertainties and by controls from the neighbor units. Further, static constraints couple all units at each time. We compare two methods to solve this problem. i) The global SDDP approach solves the problem directly. ii) The nodal SDDP approach uses spatial decomposition to split the global problem node by node and solves each subproblem independently by SDDP. We show that depending on the decomposition scheme employed, we obtain upper and lower bounds for the global problem. We compare global and nodal SDDP on numerical studies that tackle the decentralized optimization of urban energy micro-grids.

3 - Energy portfolio optimization for Brazilian distribution companies: a multistage

Speaker: Vitor de Matos, Plan4, BR, talk 1373

Co-Authors: *Guilherme Ramalho*, *Paulo Larroyd*, *Rodrigo Antunes*, *Luis Baran*, *Julia Paul*, *Marcos Coelho*,

The present study discusses an instrument to assist a Brazilian Electricity Distribution Company (EDC) in its strategy of energy portfolio management in the Brazilian regulated market framework. Firstly, we present a brief description of the Brazilian commercialization environment, the available means provided for the EDCs balance their portfolio and the main uncertainties and risks faced by them in this process. Then, we show the proposed optimization method based on the definition of a long-term multistage stochastic linear programming problem, which is compared to a two-stage based model with heuristics. The solution provided by the method is an energy contracting strategy aiming at reducing the financial impact due to exposition to short-term energy prices and penalties. Case studies are evaluated in order to compare the results and analyze the system capabilities. The results indicate that the provided optimization method can be an interesting auxiliary tool to help the EDC in the task to trace its future purchase/selling energy strategy.

4 - Stochastic programming framework for risk aversion representation with SDDP

Speaker: Luiz Carlos da Costa Junior, PSR, BR, talk 1498

Co-Authors: *Raphael Chabar*, *Joaquim Dias Garcia*,

In this talk we discuss a theoretical and practical framework extension to consider risk aversion in multistage linear stochastic programming problems solved by the SDDP algorithm. We focus on problems with relatively complete recourse. In the first approach the problem is changed to enforce complete recourse and risk aversion is represented in the objective function as the convex combination of expected value and CVaR. In the second approach we use feasibility cuts in SDDP to construct a "risk aversion surface" that represents the feasibility set of the original problem and an extension for critical scenarios in a hybrid stochastic/robust optimization scheme. Finally, in the third approach we derive a convex chance-constrained SDDP extension to represent the probability of meeting such constraints by using an approximated CVaR constraint. We present computational experiments for real-life hydrothermal scheduling problems.

Approximation algorithms for combinatorial optimization problems

Discrete Optimization & Integer Programming

COMB - Th 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 41 Building: C, 3rd floor, Zone: 1

Invited Session 265

Organizer: Thomas Rothvoss, University of Washington, US

1 - Approximation Algorithms for Diverse Subset Selection Problems

Speaker: Mohit Singh, Georgia Institute of Technolog, US, talk 868

Co-Authors: *Aleksander Nikolov*, *Weijun Xie*, *Uthaipon Tantipongpipat*,

Selecting a diverse subset of items from a collection occurs as a fundamental problem in various applications including selecting representative documents from a corpus, selecting diverse geographical locations for sensor placement and designing most informative experiments. Among the different formulations of the problem in many of these areas, a common occurrence is to use the determinantal measure as a proxy for diversity or information. I will talk about recent works on approximation algorithms for constrained subset selection problems under the determinantal and similar measures. I will also outline the rich connections of these problems to many well-studied problems including counting matchings in graphs, graph sparsification as well as the theory of stable polynomials and positive and negative dependence in probability theory.

2 - Local Guarantees in Graph Cuts and Clustering

Speaker: Roy Schwartz, Technion, IL, talk 1153

Co-Authors: *Moses Charikar*, *Neha Gupta*,

Correlation Clustering is an elegant model that captures fundamental graph cut problems and was extensively studied in combinatorial optimization. Here, we are given a graph with edges labeled + or − and the goal is to produce a clustering that agrees with the labels as much as possible: + edges within clusters and − edges across clusters. The classical approach towards Correlation Clustering (and other graph cut problems) is to optimize a global objective. We depart from this and study local objectives: minimizing the maximum number of disagreements for edges incident on a single node, and the analogous max min agreements objective. This naturally gives rise to a family of basic min-max graph cut problems. A prototypical representative is Min-Max $s-t$ Cut: find an $s-t$ cut minimizing the largest number of cut edges incident on any node. We present the following results: (1) an $O(\sqrt{n})$-approximation for the problem of minimizing the maximum total weight of disagreement edges incident on any node (thus providing the first known approximation for the above family of min-max graph cut problems). (2) a remarkably simple 7-approximation for minimizing local disagreements in complete graphs (improving upon the previous best known approximation of 48). (3) a $\frac{1}{(2+\varepsilon)}$-approximation for maximizing the minimum total weight of agreement edges incident on any node, hence improving upon the $\frac{1}{(4+\varepsilon)}$-approximation that follows from the study of approximate pure Nash equilibria in cut and party affiliation games.

3 - Scheduling Stochastic Jobs on Unrelated Machines

Speaker: Anupam Gupta, Carnegie Mellon University, US, talk 224

Co-Authors: *Amit Kumar*, *Xiangkun Shen*, *Viswanath Nagarajan*,

We consider the problem of makespan minimization: i.e., scheduling jobs on machines to minimize the maximum load. For the deterministic case, good approximations are known even when the machines are unrelated. However, the problem is not well-understood when there is uncertainty in the job sizes. In our setting the job sizes are stochastic, i.e., the size of a job j on machine i is a random variable X_{ij}, whose distribution is known. (Sizes of different jobs are independent of each other.) The goal is to find a fixed assignment of jobs to machines, to minimize the expected makespan, i.e., the expected value of the maximum load over the m machines. Our main result is a constant-factor approximation for the most general case of unrelated machines.

Relaxations in MINLP

Discrete Optimization & Integer Programming
MINLP - Th 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3
Contributed Session 280
Chair: Jan Kronqvist, Åbo Akademi University, FI

1 - Tight Convex Relaxations for Expansion Planning of Potential Driven Networks
Speaker: Ralf Lenz, Zuse Institute Berlin, DE, talk 1063
Co-Authors: *Felipe Serrano*,
Expansion planning of potential driven networks is typically modeled as a nonconvex MINLP, where nonlinearities are due to the potential loss function in pipelines. We present a model formulation for extending potential driven networks by building new pipelines. The decisions to be taken comprise selecting the pipelines themselves, as well as the appropriate choice of diameters out of a discrete set. Since we are able to determine the best diameters a priori, we can efficiently reduce the problem size of the resulting MINLP. This model is still nonconvex, however we solve it to global optimality using outer approximation and spatial branching. In this talk, we focus on how to strengthen our model formulation by analytically deriving the convex envelope of the constraint function that describes the potential loss in a pipe with variable diameters. We conclude with the presentation of a computational study that illustrates the impact of these tight relaxations.
2 - Using Regularization and Second Order Derivatives with Outer Approximation
Speaker: Jan Kronqvist, Åbo Akademi University, FI, talk 1362
Co-Authors: *David Bernal*, *Ignacio Grossmann*,
Several methods for solving convex MINLP problems use a technique of constructing a linear approximation and utilize the approximation to find new trial solutions. Such methods are, for example, extended cutting plane, extended supporting hyperplane, outer approximation and generalized benders decomposition. This technique enables a decomposition of the MINLP problem, where the integer values are obtained by solving MILP subproblems. Unfortunately, the linear approximations only provide a good approximation in the neighborhood of the linearization point, and for highly nonlinear MINLP problems it may cause slow convergence. Here we propose a technique to combine outer approximation with concepts from nonlinear programming to handle nonlinearities more efficiently. We present a regularization technique inspired by the level method, equivalent to adding a trust region to the MILP subproblem. Furthermore, we show that the same technique allows us to incorporate second order derivatives when choosing the integer combinations. Finite convergence is proven, and numerical results demonstrate the benefits of the proposed methods.
3 - The Supporting Hyperplane Optimization Toolkit for Convex MINLP
Speaker: Andreas Lundell, Åbo Akademi University, FI, talk 998
Co-Authors: *Jan Kronqvist*,
SHOT (Supporting Hyperplane Optimization Toolkit) is a new open source solver for convex mixed-integer nonlinear programming (MINLP). SHOT combines polyhedral outer approximation for obtaining a dual (lower) bound and deterministic primal heuristics for obtaining a primal (upper) bound on the optimal solution to minimization problems. The dual strategy in SHOT is based on the extended supporting hyperplane (ESH) and extended cutting plane (ECP) algorithms which have been deeply integrated into the mixed-integer programming (MIP) solvers CPLEX and Gurobi. Whenever the MIP solver finds a new integer-feasible solution, that does not fulfill the nonlinear constraints in the MINLP problem, a callback is activated and a lazy constraint is added to remove that solution point. Utilizing callbacks means that only one branching tree needs to be maintained in contrast to most polyhedral approximation strategies that normally requires a new tree built per iteration, and thus significant performance gains are obtained in SHOT. The new solver has been benchmarked to other state-of-the-art solvers on the convex instances in MINLPLib2, and the results show that SHOT was the most efficient solver for this problem class. This clearly illustrates the benefit of the single-tree approach for polyhedral outer approximation methods.

Applications in MINLP

Discrete Optimization & Integer Programming
MINLP - Th 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 35 Building: B, Intermediate, Zone: 4
Contributed Session 283
Chair: Justo Puerto, University of Seville, ES

1 - Modeling and optimization of traffic at traffic-light controlled intersections
Speaker: Do Duc Le, OVGU Magdeburg, DE, talk 1319
Co-Authors: *Maximilian Merkert*, *Sebastian Sager*, *Stephan Sorgatz*, *Mirko Hahn*,
Assisted and autonomous driving is a growing field of interest. The coordination of traffic at traffic-light controlled intersections offers great potential for improvement and optimization. The high number of vehicles coupled with imperfect human driving behavior can cause problems like long waiting times, traffic jams, air pollution and high fuel and energy consumption. Additionally, controlling traffic light signals play a vital role in effective traffic management. In this talk we use a discretized motion model to calculate the optimal trajectories of vehicles through the network while avoiding collisions. Traffic lights are modeled via binary variables and a special trigger mechanism. This approach yields a solution from a global point of view where everything is coordinated centrally. It serves as a benchmark and basis for decentralized concepts. We give numerical results and evaluate the resulting traffic with the aid of microscopic traffic simulations, including comparisons to mixed traffic with varied percentages of autonomous vehicles.
2 - Flow-based extended formulations for feasible traffic light controls
Speaker: Maximilian Merkert, OVGU Magdeburg, DE, talk 1295
Co-Authors: *Gennadiy Averkov*, *Do Duc Le*, *Sebastian Sager*,
We study polyhedra that arise in the context of centralized

optimization of traffic-light controlled intersections. Traffic light controls have to fulfill certain requirements in order to be reasonable or even legal such as minimum green and red phases or minimum and maximum cycle times of individual traffic lights, leading to extensions of min-up/min-down polytopes. Other constraints may affect several traffic lights at a given intersection simultaneously. Incorporating these rules vastly increases the computational difficulty of the overall MINLP formulation. We demonstrate that many natural requirements can be implemented by finite automata - enabling flow-based extended formulations of the corresponding 0-1 polytope. These also allow us to recover the complete description of min-up/min-down polytopes that is known from the context of unit commitment problems. Moreover, we discuss computational experiments on the impact of our extended formulations.

3 - MINLP for pricing transaction costs in different models of portfolio selection

Speaker: Justo Puerto, University of Seville, ES, talk 972
Co-Authors: *Marina Leal-Palazon*,

The contribution of this paper is to incorporate transaction costs as decision variables on portfolio optimization problems. In order to do that, we consider two different level of decision-making in the optimization problem: 1) the financial institution that will set transaction costs trying to maximize its benefits, and 2) the investor, that will try to optimize its portfolio return, minimizing the risk and ensuring a given expected profit. Based on the structure of actual financial markets, we assume a hierarchical relationship between the parties. We consider a model in which the bank sets the prices first, trying to anticipate the rational response of the investor. Once the prices are fixed, the investor chooses his optimal portfolio. We also analyze the case in which the investor chooses his portfolio first, and then, the bank sets the transaction costs. To model this hierarchical structure we use bilevel optimization approach. Furthermore, we consider the model in which both, bank and investor, cooperate to maximize their returns and then we analyze the allocation of the generated extra return (surplus). We assume in the different models that all economical or financial information is common knowledge. We propose exact bilevel programming formulations for the different models and then we transform them into single level models with nonliearities and integer variables. We theoretically compare the models and report exhaustive computational experiments based on actual data from the IBEX and Dow-Jones markets.

Gas Network and Market Optimization

Specific Models, Algorithms, and Software
Energy - Th 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 23 Building: G, 3rd floor, Zone: 6

Invited Session 293
Organizer: Jonas Schweiger, Zuse Institute Berlin, DE

1 - Foresighted decision support for gas network operation

Speaker: Jonas Schweiger, Zuse Institute Berlin, DE, talk 856

Due to the liberalized market setting, operating a large gas network is even more challenging than it has been before. In this presentation, we will describe a mathematical programming based tool to support gas network dispatching by providing foresighted recommendations on how to operate the network in the next 24 hours. Such a tool needs to take the capacity of the network to store gas into account and thus is based on a non-stationary gas flow model. Furthermore, the technical equipment and in particular compressor stations with its complex operating restrictions need to be modeled. This work is done in cooperation with Germany's largest gas network operator and is an ongoing project. We will describe our current solution approach based on a hierarchy of models. Furthermore, we will address several practical issues we faced in this project.

2 - Controlling complex network elements by target values

Speaker: Felix Hennings, Zuse Institute Berlin, DE, talk 456

The attempt to solve optimization problems emerging from real world applications always requires a certain level of abstraction in which details are neglected and simplifying assumptions are made. In gas network optimization, one often expects to have the possibility to directly control complex technical elements like compressors or regulators by specifying their exact point of operation. However, this is not the case for gas network operators. They can only specify a combination of so-called target values for the flow and the pressures of the corresponding elements. The element itself, then determines the actual point of operation while trying to meet these target values, which have a fixed priority list. Since our goal is to give meaningful advice to the operators supporting them in their daily work, we have to take this relationship into account. We present different approaches to incorporate the described behavior in transient gas network optimization problems and show results of first experiments on real world data.

3 - Nonconvex Equilibrium Models for Gas Market Analysis

Speaker: Julia Grübel, FAU Erlangen-Nürnberg, DE, talk 981
Co-Authors: *Veronika Grimm*, *Martin Schmidt*, *Lars Schewe*, *Gregor Zöttl*,

We provide an approach to assess gas market interaction on a network with nonconvex flow models. In the simplest possible setup that adequately reflects gas transport and market interaction, we elaborate on the relation of the solution of a simultaneous competitive market game, its corresponding mixed nonlinear complementarity problem (MNCP), and a first-best benchmark. We provide conditions under which the solution of the simultaneous game corresponds to the MNCP solution. However, equilibria cannot be determined by the MNCP as the transmission system operator's (TSO's) first-order conditions are insufficient. This also implies that the welfare maximization problem may have multiple solutions that sometimes do not even coincide with any of the market equilibria. Our analysis shows that, even in the absence of strategic firms, market interaction fails to implement desirable outcomes from a welfare perspective. We conclude that the technical environment calls for a market design that commits the TSO to a welfare objective through regulation and propose such a design.

Recent Progress on Second-order Type Optimization Methods

Continuous Optimization
RandomM - Th 5:00pm-6:30pm, Format: 3x20 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 302
Organizer: Andre Milzarek, PKU, CN

1 - Inexact Successive Quadratic Approximation for Regularized Optimization
Speaker: Ching-pei Lee, Univ. of Wisconsin-Madison, US, talk 393
Co-Authors: *Stephen Wright*,
Successive quadratic approximations, or second-order proximal methods, are useful for minimizing functions that are a sum of a smooth part and a convex, possibly nonsmooth part that promotes a regularized solution. Most analyses of iteration complexity focus on the special case of proximal gradient method, or accelerated variants thereof. There have been only a few studies of methods that use a second-order approximation to the smooth part, due in part to the difficulty of obtaining closed-form solutions to the subproblems at each iteration. In practice, iterative algorithms need to be used to find inexact solutions to the subproblems. In this work, we present global analysis of the iteration complexity of inexact successive quadratic approximation methods, showing that it is sufficient to obtain an inexact solution of the subproblem to fixed multiplicative precision in order to guarantee the same order of convergence rate as the exact version, with complexity related proportionally to the degree of inexactness. Our result allows flexible choices of the second-order terms, including Newton and quasi-Newton choices, and, and does not necessarily require more time to be spent on the subproblem solves on later iterations. For problems exhibiting a property related to strong convexity, the algorithm converges at a global linear rate. For general convex problems, the convergence rate is linear in early stages, while the overall rate is $O(1/k)$. For nonconvex problems, a first-order optimality criterion converges to zero at a rate of $O(1/\sqrt{k})$.

2 - Structured Quasi-Newton method For Optimization with Orthogonality Constraints
Speaker: Jiang Hu, Peking university, CN, talk 960
Co-Authors: *Zaiwen Wen*, *Yaxiang Yuan*,
Minimization with respect to a matrix X subject to orthogonality constraints $X'X = I$ is a very important tool in many science and engineering problems. We consider cases where some parts of the objective functions are much more computationally expensive than other parts. We will present a structured Quasi-Newton approach without vector-transport. Numerical experiments compared with a few state-of-the-art methods show its effectiveness especially in the Hartree-Fock total energy minimization problem.

3 - A stochastic semismooth Newton method for nonsmooth nonconvex optimization
Speaker: Andre Milzarek, PKU, CN, talk 958
Co-Authors: *Xiantao Xiao*, *Shicong Cen*, *Zaiwen Wen*, *Michael Ulbrich*,
In this talk, we present a globalized semismooth Newton method for solving stochastic optimization problems involving smooth nonconvex and nonsmooth convex terms in the objective function. The class of problems that can be solved within our algorithmic framework comprises a large variety of applications such as l1-logistic regression, structured dictionary learning, and other minimization problems arising in machine learning, statistics, or image processing. We assume that only noisy gradient and Hessian information of the smooth part of the objective function is available via calling stochastic first- and second-order oracles. Our approach utilizes approximate second order information and stochastic semismooth Newton steps for a prox-type fixed-point equation, representing the associated optimality conditions, to accelerate the basic stochastic proximal gradient method for convex composite programming. Inexact growth conditions are introduced to monitor the quality and acceptance of the Newton steps and to combine the two different methods. We prove that the proposed algorithm converges globally to stationary points in expectation and almost surely. Moreover, under standard assumptions, the method can be shown to locally turn into a pure semismooth Newton method and fast local convergence can be established with high probability. Finally, we provide numerical experiments illustrating the efficiency of the stochastic semismooth Newton method.

First-order methods for large-scale convex problems II

Specific Models, Algorithms, and Software
Learning - Th 5:00pm-6:30pm, Format: 4x20 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 318
Organizer: Stephen Vavasis, University of Waterloo, CA

1 - Convex Low Rank Semidefinite Optimization
Speaker: Madeleine Udell, Cornell, US, talk 770
Co-Authors: *Lijun Ding*, *Volkan Cevher*, *Joel Tropp*, *Alp Yurtsever*,
Is it possible to solve an optimization problem using far less memory than the natural size of the decision variable? In this talk, we consider a particular class of semidefinite optimization problems (SDP), and propose an affirmative answer to this question when both the problem data and solution have a concise representation. We present an algorithm for provably solving these problems, whose natural size is O(n^2), using no more than O(n) memory. Importantly, and in contrast to recent work on non-convex methods for this problem class, our method inherits all the benefits of convex optimization, including robustness, flexibility, and a well understood convergence theory.

2 - Frank-Wolfe Splitting via Augmented Lagrangian Method
Speaker: Simon Lacoste-Julien, Université de Montréal, CA, talk 1514
Co-Authors: *Gautheir Gidel*, *Fabian Pedregosa*,
Minimizing a function over an intersection of convex sets is an important task in optimization that is often much more challenging than minimizing it over each individual constraint set. While traditional methods such as Frank-Wolfe (FW) or proximal gradient descent assume access to a linear or quadratic oracle on the intersection, splitting techniques take advantage of the structure of each sets, and only require access to the oracle on the individual constraints. In this work, we develop and analyze the Frank-Wolfe Augmented

Lagrangian (FWAL) algorithm, a method for minimizing a smooth function over convex compact sets related by a "linear consistency" constraint that only requires access to a linear minimization oracle over the individual constraints. It is based on the Augmented Lagrangian Method (AL), also known as Method of Multipliers, but unlike most existing splitting methods, it only requires access to linear (instead of quadratic) minimization oracles. We use recent advances in the analysis of Frank-Wolfe and the alternating direction method of multipliers algorithms to prove a sublinear convergence rate for FWAL over general convex compact sets and a linear convergence rate over polytopes.

3 - Extending performance estimation beyond exact convex fixed-step methods

Speaker: Francois Glineur, UCLouvain, BE, talk 1072

Co-Authors: *Adrien Taylor*, *Théo Golvet*,

Performance estimation (PE) is a framework where the problem of computing the worst-case behaviour of a given optimization method is expressed and solved as an optimization problem. The approach, pioneered by Drori and Teboulle, and later improved by the first two authors and J. Hendrickx, reduces the PE problem to an explicit semidefinite program. It led to tight worst-case guarantees for a large class of oracle-based first-order methods that use fixed step-size coefficients to solve convex problems, which includes projected, proximal, sub- and conditional gradient methods. In this talk, we present three extensions of the approach: (1) we show how to estimate the performance of first-order methods when applied to nonconvex problems, (2) we study the behaviour of first-order methods when used with an inexact oracle, and (3) we try to tackle more general methods that are not based on fixed step sizes. The first two extensions mostly preserve the tractable semidefinite PE formulation, while the third makes it nonconvex.

4 - Low-Storage Conditional Gradient Method for Low-Rank and Sparse Optimization

Speaker: Xuan Vinh Doan, The University of Warwick, GB, talk 1286

Co-Authors: *Stephen Vavasis*, *Jimit Majmudar*,

We propose a convex optimization formulation with duals of three matrix natural norms induced by vector p-norms to find a low-rank submatrix of a given matrix. We develop optimality conditions for the formulation and characterize the properties of the optimal solutions. Computationally, we propose a low-storage conditional gradient method to solve the problem which emphasizes on how to store low-rank and sparse matrices efficiently. Some preliminary numerical results will be reported. This is a joint work with Steve Vavasis and Jimit Majmudar.

Advances in Reinforcement Learning Algorithms

Specific Models, Algorithms, and Software Learning - Th 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 16 Building: I, 2nd floor, Zone: 7

Invited Session 329

Organizer: Lin Xiao, Microsoft Research, US

1 - Compressive Learning for Sequential Decision Process

Speaker: Mengdi Wang, Princeton University, US, talk 775

Model reduction has been a central problem in system management and data science. This talk presents a data-driven methodology for learning reduced-order representations of stochastic decision process. In particular, we develop a tractable method for state compression of Markov processes. The state compression method is able to " sketch" a black-box system from its empirical data, for which we provide both minimax statistical guarantees and scalable computational tools. We demonstrate applications of state compression in modeling taxi-trip data and clinical pathways. Furthermore, the state compression method applies to high-dimensional reinforcement learning and policy imitation. It helps decision makers take advantages of past experiences and significantly reduces the complexity of learning to perform a new task.

2 - Posterior sampling for reinforcement learning

Speaker: Shipra Agrawal, Columbia University, US, talk 1179

Co-Authors: *Randy Jia*,

Reinforcement Learning is one of the most powerful paradigm of learning and sequential decision making with a broad range of applications, including autonomous vehicle control, robot navigation, personalized medical treatments, intelligent game playing and problem solving. We develop a variation of "Thompson Sampling" (TS), a Bayesian posterior sampling heuristic, for managing the exploration-exploitation trade-off in a reinforcement learning problem. We demonstrate that this elegant algorithm achieves near-optimal worst-case regret bounds for any weakly communicating MDP with finite states and finite actions. Here, regret compares the average reward of the algorithm to the average reward of an optimal stationary policy over a given time horizon.

3 - SBEED learning: Convergent control with nonlinear function approximation

Speaker: Lihong Li, Google, US, talk 535

Co-Authors: *Bo Dai*, *Albert Shaw*, *Lin Xiao*, *Niao He*, *Zhen Liu*, *Jianshu Chen*, *Le Song*,

When function approximation is used, solving the Bellman optimality equation with stability guarantees has remained a major open problem in reinforcement learning for decades. The fundamental difficulty is that the Bellman operator may become an expansion in general, resulting in oscillating and even divergent behavior of popular algorithms like Q-learning. In this paper, we revisit the Bellman equation, and reformulate it into a novel primal-dual saddle-point optimization problem using Nesterov's smoothing technique and the Legendre-Fenchel transformation. We then develop a new algorithm, called Smoothed Bellman Error Embedding (SBEED), to solve this optimization problem where any differentiable function class may be used. We provide what we believe to be the first convergence guarantee for general nonlinear function approximation, and analyze the algorithm's sample complexity. Empirically, our algorithm compares favorably to state-of-the-art baselines in several benchmark control problems.

4 - Zap Q-Learning: Fastest Convergent Q-learning

Speaker: Adithya M Devraj, University of Florida, US, talk 939

Co-Authors: *Sean Meyn*,

In this talk, we will be introducing the Zap Q-learning algorithm which is an improvement of Watkins' original algorithm and recent competitors in several respects. It is a matrix-gain algorithm designed so that its asymptotic variance is optimal. Moreover, an ODE analysis suggests that its transient behavior is a close match to a deterministic Newton-Raphson implementation. This is made possible by a two time-scale update equation for the matrix gain sequence. The analysis suggests that the approach will lead to stable and efficient computation even for non-ideal parameterized settings. Numerical experiments confirm the quick convergence, even in such non-ideal cases.

Variational Analysis 5

Continuous Optimization
Variat - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Invited Session 371
Organizer: David Sossa, Universidad de O'Higgins, CL

1 - A global-local approach for stochastic programs with complementarity constraints
Speaker: Francisco Jara-Moroni, Northwestern University, US, talk 1436
Co-Authors: *Andreas Waechter*,
We propose a global-local approach to obtain good quality local solutions to stochastic linear programs with complementarity constraints (SLPCC) derived from stochastic bilevel linear programs. They arise in problems with upper-level here-and-now and lower-level wait-and-see decisions. A cut generation scheme finds a global optimum of the upper-level decisions for a subset of the sampled scenarios. This solution serves as the starting point for a difference-of-convex-functions algorithm applied to a penalized formulation of the full SLPCC. Preliminary numerical results show that this approach is promising.

2 - Conical Regularization of Multiobjective Optimization Problems
Speaker: Miguel Sama, UNED, ES, talk 502
Co-Authors: *Ruben López*, *Akhtar Khan*, *Baasansuren Jadamba*,
By conical regularization of an abstract constrained optimization problem, we understand those methods which construct a family of approximate problems by replacing the constraint cone by an approximating family of cones. These methods are particularly designed for those problems where either the KKT conditions are not available, or the associated multipliers exhibit low regularity in infinite dimensional problems. In scalar optimization, this method was introduced in [A.A. Khan, M. Sama, A new conical regularization for some optimization and optimal control problems: Convergence analysis and finite element discretization, Numer. Funct. Anal. Optim. 34(8), 861-895 (2013)] by using a family of Henig dilating cones. In Multiobjective Optimization, the same idea was introduced in [Schiel, R. Vector Optimization and Control with PDEs and Pointwise State Constraints. Ph.D. Thesis, FAU Erlangen-Nurnberg, (2014)]. In this talk, we present new results on the conical regularization for the multiobjective case. To be specific, we perform a detailed stability analysis of the set-valued map such as each regularization assigns the Pareto Efficient Solution of the corresponding regularized problem. In particular, we establish a priori Holder estimates regarding the regularization parameter for the regular case. We illustrate these results using two examples in finite and infinite dimensional spaces, respectively.

3 - Complementarity problems with respect to Loewnerian cones
Speaker: David Sossa, Universidad de O'Higgins, CL, talk 1579
Co-Authors: *Alberto Seeger*,
This work deals with the analysis and numerical resolution of a broad class of complementarity problems on spaces of symmetric matrices. The complementarity conditions are expressed in terms of the Loewner ordering or, more generally, with respect to a dual pair of Loewnerian cones.

4 - Relaxed Peaceman-Rachford Splitting Method: Convergence Study
Speaker: Chee Khian Sim, University of Portsmouth, GB, talk 485
Co-Authors: *Renato Monteiro*,
The relaxed Peaceman-Rachford splitting method is considered to solve the monotone inclusion problem to find zeroes to the sum of two maximal strongly monotone operators. New convergence, pointwise convergence rate and ergodic convergence rate results for the method to solve the problem are obtained. An example is provided that shows nonconvergence of the method when the relaxation parameter is beyond certain value. This example indicates that our convergence result cannot be further improved. Convergence analysis is based on the non-Euclidean hybrid proximal extragradient framework.

Approximation in dynamic programming

Optimization under Uncertainty
Markov - Th 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 31 Building: B, Ground Floor, Zone: 5

Contributed Session 382
Chair: Philip Placek, CityBldr, US

1 - Dynamic Programming via a State Abstract Machine and Implementation
Speaker: Wolf Kohn, Veritone, US, talk 160
Co-Authors: *Zelda Zabinsky*,
Dynamic programming (DP) is a representation of general optimization for many applications, including reinforcement learning, optimal control theory, and non-linear optimization. However, due to DP complexity (curse of dimensionality), many approximate solution methods have been proposed. We propose an implementation of DP using spectral logic as a formalism to implement Bellman's equation as a generalized state abstract machine (SAM). Both policy iteration and value iteration approaches are captured by this general approach. The proposed SAM is a device that generates policy trajectories using inference operators, that define the state transitions of the SAM. The states of the SAM are open sets in a Sigma-algebra that are partial solutions of Bellman's equation. The representation of the dynamics of the SAM is given by a special form of the Kleene-Schutzenberger equation (KSE). The KSE in the spectral domain allows a distributed decomposition into parallel unitary KSEs, each of which has a common initial state and a unique terminal state solving a component

of the policy control law. Further, each unitary KSE consists of a prefix KSE and a loop KSE in which the initial state and the terminal state is the same. This leads to an efficient implementation because we provide a trimming algorithm that eliminates unnecessary states and trajectories that do not contribute to the construction of the control law. This approach allows optimization of general systems, including computational procedures and algorithms that are only represented by rules.

2 - An Incremental Probability Model for Dynamic Systems

Speaker: Philip Placek, CityBldr, US, talk 163

Co-Authors: *Wolf Kohn*, *Zelda Zabinsky*, *Jonathan Cross*,

We present an incremental probability model for dynamic systems that combines historical data and new, real-time sequential data as it becomes available. Traditionally, models and algorithms assume the data follows a Gaussian distribution or other specified form. Instead, we propagate the transition probabilities directly which allows us to build the probability distribution from data. This provides a more realistic algorithm for probabilistic forecasting. To address large scale problems, our method is made computationally efficient by using an incremental model to construct probabilities relative to the nominal (or mean) of the state which is allowed to change over time. A meanfield approach further reduces computation while preserving statistical dependencies.

3 - A Stochastic Min-plus Algorithm for Deterministic Optimal Control

Speaker: Benoît Tran, CERMICS, FR, talk 1567

Co-Authors: *Marianne Akian*, *Jean-P. Chancelier*,

We study a discrete time optimal control problem with finite horizon involving both continuous and discrete controls, with linear dynamics and convex costs. Exploiting the min-plus linearity of the Bellman operators involved in the Dynamic Programming equation, we can compute the value functions as a finite infimum of convex functions. This approach inspired by the work of McEneaney is not constrained by the so-called curse of dimensionality. However the number of convex functions involved in the previous infimum grows exponentially as the time decreases. Inspired by the work of Zheng Qu, we propose an algorithm which selects some of the convex functions involved in the previous infimum by testing if they improve the current approximation at random points of compact sets. When the final cost and its successive images by the Bellman operators are equicontinuous, we prove the almost sure convergence of this algorithm. In the special case of quadratic costs, the succesive images by the Bellman operators can be computed explicitly by solving an algebraic Riccati equation. Moreover, the previous equicontinuity assumption is verified. This gives the basis for numerical applications in the general case: we approximate the final convex cost function by a finite (or countable) infimum of convex and quadratic functions that we propagate using the Bellman Operators.

Planning

Invited Talks

INTERFACE - Th 5:00pm-6:30pm, Format: 4x20 min

Room: SIGALAS Building: C, 2nd floor, Zone: 2

Contributed Session 389

Chair: Jeanjean Antoine, Recommerce Group, FR

1 - Planning model for recommerce activities

Speaker: Jeanjean Antoine, Recommerce Group, FR, talk 1251

Co-Authors: *Nabil Absi*, *Xavier Schepler*,

Our work deals with modeling a real-life recommerce planning activity that consists in buy-backing pre-owned products, repairing or refurbishing them in order to sell them as second hand products. Planning modelling is a key problem in a recommerce activity. The activity starts by proposing a price per product and per quality. Qualities are declared and established according to the answer to a set of questions, so the announced quality may differ from the actual one. All products should be bought-back if the customer wants to sell it: that's the reason why the sourcing is undergone and there is no optimization to perform but there is an uncertainty on the collected volumes. The optimization consists in deciding the best routing of these products in the remanufacturing process. This process should be performed as fast as possible through our logistics chain, i.e. to be sent to the best warehouse able to test them, to remanufacture the products if needed and then prepare them for being resold. The choice of the final resale channel and the final resale quality will have an impact on the benefits. In fact, sometimes it is be better to resale directly the product as is since the final benefits can be higher comparing to deciding to pay extra costs to make the production as new (i.e. after executing the full remanufacturing process) and resell it after several weeks. Furthermore, the production volume per product quality should also fit the market demands. The planning model proposed in this work optimizes the full recommerce activity from the collection to resale.

2 - A Propagation Approach for Railway Rolling Stock Optimization

Speaker: Boris Grimm, Zuse Institute Berlin, DE, talk 1332

Co-Authors: *Ralf Borndörfer*, *Stanley Schade*, *Markus Reuther*, *Thomas Schlechte*,

We are considering the problem to operate a railway timetable with a minimal number of vehicles as efficiently as possible. Railway timetables are often very regular and long lasting, i.e., identical departure times for similar train routes on different weekdays for multiple weeks. While being valid there might be maintenance events that force a revision of (parts of) the timetable. Every time a timetable is changed it defines a new optimization problem for the railway operator. It is highly desired that slightly changed problems lead to only slightly changed solutions. Hence, we propose an approach that optimizes over several weeks containing multiple similar subtimetables. The approach is based on an IP-formulation that propagates a solution of an optimization problem for a preceding subtimetable (week) to the optimization problem defined by the succeeding subtimetable to ensure connectivity and similar structures in both subsolutions. This approach evaluated on real world scenarios of DB Fernverkehr AG.

3 - Real Size Exam Timetabling at Montpellier University (France)

Speaker: Eric Bourreau, LIRMM, FR, talk 687

Co-Authors: *Valentin Pollet*,

Exam Timetabling is a classic Educational Problem in University: How to schedule exams in rooms such that no students will have time conflict. We present here our prototype developed at Montpellier University (France) to solve heuristically this problem with MIP (Matheuristics). It has been applied on very diversify data sets: classic exams (more than ten thousand students into hundred rooms during two weeks), time dependant exams (exams must start synchronously in multiple places from different time zone), big size exam (some exams had to start simultaneously in more than ten main lecture rooms for more than three thousand students). Despite the fact it was very hard to satisfy a lot of soft constraints (location preference, time slot required, . . .) we try to maximise revision time between each tests. Actual solver computations take from one to ten minutes long (to compare with the two weeks long procedure in the previous manual phase).

4 - An Hypergraph Model for the Rolling Stock Rotation Planning and Train Selection

Speaker: Mohamed Benkirane, IMB and SNCF, FR, talk 1599

Co-Authors: *François Clautiaux*, *Boris Detienne*, *Jean Damay*,

The subject of our presentation is an integrated optimization approach for timetable and rolling stock rotation planning in the context of passenger railway traffic. Our approach is based on an hypergraph based integer programming model, which can handle trains composed by multiple heterogeneous self-powered railcars. The method aims at producing a timetable and solving the rolling stock problem given a non-fixed set of passenger trips, a service requirement and a fleet of self-powered rail cars. The produced timetable optimises the production cost and especially the use of rail-cars. To solve our optimisation problem, we build a network-flow model in an hypergraph. The particularity of such models is that they can easily handle constraints related to coupling and decoupling rail-cars. We show by using some techniques of recombining flow units that the generated models are scalable. We finally present some results based on several French regional railway traffic case studies.

Medicine and Metabolic engineering

Specific Models, Algorithms, and Software Sciences - Th 5:00pm-6:30pm, Format: 4x20 min

Room: Salle LA4 Building: L, Basement, Zone: 8

Contributed Session 396

Chair: Mahdi Doostmohammadi, University of Edinburgh, GB

1 - Model Predictive Control and Robust Optimization in Adaptive Radiation Therapy

Speaker: Michelle Boeck, KTH, SE, talk 1228

Co-Authors: *Anders Forsgren*, *Kjell Eriksson*,

Uncertainties in radiation therapy are a major contributor to deviations of the actual delivered dose from the prescribed dose distribution, possibly leading to non-negligible deficiencies in treatment quality, which can be addressed by robust optimization. Adaptive radiation therapy (ART) refers to adapting treatment plans in response to the impact of uncertainties on the delivered dose that cannot be accounted for during the planning process. We present a novel approach to ART, by introducing dynamic variables to the robust optimization problem and exploiting the look-ahead feature of model-predictive control (MPC). A one-dimensional model is used in order to focus on the relevant aspects of robustness, MPC and treatment plan adaptation. In our MPC-framework, the adapted plan is optimized in response to already delivered dose and dose predictions over a finite-time horizon. By computing the optimally adapted plan, based on dose predictions and fed-back information on the impact of uncertainties on the so far recieved dose, the dose delivered in the subsequent fractions can be steered as close as possible to the prescribed dose distribution. We study the effectiveness of our MPC-framework in comparison with the exact strategy of creating a plan for every fraction and uncertainty scenario and the conventional approach of applying the same plan throughout the course of treatment. The performance of the MPC-framework is evaluated for three different prediction horizons and robust optimization models, expected value-, minimax- and conditional-value-at-risk optimization.

2 - Improving a Dose-Volume Model for HDR Brachytherapy to Reduce Tumour Cold Spots

Speaker: Björn Morén, Linköping University, SE, talk 613

Co-Authors: *Torbjörn Larsson*, *ÅSa Carlsson Tedgren*,

High dose-rate brachytherapy is a method of radiotherapy for cancer treatment where the radiation source is placed within the body. In addition to give a high enough dose to a tumour it is also important to spare nearby healthy organs. Dosimetric indices are important for evaluating dose plans. For the tumour, the portion of the volume that receives a sufficiently high dose is quantified. Dosimetric indices are increasingly used in optimization models, but such models, which contain indicator variables, are very hard to solve. Radiobiological modelling indicates that underdosage to small volumes can have large effect on treatment results. A weakness of models with dosimetric indices is that the dose to the coldest (least irradiated) volume in the tumour is not evaluated. Therefore, we propose an improved model which also considers the mean dose to the coldest volume in the tumour. Our results show that the dose to the coldest volume can be increased while also solution times are improved.

3 - New bilevel formulations for optimizing flux bounds in metabolic engineering

Speaker: Amanda Smith, Univ. of Wisconsin-Madison, US, talk 303

Co-Authors: *Jim Luedtke*,

Bilevel mixed-integer programming models are frequently used to solve metabolic engineering problems. However, these models tend to push cells close to infeasibility, and solutions may yield non-viable organisms. To overcome this drawback, we investigate three new bilevel MIP models that attempt to offer a compromise between desired output and organism viability. First, we introduce a bi-objective top-level problem. We then augment this model by incorporating enzyme kinetics and conclude with a stochastic extension that accounts for uncertainty in cellular behavior.

4 - MOMO - Multi-Objective Mixed integer Optimisation for metabolic engineering

Speaker: Mahdi Doostmohammadi, University of Edinburgh, GB, talk 519

Co-Authors: *Ricardo Andrade*, *Joao Santos*, *Marie-France Sagot*, *Nuno Mira*, *Susana Vinga*,

In this work, we explore the concept of multi-objective mixed integer optimization in the field of metabolic engineering when both continuous and integer decision variables are involved in the model. In particular, we propose a multi-objective model which, among other things, may be used to suggest reaction deletions that maximize and/or minimize several functions simultaneously. The applications may include, among others, the concurrent maximization of a bioproduct and of biomass, or maximization of a bioproduct while minimizing the formation of a given by-product, two common requirements in microbial metabolic engineering. The multi-objective programming framework we developed, called MOMO, is open-source and uses PolySCIP as underlying multi-objective solver. Production of ethanol by the widely used cell factory Saccharomyces cerevisiae was then adopted as a case-study to demonstrate the usefulness of the proposed approach in identifying genetic manipulations that improve productivity and yield of this economically highly relevant bioproduct. MOMO can be applied in the future to a very wide range of problems that involve the simultaneous optimization of different objectives in metabolic engineering applications.

Vehicle Routing III

Specific Models, Algorithms, and Software
Logistics - Th 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6

Contributed Session 413
Chair: Raquel Bernardino, CMAFCIO-FCUL, PT

1 - A hybrid algorithm for the family traveling salesman problem
Speaker: Raquel Bernardino, CMAFCIO-FCUL, PT, talk 821
Co-Authors: *Ana Paias*,
The problem addressed in this talk is the family traveling salesman problem (FTSP), which is a generalization of the well-known traveling salesman problem. In the FTSP we have a depot and a set of cities which is partitioned into several subsets called families. Given the traveling costs, the objective of the FTSP is to determine the minimum cost route that: i) begins and ends at the depot; and ii) visits a given number of cities per family. We propose the first hybrid algorithm for the FTSP. This algorithm starts by using a non-compact integer linear programming model to solve a partial FTSP which is induced by considering only a subset of the families, and then, if needed, by using implicit variable generation and heuristic methods to complete the solution. The hybrid algorithm is exact for medium-sized instances (the partial FTSP contains all the families) and, for the higher dimensioned benchmark instances, was able to improve some of the best known upper bounds from the literature.

2 - Snow removal: Modeling and bounds by relaxation, heuristic and branch-and-bound
Speaker: Roghayeh Hajizadeh, Linköping University, SE, talk 1037
Co-Authors: *Kaj Holmberg*,
Snow removal is an important problem in some countries. A number of streets in a city need to be cleared of snow by a limited number of vehicles within a certain time. We have formulated the problem as a very large mixed integer programming problem, but the practical goal is to find good lower and upper bounds on the optimal objective function value. We present some relaxation models that yield rather good lower bounds in rather short time. We also consider the problem facing a single vehicle and describe a detailed solution approach for it. First, we reformulate the problem to an asymmetric traveling salesman problem in an extended graph. Then we describe a heuristic for finding a feasible solution and a reordering procedure for handling precedences. This yields a feasible solution and an upper bound. Finally, we describe how to use a branch and bound method for improving the bounds, using all the parts mentioned above.

3 - Column Generation Based Local Search for Pickup-and-Delivery problems
Speaker: Vitor Nesello, Université de Bordeaux, FR, talk 1577
Co-Authors: *Francois Vanderbeck*, *Ruslan Sadykov*, *Artur Pessoa*, *Issam Tahiri*,
We consider large-scale instances of the Pickup-and-Delivery Routing problem with time constraints on the Period where request must be delivered. Our Dantzig-Wolfe approach decomposes the problem in set partitioning master problem (where variables represent feasible routes) and pricing subproblems consisting of a resource constrained shortest path problem in an extended arc-flow formulation. The latter is solved by a bucket graph based labelling algorithm. However this overall process does not scale up to very large size instances. We overcome this difficulty by restricting the exact solver (for instance by limiting the number of labels in each bucket, and using primal heuristic solution of the master program). Even so, the size of instances that can be handle remains limited to about 200 requests. Hence we apply this process to search a neighborhood of an existing solution which we define as the re-optimization of a set of routes that are geographically close by. Preliminary computational results shall be presented.

Heuristics for combinatorial optimization problems

Discrete Optimization & Integer Programming
COMB - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Contributed Session 428
Chair: Evren Guney, Istanbul Arel University, TR

1 - A Matheuristic to the Firefighter Problem on Graphs
Speaker: Cid de Souza, University of Campinas, BR, talk 598
Co-Authors: *Natanael Ramos*, *Pedro de Rezende*,
The firefighter problem (FFP) models the fire spreading and containment in a graph. Initially the fire ignites at a subset of vertices given rise to an iterative process where, at each step, a limited number of vertices are defended or, otherwise, are burned if they are adjacent to any vertex consumed by the fire in the previous iteration. The fire is contained and the process terminates if, in an iteration, no new vertices are burned. The goal of the problem is to minimize the number of vertices that are burned. Practical applications of the FFP can be found in areas such as disease control and network security. The FFP is NP-hard and heuristics to tackle the problem were proposed earlier in the literature. In this work we devise a matheuristic for the FFP where a set of elite solutions yielded by greedy randomized heuristics are input to a local search procedure based on an integer programming model. Thorough computational experiments were conducted on a public benchmark both for parameter tuning and to compare our results with those obtained previously. Rigorous statisti-

cal analysis show that our new matheuristic outperforms the existing approaches.

2 - Accelerated Best-first Search for Monotone Submodular Function Maximization

Speaker: Shinsaku Sakaue, NTT, JP, talk 680

Co-Authors: *Masakazu Ishihata*,

Submodular function maximization (SFM) has been attracting much attention since it appears in many realistic scenarios. Although the greedy-based algorithm is guaranteed to find a $(1 - 1/e)$-approximate solution for monotone SFM, many applications require solutions with better approximation guarantees; this is generally impossible to achieve in polynomial-time, and thus we turn to exponential-time, but empirically efficient, methods. One such method is the best-first search (BFS), and several BFS-based methods for SFM has been studied recently. However, existing BFS-based methods sometimes suffer excessive computation cost since their heuristic functions are not well designed. In this talk, we present an accelerated BFS for monotone SFM with a knapsack constraint. The acceleration is attained by employing an effective method for estimating the optimal value of SFM, which enables us to use a better heuristic function. Experiments show that our accelerated BFS is far more efficient in terms of both time and space complexities than existing methods.

3 - A statistical stopping criterion for simulated annealing

Speaker: Kazuya Fukuoka, Kyoto University, JP, talk 1225

Co-Authors: *Hiroyuki Masuyama*, *Hiroshige Dan*, *Shunji Umetani*,

Simulated annealing (SA) is a powerful tool for solving hard combinatorial optimization problems. However, we often encounter a serious problem of determining when to stop the procedure of SA. To overcome this, we develop a stopping criterion using the extreme value theory as the following steps: (i) We first group the feasible solutions obtained by SA into a number of blocks with the same size; (ii) We next fit the sequential maxima of the blocks to a non-stationary stochastic process with a generalized-extreme-value-distributed noise; (iii) We then calculate the standard error of the estimated convergent value of the feasible solutions generated by SA; (iv) We finally stop the procedure of SA if the standard error is smaller than a given error tolerance. The computational results illustrate that the proposed method performs effectively for the benchmark instances of TSP.

4 - A Lagrangean Relaxation Based Heuristic For Efficient Influence Maximization

Speaker: Evren Guney, Istanbul Arel University, TR, talk 989

The Influence Maximization Problem (IMP), which seeks for a small subset of influentials that can activate maximum number of individuals out of a large stochastic social network, has been a popular topic among researchers and practitioners recently. Assuming that the spread of influence is following certain popular diffusion models, such as independent cascade or linear threshold models, the expected influence which is the objective of the optimization problem possesses submodularity property. Benefiting from this property most of the researchers apply greedy based heuristics that provide a (1-1/e) performance guarantee. Since the network is stochastic, exact solution methods are intractable for even small networks, therefore sampling based strategies are used for approximate solutions. In this study we focus on the optimal solution of IMP, which is usually neglected by most of the researchers. Exact binary integer programming formulations for two different diffusion versions of the problems will be introduced. Then a Lagrangean Relaxation based solution approach will be explained for efficiently estimating the optimal solution of the original problem. Finally we will provide various computational results and compare our approach with the state-of-the-art methods.

First Order Methods II

CONTINUOUS OPTIMIZATION

NLP - Th 5:00pm-6:30pm, Format: 3x20 min

Room: Salle KC7 Building: K, Intermediate 2, Zone: 10

CONTRIBUTED SESSION 437

Chair: Guillaume Berger, UCLouvain, BE

1 - Hölder-continuous gradient and first-order approximation accuracy

Speaker: Guillaume Berger, UCLouvain, BE, talk 231

Co-Authors: *P.-A. Absil*, *Raphaël Jungers*, *Yurii Nesterov*,

Functions with Hölder-continuous gradient form an important class of functions in first-order optimization. The reason is that, for these functions, we have a global upper bound on the accuracy of the first-order approximation of the function value at any point. However, little is known about a converse result. In this talk, we show that a function with such a global upper bound on the accuracy of the first-order approximation must have a Hölder-continuous gradient. Moreover, we establish the link between the best upper bound on the first-order approximation accuracy and the Hölder constant of the gradient. From this converse result, the Hölder constant can be used to compute bounds on the worst-case complexity of first-order optimization methods. For functions with Lipschitz-continuous gradient, a widely used subclass of functions with Hölder-continuous gradient, we show that our bounds are exact.

2 - Accelerating Nonnegative Matrix Factorization Algorithms using Extrapolation

Speaker: Andersen Ang, UMONS, BE, talk 1240

Co-Authors: *Nicolas Gillis*,

In this talk, we present a general framework to accelerate significantly the algorithms for nonnegative matrix factorization (NMF). This framework is inspired from the extrapolation scheme used to accelerate gradient methods in convex optimization. However, the use of extrapolation in the context of the two-block coordinate descent algorithms tackling the non-convex NMF problems is novel. We propose several effective strategies to tune the extrapolation parameters, and illustrate the performance of this approach on synthetic, image and document data sets.

3 - First-Order Primal-Dual Method for Nonlinear Convex Cone Programs

Speaker: Lei Zhao, Shanghai Jiaotong University, CN, talk 1636

Co-Authors: *DaoLi Zhu*,

Nonlinear convex cone programs (NCCP) are important problems with many practical applications, but these problems are hard to solve by using existing methods. This paper introduces a flexible first-order primal-dual augmented Lagrangian decomposition algorithm called Varying Auxiliary Problem Principle (VAPP) for solving NCCP when the objective or constraints are nonseparable and possibly nonsmooth. This method can serve as a framework for a decomposition algorithm to solve composite NCCP. Each iteration of VAPP generates a nonlinear approximation to the primal problem of an augmented Lagrangian method. The approximation incorporates both linearization and a variable distance-like function or auxiliary core function. In this way, the primal problem can be decomposed into smaller subproblems, each of which has a closed-form solution or an easily approximated solution. Moreover, these subproblems can be solved in a parallel way. This paper proves convergence and an O(1/t) convergence rate on average for primal suboptimality, feasibility, and dual suboptimality. A backtracking scheme is discussed to treat the case where the Lipschitz constants are not known or computable.

Ranking and recommendation

Specific Models, Algorithms, and Software
Learning - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

Contributed Session 472
Chair: Aleksandra Burashnikova, Skoltech, RU

1 - Learning Online Ranking Models with a Sequential Optimization Algorithm
Speaker: Aleksandra Burashnikova, Skoltech, RU, talk 1208
We propose a novel unified framework based on a sequential optimization algorithm for large-scale ranking models. In our model we assume that we deal with an implicit feedback (mostly represented in the form of clicks) as it is more specific for real online problems. The learning strategy is based on the minimization of a convex surrogate ranking loss over the average number of previous unclicked items showed to the user and the current clicked one as we update the weights only in case when the positive feedback comes to the system by assuming that only positive feedbacks provide relevant information. It was proved that usage the proposed sequantial update rule for the weights leads to the convergence of the surrogate ranking loss to the global minimum for settings where the system is or not simulteneously affected by the previously mentioned update rule. Experiments on four real-world benchmarks show the learnability and the interest of the proposed approach supporting the received theoretical proofs.

2 - Integrating Individual and Aggregate Diversity in Top-N Recommendation
Speaker: Ibrahim Muter, University of Bath, GB, talk 1529
Co-Authors: *Ethem Canakoglu*, *Tevfik Aytekin*,
Recommender systems have become one of the main components of web technologies that help people to cope with the information overload. Two of the most important metrics used to analyse the performance of these systems are accuracy and diversity of the recommendation lists. While all the efforts exerted in the prediction of the user interests aim at maximizing the former, the latter emerges in various forms, such as diversity in the lists across all user recommendation lists, referred to as aggregate diversity, and diversity in the lists of individuals, known as individual diversity. To the best of our knowledge, no study has been done to consider both individual diversity and aggregate diversity, along with accuracy. In this paper, we tackle the combination of these three objectives, and justify this approach by showing through experiments that handling these objectives in pairs does not yield satisfactory results in the third one. To that end, we develop a mathematical model that is formulated using multi-objective optimization approaches. To cope with the intractability of this non-linear integer programming model, its special structure is exploited by a decomposition technique. For the solution of the resulting formulation, we propose an iterative framework that is composed of a clique generating genetic algorithm and constructive/improvement heuristics. We conduct experiments on three data sets and show that the proposed modeling approach successfully handles all objectives according to the needs of the system.

3 - A stochastic gradient descent algorithm for learning to rank
Speaker: Engin Tas, Afyon Kocatepe University, TR, talk 12
Co-Authors: *Senay Ozdemir*,
One of the main problems in machine learning is the determination of preference relations between interested units. In this context, ranking can be defined as learning a function with the ability to organize units according to a given preference relation. This type of problem is often treated as a classification problem where the examples are formed by pairs. In this study, an approach based on pairwise comparisons is presented for an estimation of a general ordering. This ranking problem which minimizes the pairwise ranking error is represented by a system of linear equations. A fast version of stochastic gradient descent algorithm is proposed to learn the ranking functions by solving this system of linear equations iteratively. Near optimal learning parameters are determined using the largest and smallest eigenvalues of the Hessian. In addition, Tikhonov regularization is also used in this context to control the generalization performance of the ranking model.

4 - The Recommender Problem with Convex Hulls
Speaker: Jose Dula, University of Alabama, US, talk 338
Co-Authors: *Marie-Laure Bougnol*,
We approach the user-based collaborative filtering recommender problem using computational geometry. This approach provides a framework for the entire recommendation process; from identifying similar users to using their proximity to predict scores. We report our results comparing this approach with more conventional methods.

Cutting Planes

Discrete Optimization & Integer Programming
IPpractice - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Contributed Session 485
Chair: Fabrizio Marinelli, Univ. Politecnica delle Marche, IT

1 - A tighter ILP model and an improved branching for a load-balancing problem
Speaker: Edvin ABlad, Chalmers - Math. Sci., SE, talk 1338
A novel method for optimizing the robot utilization in automotive manufacturing multi-robot assembly cells has recently been published (DOI:10.1109/TASE.2017.2761180). It suggests an integer linear programming (ILP) model of the machine load-balancing in order to find a space partition of the

cell which prevents all robot-robot collisions. We have improved this ILP model by replacing a large set of constraints with fewer, tighter, and valid linear inequalities. Using the improved ILP model, a MILP solver (Gurobi) found an optimal solution within approximately half the computation time. Moreover, we have proved that our valid inequalities are indeed facets of the convex hull of the ILP for a large class of problem instances. Finally, we suggest a tailor-made branch-and-bound algorithm for the solution of this model that outperforms both our published routine and Gurobi. Our contributions reduce considerably the time for optimizing a multi-robot assembly cell and enables the development of improved algorithms resulting in a higher robot utilization.

2 - A Branch-and-Cut Approach for the Car Renter Salesman Problem

Speaker: Sávio Dias, UFRJ, BR, talk 375

Co-Authors: *Luidi Simonetti*, *Pedro González*,

This work presents a new formulation for the Car Renter Salesman Problem (CaRS). In CaRS, the goal is to travel through a set of cities using rented vehicles at minimum cost. This problem aims to establish an optimal route taking into consideration the scheduling of rental vehicles. The CaRS was originally proposed as tourism-driven, with its application drawn directly from Car Rental Industry. However, this is an understatement since CaRS can also be employed in public transportation, manufacture processes and multilayer circuits design. CaRS is a TSP generalization, thus it is a NP-Hard problem. This work proposes a Mixed Integer Linear Programming Formulation and a Branch-and-Cut technique. The proposed formulation is shown to have stronger bounds when compared to others from literature. Computational experiments show that the proposed approach is able to solve to optimality 35 out of 47 instances. In additition, 17 of the 35 had its optimality proved for the first time.

3 - On Lifted Cover Inequalities: A New Lifting Procedure with Unusual Properties

Speaker: Georgia Souli, Lancaster University, GB, talk 294

Co-Authors: *Adam Letchford*,

Lifted cover inequalities (LCIs) constitute a well-known family of cutting planes for 0-1 linear programs. They are obtained from a weaker family of inequalities, the so-called cover inequalities, by a process called lifting. Several lifting procedures have been proposed in the literature. We take one of the earliest procedures, due to Balas, and show that it can be significantly improved. The resulting procedure is extremely fast and yields both stronger and more general LCIs. The improved procedure is sequence-independent and has some unusual properties: (i) it can increase coefficients for variables inside the cover as well as outside, (ii) it can yield facet-defining LCIs even if the given cover is not minimal, (iii) it can yield facet-defining inequalities that cannot be obtained by standard lifting procedures, and (iv) the associated lifting function is integer-valued almost everywhere and superadditive.

4 - Exploiting star inequalities for the maximum quasi-clique problem

Speaker: Fabrizio Marinelli, Univ. Politecnica delle Marche, IT, talk 838

Co-Authors: *Andrea Pizzuti*, *Fabrizio Rossi*,

Mining of dense subgraphs is of substantial interest in graph-based applications where the interactions between elements encode meaningful properties of the solutions. Cohesive structures are well described by several clique relaxations. The maximum γ quasi-clique problem ask to find an induced γ quasi-clique of maximum order, i.e., the largest subgraph whose edge density is at least γ. We present a new MILP formulation obtained by the integer decomposition of star inequalities, and a surrogate relaxation whose number of constraints is linear in the number of vertices of the graph. The former provides a dual bound potentially better than that obtained by the MILP formulations available in the literature; the latter can be exploited to handle dense graphs of large size. The practicability and usefulness of the proposed mathematical programs have been assessed through extensive computational experiments.

Topics in multistage stochastic optimization

Optimization under Uncertainty

Stoch - Th 5:00pm-6:30pm, Format: 3x20 min

Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 492

Chair: Felipe Beltrán, UFSC, BR

1 - Risk Minimization, Regret Minimization and the Progressive Hedging Algorithm

Speaker: Min Zhang, Curtin University, AU, talk 286

Co-Authors: *Jie Sun*, *Xinmin Yang*, *Qiang Yao*,

Optimization models based on coherent and averse risk measures are of essential importance in financial management and business operations. This talk begins with a study on the dual representations of risk and regret measures and their impact on modeling multistage decision making under uncertainty. The relationship between risk envelopes and regret envelopes is established by using the Lagrangian duality theory. It is then pointed out that such a relationship opens a door to a decomposition scheme, called progressive hedging, for solving multistage risk minimization and regret minimization problems. In particular, the classical progressive hedging algorithm is modified in order to handle a new class of constraints that arises from a reformulation of risk and regret minimization problems. Numerical results are provided to show the efficiency of the progressive hedging algorithms.

2 - Recursive Evaluate and Cut for combinatorial Multistage Programs

Speaker: David Hemmi, Monash University, Data61, AU, talk 1165

Co-Authors: *Guido Tack*, *Mark Wallace*,

Stochastic programming is concerned with decision making under uncertainty, seeking an optimal policy with respect to a set of possible future scenarios. Our work looks at multistage optimisation problems where the uncertainty is revealed over time. First, decisions are made with respect to all possible future scenarios. Secondly, after observing the random variables, a set of scenario specific decisions is taken. Our goal is to develop algorithms that can be used as a back-end solver for high-level modelling languages. We propose a scenario decomposition method to solve combinatorial stochastic multistage optimisation problems recursively. Our approach is applicable to general problem structures, utilizes standard solving technology and is highly parallelizable. Furthermore, opposed to other algorithms no parameter tuning is required, making our approach a prime candidate for solving stochastic programs in a "model-and-run" fashion. Experimentally we have shown how it effectively solves benchmarks with hundreds of scenarios.

3 - Stochastic dual dynamic programming with Chebyshev centers

Speaker: Felipe Beltrán, UFSC, BR, talk 1354

Co-Authors: *Erlon Finardi*, *Welnigton de Oliveira*, *Guilherme Fredo*,

In systems with hydraulic predominance, the long-term hydrothermal scheduling problem (LTHS) aims to obtain an implementable power generation policy providing minimal costs at an instant in which the future water inflows in the system are unknown. Usually, the LTHS is solved by the stochastic dual dynamic programming (SDDP) method, which employs two steps: a forward step for generating trial points, and a backward one to construct policies (Benders cuts). As the SDDP is a sort of cutting-plane method, it can exhibit slow convergence when dealing with large-scale problems. In order to accelerate the SDDP method, we modify its cuts in the forward step by employing some ideas related to the Chebyshev center of the SDDP subproblems' feasible sets without compromising convergence analysis. Numerical assessments on the large-scale Brazilian LTHS problem with individualized decisions per plant, over a five-year planning horizon with monthly decisions, indicate that the new proposal significantly accelerates the SDDP method performance. The new technique computes better lower bounds and (approximately optimal) implementable policies in less than 90 percent of the CPU time required by the classical method.

Advances in DFO III

Continuous Optimization

DerFree - Th 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 496

Chair: Juan Meza, NSF, US

1 - Utilizing Non-Commutative Maps in Derivative-Free Optimization

Speaker: Jan Feiling, University of Stuttgart, DE, talk 965

Co-Authors: *Christian Ebenbauer*,

A novel class of gradient-free optimization algorithms is developed. The main idea is to utilize certain non-commutative maps in order to approximate the gradient of the objective function. Recently, non-commutativity between two vector fields has been used in the field of adaptive control to approximate gradients and to design continuous-time gradient-free optimization and extremum seeking algorithms for unconstrained, constrained, and distributed optimization problems. The proposed class of discrete-time gradient-free algorithms are inspired by these continuous-time, explorative optimization methods but our approach is not simply a discretization of continuous-time methods. For example, utilizing non-commutative maps based on Euler-integration steps lead to approximation results which are different from continuous-time approximation results, yet we show how they can be used for gradient approximations. Moreover, we show suitable integration schemes in order to approximate the results known from continuous-time methods. Finally, we analyze the convergence of the proposed class of algorithms.

2 - Generalization of DIRECT algorithm supporting interactive problem redefinition

Speaker: Richard Carter, DNVGL, US, talk 1137

Don Jones' DIRECT algorithm fills an interesting niche in the derivative-free-optimization taxonomy, with both significant advantages and significant limitations. A generalized version can be effective for local, global, and multi-local blackbox optimization, for finding Pareto sets associated with multiple objectives, and for problems with hidden constraints. With modification to the partitioning scheme, it can be applied to mixed continuous/discrete search variables. It also adapts naturally to large scale parallel environments, which can somewhat mitigate its dimensionality limitations. In this talk we review its capabilities, and show how it can be interactively run to support on-the-fly objective and constraint refinement and redefinition. We demonstrate its operation on a representative application from gas pipeline optimization.

3 - Pattern Search Methods With Surrogates for Surface Structure Determination

Speaker: Juan Meza, NSF, US, talk 1683

Co-Authors: *Mark Abramson*,

Many material properties depend on the atomic configuration at the surface. One common technique used for determining this surface structure is based on the low energy electron diffraction (LEED), which compares spectra computed via computational physics models with experimental results. While this approach can be effective, the computational cost of the simulations can be prohibitive for large systems. In this work, we use a direct search method, NOMADm, in conjunction with surrogates, to find optimal atomic configurations that best describe the data.

Using coning programming in problems solving

Continuous Optimization

SDP - Th 5:00pm-6:30pm, Format: 4x20 min

Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

Contributed Session 497

Chair: Kurt Majewski, Siemens AG. CT RDA BAM ORD-DE, DE

1 - Linear Relaxation of Maximum k-Cut with Semidefinite-Based Constraints

Speaker: Vilmar Jefte De Sousa, Polytechnique Montreal, CA, talk 666

Co-Authors: *Miguel Anjos*, *Sébastien Le Digabel*,

We consider the maximum k-cut problem that consists in partitioning the vertex set of a graph into k subsets such that the sum of the weights of edges joining vertices in different subsets is maximized. The associated semidefinite programming (SDP) relaxation is known to give strong bounds but it suffers from high CPU times. We deploy a cutting plane algorithm that exploits the early termination of an interior-point method, and we study the performance of SDP and linear programming (LP) relaxations for a variety of values of k and of types of instances. The LP relaxation is strengthened using combinatorial facet-defining inequalities as well as SDP-based constraints. Our computational results suggest that the LP approach, especially with the addition of SDP-based constraints, outperforms the SDP relaxations for graphs with positive weights edges and k is equal or greater than 7.

2 - Feedback Controller and Topology Design for uncertain mechanical systems

Speaker: Anja Kuttich, TU Darmstadt, DE, talk 1249

Co-Authors: *Stefan Ulbrich*,

Structural vibration may occur in mechanical systems leading to fatigue, reduced durability or undesirable noise. In this context, vibrations are undesirable and reduction of vibration is an important goal in a variety of engineering applications. In addition, imperfect and/or unknown information in the design process leads to uncertain parameters in the system which in turn may lead to undesirable states. We use a robust topology optimization approach to reduce vibrations and control uncertainty in mechanical systems. Moreover we combine the robust topology optimization problem with a feedback controller design via the H_∞-control problem. Using the Bounded Real Lemma the robust topology and feedback controller design problem can be formulated as a nonlinear semidefinite programming problem. The main advantage of our approach is that we can simultaneously optimize the topology of the system and the design of the feedback controller. We solve the resulting nonlinear semidefinite programming problem using a sequential semidefinite programming approach. The considerations are complemented by numerical results for truss structures under uncertain dynamic loads.

3 - Stabilization of the moment-based approach to prove global optimality for ACOPF

Speaker: Julie Sliwak, RTE, FR, talk 579

Co-Authors: *Miguel Anjos*, *Lucas Letocart*, *Manuel Ruiz*, *Emiliano Traversi*,

The Alternative Current Optimal Power Flow problem (ACOPF) is one of the most challenging problem in power systems optimization. This nonconservative flow problem is nonlinear and nonconvex, which means that only local optimality can be guaranteed by first-order KKT conditions. Yet solutions provided by typical local heuristics are often globally optimal. The rank relaxation ensures global optimality when there is no duality gap. However, solving this SDP relaxation does not always permit to conclude and moment relaxations of higher order may have to be solved. A moment relaxation of order d is a SDP problem with monomials of degree maximal 2d as variables. Increasing the order improves the quality of the relaxation but increases significantly the size of the problem. Since solving large-scale SDP problems is still a computational challenge, we propose to exploit the local optimum provided by a nonlinear solver using a conic-bundle algorithm. The iterative procedure described in this work solves the moment-based relaxations in increasing order, and is reoptimized as the order increases, until global optimality is proved. Results on small well-known instances are presented to validate the method.

4 - Maximum Volume Inscribed Ellipsoids for Specific Absorption Rate Bounds in MRI

Speaker: Kurt Majewski, Siemens AG. CT RDA BAM ORD-DE, DE, talk 1152

In medical magnetic resonance imaging, parallel radio frequency (RF) excitation pulses have to respect a large number of specific absorption rate (SAR) constraints. Each SAR constraint can be interpreted as a complex centered, C-dimensional ellipsoid where C is the number of RF excitation coils. We propose to replace these SAR constraints by the single constraint which corresponds to the associated maximum volume inscribed ellipsoid (MVIE). This reduces the burden of handling SAR constraints in the excitation pulse design problem, but cuts away parts of the feasible region. We transfer the well known result that blowing up the MVIE by $\sqrt{C}$, gives an ellipsoid which contains the intersection of the original ellipsoids, from the real- to the complex-valued setting. We present heuristics for the calculation of the MVIE via convex programming, suited to cope with the large number of ellipsoids. We report the performance of these algorithms in numerical examples.

Global Optimization 3

Continuous Optimization

Global - Th 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 20 Building: G, 1st floor, Zone: 6

Contributed Session 503

Chair: Jean-Baptist Hiriart-Urruty, Paul Sabatier University, FR

1 - Tighter McCormick relaxations through subgradient propagation in a BaB framework

Speaker: Jaromil Najman, AVT.SVT RWTH Aachen University, DE, talk 1241

Co-Authors: *Alexander Mitsos*,

Deterministic Global Optimization relies on tight convex and concave relaxations, in best-case envelopes, of the functions used in the underlying model. In chemical engineering optimization problems, the number of degrees of freedom is often relatively small and this fact can be exploited by the application of the McCormick technique to algorithmic structures presented in (Mitsos 2009). The original McCormick rules (McCormick 1976) are applicable to factorable functions, where outer functions F are univariate and inner functions f are multivariate functions and were extended to multivariate outer functions by (Tsoukalas 2014). When constructing McCormick under- and overestimators, valid range bounds for each factor are needed. With an increasing number of propagations, the quality of estimated range bounds gets worse (Bompadre 2012). This is particularly true when using simple interval arithmetic for the underlying variable bounds and each factor in the propagation procedure. To overcome this issue, we present a heuristic to improve the range bounds in each factor based in part on subgradient propagation (Mitsos 2009). Theoretically, the heuristic cannot worsen the range bounds but it does not guarantee to improve the bounds. Practically, we demonstrate substantial improvement, especially for in-house flow sheet optimization models (Bongartz 2017), where the number of complicated propagated factors is very large. Finally, we compare the performance of the presented heuristic to other range reduction techniques and state-of-the-art global optimization solvers.

2 - Nonlinear branch-and-bound improvements for global optimization

Speaker: Simon Boulmier, LocalSolver, FR, talk 1266

LocalSolver is a general mixed-integer nonlinear programming solver based on local search techniques. It is highly efficient to give upper bounds to minimization problems, but doesn't provide any guarantee on the quality of these solutions. In the context of computing tight lower bounds, we are interested in the lower bounding step of a global optimization algorithm. The main ingredients for this are the enumeration and solving of tight convex relaxations in a spatial branch-and-bound framework, along with efficient bound tightening techniques and branching rules. Solving the convex relaxations to optimality is the most time consuming part of the algorithm and must provide quick infeasibility detection. The practical gap between linear and nonlinear solvers in terms of speed, robustness, and infeasibility detection is such that most global optimization softwares use linear relaxations by default, or limit the nonlinear part to quadratic terms. Our goal is to design from scratch a nonlinear solver in an attempt to fill this gap, at least in terms of speed and infeasibility detection. We reduce the computing cost of each node to the resolution of one unconstrained minimization problem that can be efficiently warmstarted and has very good theoretical convergence speed. Infeasibility detection during solve is completely discarded and all nodes are handled in the same way. The approach is generic and numerical experiments show that it is able to compete against highly tuned commercial nonlinear branch and bound, such as the quadratic simplex method.

3 - JAVA implementation of a modular, population based global optimizer package

Speaker: Mester Abigél, SZTE, HU, talk 1412

Co-Authors: *Balázs Bánhelyi*, *Tibor Csendes*, *Dániel Zombori*, *Balázs Lévai*, *László Pál*,

There are many suitable global optimization methods to find the minimum of a nonlinear objective function. In our presentation we improve the GLOBAL optimization method which is developed by the Institute of Informatics, University of Szeged. GLOBAL was used successfully for the solution of very complex optimization problems. GLOBAL is a stochastic technique that is a sophisticated composition of sampling, clustering, and local search. It compares well with other global optimization software for the solution of the low dimensional black-box-type problems (when only the objective function is available, while the derivatives should be approximated). It is usually very successful on problems where the relative size of the region of attraction of the global minimizer is not negligible. The talk presents the architecture of the stochastic global optimization algorithm GLOBAL and the single thread Java implementation. Then we present the parallel clustering method which applied in our solution. After this, we show the sampling, clustering, and local search methods working in parallel. We applied a technique which is based on the priority of the earlier mentioned methods, and all threads determine alone the next methods to complete. Finally we illustrate the efficiency of our method on large scale popular test functions.

4 - A rigorous MINLP solver using interval unions

Speaker: Tiago Montanher, University of Vienna, AT, talk 1633

Co-Authors: *Mihály Markót*, *Arnold Neumaier*,

Interval unions are finite sets of closed and disjoint intervals designed to represent the division by intervals containing zero. This talk introduces a rigorous MINLP solver based on interval unions. We denote integer variables as interval unions and extend state-of-the-art methods from interval analysis such as constraint propagation, feasibility verification and first order filtering to handle with continuous and discrete variables indistinguishably. The result is a branch-and-bound procedure which can enclose every solution of MINLPs with certainty, even in the presence of rounding errors. The branching step of our algorithm differs from the pure continuous approach since the number of elements on each interval union can grow exponentially. We present a gap filling-strategy to avoid this behavior. We implement the method discussed in this talk on JGloptLab, a Java software for rigorous computations. Numerical experiments with problems from publicly available test sets show the capabilities of our approach.

Cutting Planes for Special Problems

Discrete Optimization & Integer Programming

IPtheory - Th 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 42 Building: C, 3rd floor, Zone: 1

Contributed Session 517

Chair: Eleazar Madriz, UFRB, BR

1 - Separation problem for 2-partition inequalities

Speaker: Ruslan Simanchev, Omsk State University, RU, talk 1220

Co-Authors: *Inna Urazova*,

In the article M. Grotschel and Y. Wakabayashi (A cutting plane algorithm for a clustering problem. Math Program 45, 59-96 (1989)) , in particular, there were introduced the 2-partition inequalities, which generate the facets of the clique partitioning polytope. There also proposed a heuristic procedure for solving the separation problem, which allowed to integrate these inequalities into the cutting plane algorithm for the clique partitioning problem. However, the question of the complexity of the separation problem for these inequalities remained open. In the article M. Oosten, J.H.G.C. Rutten, F.C.R. Spieksma (The clique partitioning problem: facets and patching facets. Networks 38(4), 209-226 (2001)) was shown the NP-completeness of the separation problem, which is considered in the following edition. For a given point $\bar{x} \in R^E$, either find a 2-partition inequality that is violated by this point, or prove that there is no such 2-partition inequality. We proved the NP-completeness of the separation problem for 2-partition inequalities in a more stronger formulation, in which the condition $\bar{x} \in R^E$ is replaced by the condition: the point $\bar{x}$ satisfies all triangle inequalities.

2 - Polyhedral results for position based scheduling of chains on a single machine

Speaker: Markó Horváth, MTA SZTAKI, HU, talk 263

Co-Authors: *Tamás Kis*,

We consider a scheduling problem where a set of unit-time jobs have to be sequenced on a single machine without preemption, and without any idle times between the jobs. In addition, the ordering of the jobs must satisfy the given precedence constraints. One has to determine a sequence of jobs which minimizes the total cost where the processing cost of a job depends on its position in the sequence. Note that this problem can be considered as a generalization of the linear assignment problem, where one has to assign n jobs to n positions such that the set of positions is ordered, and each job must be assigned a later position than any of its predecessors according to the precedence constraints. In this talk we deal with chain precedence constraints, and investigate the polyhedron associated with the set of feasible solutions. In particular, we show that already a special case is NP-hard, that is, when each chain is of length 2, then optimizing over the polyhedron is strongly NP-hard, furthermore, for the same special case we present a class of facet-defining inequalities along with a polynomial-time separation procedure. We extend these results for the general case, i.e., where chains have arbitrary lengths. Our computational results show that separating our inequalities can significantly improve an LP-based branch-and-cut procedure to solve the problem. That is, when applying our cutting planes in branch-and-cut, our procudure is up-to two orders of magnitude faster than default CPLEX.

3 - A Benders procedure for the b-complementary multisemigroup dual program.
Speaker: Eleazar Madriz, UFRB, BR, talk 659
Co-Authors: *Yuri Passos*,
Let $(A, \widehat{+})$ be an b-complementary finite multisemigroup, a b-complementary multisemigroup integer program is the problem $min\{ct : t \in P(A, b)\}$ where $c \in \mathbb{R}^{|A|}$ and $P(A, b)$ is the convex hull of the set $\{t \in \mathbb{Z}^{|A|} : b \in \widehat{\sum_{g \in A}} t(g)g\}$. Given a base for the subadditivity cone (L, E) for A, a b-complementary multisemigroup integer program is the problem

$$P_p : \min\{ct : \sum_{g \in A} \rho(g)t(g) = \rho(b), \rho \in L,$$

$$\sum_{g \in A} \pi(g)t(g) \geq \pi(b), \pi \in E,$$

$$t(g) \geq 0, g \in A\},$$

For a b-complementary finite multisemigroup dual program of P_p, we propose a Benders descomposition procedure. This procedure is based on the resolution of only linear subproblems in spaces of smaller dimension than the one of P_p. Preliminary computational results are also presented.

Supply Chain

SPECIFIC MODELS, ALGORITHMS, AND SOFTWARE
SCHEDULING - Th 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 18 Building: I, 1st floor, Zone: 7

CONTRIBUTED SESSION 533
Chair: Daniel Ramón-Lumbierres, UPC, ES

1 - Using SAP Integrated Business Planning to Optimize Supply Chain
Speaker: Wei Huang, SAP, DE, talk 1533
Powered by in-memory computing technology within SAP HANA, the cloud-based solution SAP Integrated Business Planning (IBP) combines capabilities for sales and operations (S and OP); demand, response, and supply planning; and inventory optimization. In this talk, we introduce how we use IBP S and OP Opmitizer, powered by Gurobi, to optimize the supply planning of our customers in manufacturing industry.

2 - Complexity of processing-time dependent profit maximization scheduling problems
Speaker: Florian Fontan, G-SCOP, FR, talk 1300
Co-Authors: *Pierre Lemaire*, *Nadia Brauner*,
Large telescopes are few and observing time is a precious resource, while more and more astronomical projects require a significant number of observations to be done during discontinuous periods spread over several months or years. In this context, Catusse et al. (2016) proposed an exact algorithm to schedule observations on a telescope during a given number of nights, the objective being to maximize the sum of the weighted number of observations (the weight of an observation corresponding to its scientific interest). However, the model must be refined to provide more applicable solutions. Currently, observation times are fixed to their maximum value (observing longer would not result in a better picture) but in practice the observation time of a star may be reduced, downgrading the quality of this observation, but potentially making room for additional ones. This is modeled with variable weights, depending on the allocated observation time. This motivated the theoretical study we present here. Consider n jobs that can be scheduled on a machine. Each job Tj has a deadline dj and an associated profit function of its allocated processing-time wj(pj). The objective is to maximize the sum of the profits of the scheduled jobs. Our goal here is to draw the line between P-easiness and NP-hardness for different cases depending on the shape of the profit function and the applied constraints.

3 - Modelization and optimization of inventory management for palletization
Speaker: Abdessamad Ouzidan, UBS Lorient, Fives Syleps, FR, talk 1301
Co-Authors: *Marc Sevaux*, *Berenger David*,
The Inventory Movement Optimization Problem (IMOP) is a new scheduling problem arising in industry. A set of N pallets has to be prepared with different products in a processing area with T preparation slots (T < N). At every step of the process, pallets of products of a single type are requested from the inventory, and brought one by one by an AGV. When a pallet of product arrives in the processing area, a palletizing robot feeds the pallets where the product is requested. The pallet of product is then returned to the inventory. As soon as a pallet is completed, it is transferred to the shipping area. The next pallet is inserted in the available slot. The objective is to minimize the number of movement of the AGV from the inventory. We develop a MILP model and solve it with a commercial solver. Comparison is conducted with a competitive heuristic and with an implementation on LocalSolver on real instances.

4 - A multistage stochastic programming model for the strategic supply chain design
Speaker: Daniel Ramón-Lumbierres, UPC, ES, talk 1006
Co-Authors: *F.-Javier Heredia*, *Robert Gimeno Feu*, *Julio Consola*, *Román Buil Giné*,
Supply chain management has been widely developed through the evolution of manufacturing, distribution, forecasting and customer behavior, encouraging the introduction of postponement strategies in its various forms. At these strategies, semi-finished goods are stored in certain operations of the chain, called decoupling points, waiting for the placement of demand orders, which trigger production flows from decoupling points to the remainder operations. Such a design problem facing the speculation/postponement paradigm must intrinsically include elements that "unveil" demand orders when they are placed, that is, the modelling approach should keep demand orders as random variables until their placement, when they are disclosed. This work proposes a multistage stochastic programming model that decides the optimal allocation of decoupling points, as well as a process selec-

tion among alternative designs for any general supply chain case, where the stochastic parameters, demands by period and product, are represented through a scenario tree, which is in turn generated using the forecasting. Both a risk-neutral model and a risk-aversion approach with stochastic dominance constraints are presented and solved with multi-stage instances of test cases based on real manufacturing problems defined in collaboration with the Accenture consultancy company.

Copositive and completely positive optimization

Continuous Optimization
SDP - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 20 Building: G, 1st floor, Zone: 6

Invited Session 24
Organizer: Olga Kuryatnikova, Tilburg University, NL

1 - A New Certificate For Copositivity
Speaker: Peter Dickinson, University of Twente, NL, talk 507
In this talk, we consider a new method of certifying any copositive matrix to be copositive. This is done through the use of a theorem by Hadeler, together with the Farkas Lemma. For a given copositive matrix, this certificate is constructed by (approximately) solving finitely many linear systems, and can be subsequently checked by checking finitely many linear inequalities. In some cases, this certificate can be relatively small, even when the matrix generates an extreme ray of the copositive cone which is not positive semidefinite plus nonnegative. This certificate can also be used to generate the set of minimal zeros of a copositive matrix, which is useful in checking properties of the matrix.
2 - Copositive Approach to adjustable robust optimization
Speaker: Markus Gabl, UNIVIE, AT, talk 232
Co-Authors: *Immanuel Bomze*,
Adjustable robust optimization aims at solving problems under uncertainty in a first stage; the second stage decisions can be adjusted after uncertainty is removed. Hence, the objective is to identify the best solution among those which in any case allow for feasible adjustment of the second stage variables. Obviously there is greater flexibility than in a general uncertainty setting and thus less conservative strategies are viable. However, the computational cost rises, also for problems where the constraint-coefficients of the second stage variables are affected by uncertainty as well (uncertain recourse). This talk reports on resarch efforts (in progress) to approach these issues by applying copositive optimization techniques.
3 - Using Binary Programming to solve Copositive Optimization Problems
Speaker: Juan Vera, Tilburg University, NL, talk 1245
Co-Authors: *Luis Zuluaga*, *Luis Zuluaga*,
We propose a solution methodology to solve copositive optimization problems. The methodology is based on solving several standard quadratic problems (STQP) in order to generate cuts to force a matrix to be copositive. We exploit the fact that solving an STQP can be written as a binary program and therefore solved using powerful commercial solvers, such as Cplex and Gurobi.
4 - Copositive certificates of non-negativity for polynomials on unbounded sets
Speaker: Olga Kuryatnikova, Tilburg University, NL, talk 729
Co-Authors: *Juan Vera*, *Luis Zuluaga*,
We construct copositive certificates of non-negativity for polynomials on unbounded sets defined by polynomial inequalities and equalities. We show that under suitable conditions, non-negativity on of a polynomial of degree d on a given semialgebraic set can be certified in terms of copositive polynomials of degree 2d, even if the semialgebraic set is unbounded. Moreover, we use existing certificates of copositivity (e.g., based on Polya's theorem) to obtain new LMI certificates of non-negativity. These certificates have a sparse structure and involve polynomials of low degrees, which is a potential advantage in comparison to the frequently used sums-of-squares polynomials. Also, our result provides an alternative proof of some existing non-negativity certificates, such as Handelman's Positivstellensatz.

Power Systems Models with Discrete Decision Variables

Specific Models, Algorithms, and Software
Energy - Fr 9:00am-10:30am, Format: 3x30 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6

Invited Session 26
Organizer: Adolfo Escobedo, ASU, US

1 - Co-optimizing Energy and Ancillary Services
Speaker: Kai Pan, Hong Kong Polytechnic Univ., HK, talk 65
Co-Authors: *Jianqiu Huang*, *Yongpei Guan*,
With significant economical and environmental benefits, renewable energy is playing a crucial role in the international electricity markets. To maintain reliability and efficiency, both the power grid and its operations are extensively changed by renewable energy. Besides traditional energy markets designed to balance the electricity supply and demand, ancillary services markets were recently introduced to help manage the significant uncertainty due to the increasing penetration of renewable energy. In this paper, we investigate the co-optimization of energy and ancillary services markets, which can be formulated via mixed-integer linear programming, from two perspectives. We first assess the valuation of different ancillary service requirements to show the importance, cost-effectiveness, and specific levels of ancillary services in an electrical power system. Next, due to the computational challenge of co-optimizing the energy and ancillary services markets, we analyze the polyhedral structure of the co-optimization model to speed up the solution process. In particular, convex hull results for certain special cases with rigorous proofs are provided, from which strong valid inequalities for the most general cases are derived. Finally, we perform numerical studies to apply our derived inequalities as cutting planes in the branch-and-cut algorithm. Significant improvement from our inequalities over commercial solvers demonstrates the tremendous effectiveness of our approach.
2 - Stochastic Framework for Coordinated Operation of Multiple Microgrids
Speaker: Harsha Gangammanavar, Southern Methodist University, US, talk 922
In this talk we present a stochastic programming framework

to study power systems comprising of a centralized grid connected to multiple microgrids. The microgrids are equipped to control their local generation and demand in the presence of uncertain renewable generation and disparate energy management systems. We consider different operational modes for microgrids including (a) completely decomposable - microgrids interact only with the central grid, and (b) partially decomposable - microgrids also interact with one another through capacitated interconnect links. The model is an extension of the classical two-stage stochastic program where the central grid occupies the role of the master, and the microgrids' energy management system optimization problems form the subproblems. We propose a sequential sampling-based optimization algorithm to tackle this framework. Our computational experiments, conducted on the US western interconnect (WECC-240) data set, illustrates that our approach can be used as a systematic optimization-simulation tool to gauge (a) the impact of energy management settings in efficiently utilizing renewable generation and (b) the role of flexible demands in reducing system costs.

3 - Generation of Angular Valid Inequalities for Transmission Expansion Planning

Speaker: Adolfo Escobedo, ASU, US, talk 58

Co-Authors: *Laura Escobar V.*, *J. Kyle Skolfield*,

In order to meet the rising demand for electricity under limited infrastructure budgets, it is necessary to determine the best transmission expansion planning (TEP) strategies from a large number of possible investment combinations. This problem can be modeled as a large-scale mixed integer program, whose solution is generally intractable due to the high number of discrete decision variables usually involved. To increase the efficiency of the solution process, we derive and formally prove the validity of a class of angular valid inequalities (AVIs), which exploit structural insights from DCOPF-based formulations. These valid inequalities are incorporated as cutting planes within the root node of the branch-and-bound tree to tighten the feasible region of the linear relaxation. To select the most effective AVIs, we also design a data-driven scheme guided by the solutions to multiple relaxation models. The effectiveness of this scheme for solving the TEP problem is tested computationally via various benchmark instances.

First order methods

Continuous Optimization

NLP - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 27

Organizer: Gerardo Toraldo, Uni. Naples Federico II, IT

1 - Variable metric techniques for the inexact inertial forward-backward algorithm

Speaker: Simone Rebegoldi, Università di Ferrara, IT, talk 392

Co-Authors: *Silvia Bonettini*, *Valeria Ruggiero*,

One of the most popular approaches for the minimization of a convex functional given by the sum of a differentiable term and a nondifferentiable one is the forward-backward method with extrapolation. The main reason making this method very appealing for a wide range of applications is that it achieves a $O(1/k^2)$ convergence rate in the objective function values, which is optimal for a first order method. More recently, the convergence of the iterates to a minimizer and an improved $o(1/k^2)$ convergence rate have also been established. In this talk, we propose a scaled inexact version of the algorithm in which both a variable metric and an inexactness criterion are allowed in the backward step. In particular, we devise implementable conditions on both the accuracy of the inexact backward step computation and the variable metric selection, so that the $o(1/k^2)$ rate and the convergence of the iterates are preserved. The effectiveness of the proposed approach is then validated with a numerical experience on an image restoration problem, showing the effects of the combination of inexactness with variable metric techniques.

2 - Combining IRN and gradient methods for TV-based Poisson image restoration

Speaker: Daniela di Serafino, Univ. Campania L. Vanvitelli, IT, talk 401

Co-Authors: *Germana Landi*, *Marco Viola*,

We focus on nonlinear optimization problems where the objective function is the Kullback-Leibler (KL) divergence plus a Total Variation (TV) term; non-negativity constraints and single linear constraint are imposed. These problem arise, e.g., in image processing, when the restoration of images corrupted by Poisson noise is modelled. We propose an algorithm where a sequence of quadratic programming problems approximating the original problem is solved by a gradient projection method. A classical quadratic model is used for the KL divergence, while an Iterative Reweighted Norm (IRN) approach is used to approximate the TV. Numerical experiments showing the effectiveness of this algorithm are presented. A convergence proof is also provided.

3 - An Active Set Algorithm for Polyhedral Constrained Optimization

Speaker: William Hager, University of Florida, US, talk 390

Co-Authors: *Hongchao Zhang*, *James Diffenderfer*,

An implementation of an active set technique for solving sparse polyhedral constrained optimization problems is developed. The algorithm exploits both gradient and conjugate gradient-based schemes, fast projection techniques, and fast techniques for updating a sparse Cholesky factorization.

4 - A line-search based proximal gradient method for (non-)convex optimization

Speaker: Ignace Loris, Université libre de Bruxelles, BE, talk 419

An iterative algorithm for the solution of convex and non-convex optimization problems is presented. The cost function is assumed to be the sum of a differentiable (possibly non-convex) part and a convex (possibly non-differentiable) part. The proposed algorithm is based on an Armijo line-search rule and uses the gradient of the smooth part and an approximation of the proximal operator of the non-smooth part. Verifiable criteria for the inexact computation of the proximal operator are given in some cases of practical interest. In general we prove that all limit points of the iterates are stationary, while in the special case of a convex objective function we prove the convergence of the whole sequence to a minimizer. In the non-convex case, we also show convergence if the objective function satisfies the Kurdyka- Lojasiewicz property at each point of its domain. The algorithm is applied to a wide range of image reconstruction problems. This presentation is based on joint work with S. Bonettini, F. Porta, M. Prato and S. Rebegoldi.

Challenging applications in DFO

CONTINUOUS OPTIMIZATION
DERFREE - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 21 Building: G, Intermediate, Zone: 6

CONTRIBUTED SESSION 38
Chair: Francesco Rinaldi, University of Padova, IT

1 - Global Direct Search and an application to Additive Manufacturing (3D Printing)
Speaker: A Ismael Vaz, University of Minho, PT, talk 473
Co-Authors: *Luis Nunes Vicente*,
We have developed a new method for unconstrained and linearly constrained global optimization when derivatives of the objective function are unavailable or are difficult to obtain. The goal is to derive a fully parallelizable method for the efficient and accurate solution of large-scale problems. The methodology is based on multistarting probabilistic direct search, a technique for optimizing without derivatives in the context of local optimization. The initial multistarted set of runs can be split or merged based on the previously evaluated points, either according to their space clusterization (with no use of their function values) or according to the solution of appropriate nonconvex model subproblems (now using their function values). We provide numerical results on a large set of nonconvex unconstrained and bound-constrained problems. We will describe the application of our global solver to the optimization of object orientation in additive manufacturing (3D printing), in the context of an applied industrial project.

2 - Derivative-free methods for complex black-box problems
Speaker: Stefano Lucidi, DIAG Sapienza Univ. of Rome, IT, talk 970
Co-Authors: *Giampaolo Liuzzi*, *Andrea Credo*, *Francesco Rinaldi*, *Marco Villani*,
In this talk, we propose a derivative free algorithm for a class of difficult black box optimization problems in optimal design. Simulation codes are usually considered when describing both objective functions and constraints in those problems. Furthermore, variables often need to satisfy some additional linear relations. Other distinguishing features of the problems are: - presence of discrete variables due to technological limits; - different variable effects on the physics of the design. After having described the algorithm and its theoretical properties, we report the numerical results obtained when tackling some optimal design problems of electric motors.

3 - Parallel Hybrid Multiobjective Derivative-Free Optimization for Machine Learning
Speaker: Steven Gardner, SAS Institute, Inc., US, talk 1084
Co-Authors: *Joshua Griffin*, *Oleg Golovidov*, *Patrick Koch*, *Scott Pope*,
With the exponential growth rate of digital data, the challenge of managing, understanding, and capitalizing on this data continues to grow. Machine learning modeling algorithms are commonly used to find hidden value in big data. These algorithms are governed by hyperparameters with no clear defaults agreeable to a wide range of applications. Ideal settings for these hyperparameters significantly influence the resulting accuracy of the predictive models. In this talk we discuss the use of multiobjective derivative-free optimization for automated hyperparameter tuning. We present our Local Search Optimization framework which implements a parallel hybrid derivative-free optimization strategy for multiobjective problems with functions that are nonsmooth, discontinuous, or computationally expensive to evaluate directly. In our multiobjective tuner, we trade-off model error and model complexity, providing users with an approximate Pareto-optimal set of nondominated solutions. We will present tuning results for multiple examples.

4 - Robust multi-objective optimization: Application to the recycling of plastics
Speaker: Lukas Adam, SUSTECH, CN, talk 1207
Co-Authors: *Frantisek Mach*,
Due to their excellent properties such as low cost or high durability, the production of plastics showed a remarkable growth in the past several decades. As plastics contain plenty of toxic materials, there is a need for their proper disposal. Since both landfilling and incineration are unsustainable in the long run, efficient recycling methods are needed. Due to different physical properties of plastics, a necessary step prior to the recycling is their separation. One of the major methods is the electrostatic separation where a mixture of plastics is crushed into small particles. These are triboelectrically charged and subsequently exposed to an electric field. Due to opposite polarities of the particles, the plastics mixture is separated and then may be recycled. In this talk, we are interested in the optimal design of the free-fall electrostatic separator. We describe it via a rigorous mathematical model and argue for the need of multiple objectives. We concentrate on the ways in which stochasticity enters the model, namely particle-to-particle interactions and noisy objectives. Due to the complexity of the model, we solve it via evolutionary algorithms. We propose a method which on one hand, is computationally feasible and on the other hand, is able to handle the stochastic nature of the problem.

Stochastic and Nonlinear Optimization II

CONTINUOUS OPTIMIZATION
NLP - Fr 8:30am-10:30am, Format: 4x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8

INVITED SESSION 48
Organizer: Jorge Nocedal, Northwestern University, US

1 - "Active-set complexity" of proximal-gradient: How long does it take to find the
Speaker: Mark Schmidt, UBC, CA, talk 482
Proximal gradient methods have been found to be highly effective for solving minimization problems with non-negative constraints or L1-regularization. Under suitable non-degeneracy conditions, it is known that these algorithms identify the optimal sparsity pattern for these types of problems in a finite number of iterations. However, it is not known how many iterations this may take. We introduce the notion of the “active-set complexity”, which in these cases is the number of iterations before an algorithm is guaranteed to have identified the final sparsity pattern. We further give a bound on the active-set complexity of proximal gradient methods in

the common case of minimizing the sum of a strongly-convex smooth function and a separable convex non-smooth function.

2 - A Positive Outlook on Negative Curvature
Speaker: Daniel Robinson, Johns Hopkins University, US, talk 804
Co-Authors: *Frank Curtis*, *Zachary Lubberts*,
The recent surge in interest in nonconvex models (e.g., in deep learning, subspace clustering, and dictionary learning) emphasizes a need for a fresh look at nonconvex optimization algorithms with provable convergence guarantees. A major factor in the design of such methods is the manner in which negative curvature is handled. In this talk, I present recent work that supports the following claims: (i) Commonly employed strategies for using negative curvature directions usually hurt algorithm performance; (ii) A new strategy based on upper-bounding models allows directions of negative curvature to be used while improving performance; and (iii) This strategy of using upper-bounding models is readily adapted for stochastic optimization, thus making it an attractive approach for large-scale “big data" problems. The talk also touches on worst-case complexity bounds and the pitfalls of attempting to associate such bounds with practical performance.

3 - Derivative-Free Optimization of Noisy Functions via Quasi-Newton Methods
Speaker: Albert Berahas, Northwestern University, US, talk 561
Co-Authors: *Jorge Nocedal*, *Richard Byrd*,
We present a finite difference quasi-Newton method for the minimization of noisy functions. The method takes advantage of the scalability and power of BFGS updating, and employs an adaptive procedure for choosing the differencing interval at every iteration, based on an estimate of the noise. The noise estimation procedure is inexpensive but not always accurate, and to prevent failures the algorithm incorporates a recovery mechanism that takes appropriate action in the case when the line search procedure is unable to produce an acceptable point. A novel convergence analysis is presented that considers the effect of a (noisy) line search routine. We report results of numerical experiments comparing the method to a popular model based trust region method.

4 - Randomized Primal-Dual Algorithms for Asynchronous Distributed Optimization
Speaker: Lin Xiao, Microsoft Research, US, talk 472
Co-Authors: *Wei Yu*, *Qihang Lin*,
Machine learning with big data often involves large optimization models. For distributed optimization over a cluster of machines, frequent communication and synchronization of all model parameters (optimization variables) can be very costly. A promising solution is to use parameter servers to store different subsets of the model parameters, and update them asynchronously at different machines using local datasets. In this paper, we focus on distributed optimization of large linear models with convex loss functions, and propose a family of randomized primal-dual block coordinate algorithms that are especially suitable for asynchronous distributed implementation with parameter servers. In particular, we work with the saddle-point formulation of such problems which allows simultaneous data and model partitioning, and exploit its structure by doubly stochastic coordinate optimization with variance reduction (DSCOVR). Compared with other first-order distributed algorithms, we show that DSCOVR may require less amount of overall computation and communication, and less or no synchronization. We discuss the implementation details of the DSCOVR algorithms, and present numerical experiments on an industrial distributed computing system.

Matching and scheduling

Discrete Optimization & Integer Programming
COMB - Fr 8:30am-10:30am, Format: 4x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2
Invited Session 54
Organizer: Seffi Naor, Technion, IL

1 - Online Matching in Regular Graphs (and Beyond)
Speaker: David Wajc, CMU, US, talk 433
Co-Authors: *Ilan Cohen*, *Seffi Naor*,
In this talk I will review two recent papers which study online matching and its generalizations under structural assumptions, focussing on online matching in the well-studied class of d-regular graphs (i.e., graphs with all vertices of degree exactly d). In the first paper, "Near-Optimum Online Ad Allocation for Targeted Advertising" (EC'15, joint with Seffi Naor), we showed that the optimal competitive ratio for deterministic algorithms on d-regular graphs is $1-(1-1/d)^d$; i.e., better than the worst-case optimal ratio of $1-1/e \approx 0.632$, but tending to this ratio from above as d increases. Thus, the problem is inherently harder for deterministic algorithms as d grows. In the second paper, "Randomized Online Matching in Regular Graphs" (SODA'18, joint with Ilan Reuven Cohen), we presented a randomized algorithm with nearly-optimal competitive ratio of roughly $1-\Theta(1/\sqrt{d})$, showing that for randomized algorithms the problem becomes <i>easier</i> as d increases, and in particular has optimal competitive ratio tending to <i>one</i>.

2 - Coflow Scheduling and beyond
Speaker: Samir Khuller, U. Maryland, US, talk 649
Applications designed for data-parallel computation frameworks such as MapReduce usually alternate between computation and communication stages. Coflow scheduling is a popular networking abstraction introduced to capture such application-level communication patterns in datacenters. In this framework, a datacenter is modeled as a single non-blocking switch with m input ports and m output ports. A coflow is a collection of flow demands that is said to be complete once all of its requisite flows have been scheduled. We consider the offline coflow scheduling problem with and without release times to minimize the total weighted completion time. Coflow scheduling generalizes the well studied concurrent open shop scheduling problem and is thus NP-hard. We develop a combinatorial primal dual approximation algorithm for coflow scheduling giving a factor 4 approximation. We give a survey of recent results on Coflow scheduling and also some recent directions. This is joint work with Saba Ahmadi, Manish Purohit and Sheng Yang.

3 - Best of Two Local Models: Centralized local and Distributed local Algorithms
Speaker: Guy Even, Tel-Aviv Univ., IL, talk 476
Co-Authors: *Moti Medina*, *Dana Ron*,
We consider two models of computation: centralized local algorithms and local distributed algorithms. Algorithms in one model are adapted to the other model to obtain improved

algorithms. Distributed vertex coloring is employed to design improved centralized local algorithms for: maximal independent set, maximal matching, and an approximation scheme for maximum (weighted) matching over bounded degree graphs. The improvement is threefold: the algorithms are deterministic, stateless, and the number of probes grows polynomially in $\log^* n$, where n is the number of vertices of the input graph. The recursive centralized local improvement technique by Nguyen and Onak (2008) is employed to obtain a distributed approximation scheme for maximum (weighted) matching.

4 - Competitive Algorithms for Online Multi-level Aggregation

Speaker: Seffi Naor, Technion, IL, talk 436

Co-Authors: *Niv Buchbinder*, *Moran Feldman*, *Ohad Talmon*,

Consider the multi-level aggregation problem in a weighted rooted tree. In this problem, requests arrive over time at the nodes of the tree. where each request specifies a deadline. A request needs to be served by sending it to the root before its deadline at a cost equal to the weight of the path from its node to the root. However, requests from different nodes can also be aggregated and served together so as to save on cost. The cost of serving an aggregated set of requests is equal to the weight of the subtree spanning the nodes containing the requests. Thus, the problem is to find a good online aggregation scheme that minimizes the total cost of the aggregated requests. The problem arises naturally in many scenarios, including multicasting, supply-chain management, and sensor networks. It is also related to the well-studied TCP-acknowledgement problem, and the online joint replenishment problem. We present an algorithm for the problem with competitive factor linear in the depth of the aggregation tree. This result significantly improves upon the competitive algorithm recently obtained (Bienkowski et al) which is exponential in the depth. We extend our competitive bounds for the version where instead of deadlines the goal is to minimize the sum of delays incurred by the requests, or more generally any non-decreasing function of the delays.

Regularization and Iterative Methods in Large-Scale Optimization

Continuous Optimization

NLP - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle KC7 Building: K, Intermediate 2, Zone: 10

Invited Session 59

Organizer: Jacek Gondzio, University of Edinburgh, GB

1 - Local analysis of a regularized primal-dual algorithm for NLP without SOSC

Speaker: Paul Armand, University of Limoges, FR, talk 611

Co-Authors: *Ngoc Nguyen Tran*,

In nonlinear optimization, the lack of the second order sufficient conditions (SOSC) at a local minimum may lead to numerical difficulties and in particular to slow down the convergence of an optimization algorithm. In this talk, we propose a regularized primal-dual algorithm for solving a bound constrained optimization problem. The regularization is based on the proximal point method, which is suitable for degenerate problems with non-strict local minimizers. This regularization technique is well known and frequently used in unconstrained optimization. Here we propose to extend and to analyse this technique within the framework of an optimization problem with bound constraints. The SOSC are replaced by a weaker assumption which uses a local error bound condition. We provide updating formula for the regularization parameter and prove that our algorithm is superlinearly convergent. Some numerical examples are presented to illustrate the behavior of the algorithm.

2 - Implementing a smooth exact penalty function for nonlinear optimization

Speaker: Dominique Orban, GERAD and Ecole Polytechnique, CA, talk 1308

Co-Authors: *Ron Estrin*, *Michael Saunders*, *Michael Friedlander*,

We describe the properties of a smooth exact merit function first proposed by Fletcher (1970), and the details of our own implementation. Regularization provides robustness towards the solution of degenerate problems. We cover extensions that can handle inequality constraints, and preliminary numerical results on academic and PDE-constrained problems. A special feature of our implementation is the ability to evaluate inexact first and second derivatives of the merit function while preserving global convergence.

3 - Dynamic primal-dual regularization in interior point methods

Speaker: Spyridon Pougkakiotis, University of Edinburgh, GB, talk 410

Co-Authors: *Jacek Gondzio*,

Interior point methods (IPMs) for linear and quadratic programming problems need to solve a large saddle point system at each iteration. Such systems are inherently ill-conditioned as the method approaches optimality. Moreover, they sometimes involve rank deficient matrices which further complicates the task. The problem is often addressed by employing a (small) regularization; its addition does not alter the linear system too much, but it improves its spectral properties. The choice of best regularization remains a challenge. In this talk we propose a regularization which acts in primal and dual spaces and dynamically chooses the right level of perturbation. Its ultimate objective is to deliver better conditioning in the KKT systems and allow for their solution with a preconditioned Krylov subspace method. We analyse the spectral properties of the regularized system, design an appropriate preconditioner for it and study the impact of inexactness introduced by the iterative method on the behaviour of interior point method. The new techniques have been implemented. Computational experience of applying it to real-life optimization problems is reported.

4 - Stabilized Optimization via an NCL Algorithm

Speaker: Michael Saunders, Stanford University, US, talk 605

Co-Authors: *Ding Ma*, *Dominique Orban*, *Kenneth Judd*,

Constrained optimization problems may have LICQ difficulties, especially if they have millions of nonlinear inequality constraints. We present Algorithm NCL as a new implementation of LANCELOT (whose BCL algorithm solves a sequence of bound-constrained augmented Lagrangian subproblems). The NCL subproblems have the same constraints as the original problem, regularized by extra variables r. Interior methods like IPOPT and KNITRO can solve the regularized subproblems efficiently (including warm starts). Algorithm NCL drives r to zero in about 10 major iterations independent of problem size. We illustrate with Taxation Policy problems modeled in AMPL.

Data-Driven Revenue Management with Customer Choice

Discrete Optimization & Integer Programming
APPROX - Fr 8:30am-10:30am, Format: 4x30 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 81
Organizer: Jacob Feldman, Washington University, US

1 - Constrained Assortment Optimization under the Markov Chain based Choice Model
Speaker: Antoine Desir, Google Inc., US, talk 8
Co-Authors: *Vineet Goyal*, *Danny Segev*, *Chun Ye*,
Assortment optimization is an important problem that arises in many practical applications such as retailing and online advertising. One of the key operational decision faced by a retailer is to select a subset of items to offer from a universe of substitutable items, that maximizes the expected revenue. The demand of any item depends on the set of offered items due to substitution behavior of consumers. For a given substitution behavior of consumers, the goal in the assortment optimization problem is to find a subset of items that maximizing the total expected revenue.In this paper, we consider the capacity constrained version of the assortment optimization problem under the Markov Chain model proposed by Blanchet, Gallego and Goyal (2016). Each item has a weight, and we want to select a revenue maximizing subset of items with total weight or capacity at most a given bound. We show that the capacitated assortment optimization is hard to approximate within better than a constant unless P=NP. Surprisingly, this is true even for the special case where the constraint is a cardinality constraint and all the revenues are equal. We present a constant factor approximation for the capacitated assortment problem under the Markov Chain model. Our algorithm is a greedy algorithm based on local ratio type updates. Those new ideas also provide new insights for the unconstrained problem.

2 - Near-Optimal Approximations for Dynamic Assortment Planning under the MNL Model
Speaker: Danny Segev, University of Haifa, IL, talk 656
Co-Authors: *Ali Aouad*,
We study the joint assortment planning and inventory management problem, where stock-out events elicit dynamic substitution effects, described by the Multinomial Logit (MNL) choice model. Up until the recent work of Aouad, Levi, and Segev (Operations Research, forthcoming), where a constant-factor approximation is proposed for demand distributions with an increasing failure rate, this problem was not known to admit efficient algorithms with analytical performance guarantees, and most of its computational aspects still remain wide open. Our main contribution is to show that MNL-based dynamic assortment planning admits a polynomial-time approximation scheme, for any demand distribution. This two-fold improvement is attained subject to a realistic assumption, asking the preference weights of all products to be within an O(1)-factor of each other. Our algorithmic approach relies on understanding how the expected revenue function behaves under small perturbations to the preference weights, which enables us to employ efficient enumeration ideas.

3 - Near-Optimal Approximations for Display Optimization Under MNL Preferences
Speaker: Ali Aouad, London Business School and Uber, GB, talk 672
Co-Authors: *Danny Segev*,
We study the display optimization problem, that seeks to determine how distinct items (ads, products, etc.) are displayed to a heterogeneous audience, whose choice preferences are influenced by their relative locations. Specifically, once items are assigned to vertically differentiated locations, customers consider a subset of the items displayed in the most favorable locations, before picking one alternative through Multinomial Logit choice probabilities. The main contribution of this paper is to derive a polynomial-time approximation scheme for the display optimization problem. Our algorithm is based on an approximate dynamic programming formulation that exploits various structural properties to derive a compact state space representation of provably near-optimal assignment decisions. These properties include unimodality of the expected revenue function, precedence order across subsets of items and parametric rounding techniques. As a by-product, our results improve on existing constant-factor approximations for closely related models, and apply to general distributions over consideration sets. We also develop the notion of "approximate assortments", that may be of independent interest and applicable in additional revenue management settings. In computational experiments, our algorithm dominates various natural benchmarks and heuristics.

4 - New Results for Assortment Optimization under the Exponomial Choice Model
Speaker: Jacob Feldman, Washington University, US, talk 685
Co-Authors: *Ali Aouad*, *Danny Segev*,
We study the assortment optimization problem under a relatively new choice model known as the Exponomial choice model, which has been recently shown to have predictive power that is on par with the classic multinomial logit choice model. In the assortment problem, a retailer seeks the revenue-maximizing set of products (or assortment) to offer to arriving customers. Our main algorithmic contribution comes in the form of the first polynomial time approximation scheme with a provable guarantee for the assortment problem under the Exponomial choice model. More specifically, we provide a fully polynomial-time approximation scheme (FPTAS), which is based on a careful discretization of the state space of a novel novel dynamic programming formulation of the problem. We also present a case study on real public transit data to further validate the predictive ability of the Exponomial model, and conduct extensive computational experiments to validate the practicality of our methods.

New Developments in Optimization Modeling Software

Specific Models, Algorithms, and Software
Algo - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 22 Building: G, 2nd floor, Zone: 6

Invited Session 101
Organizer: Robert Fourer, AMPL Optimization Inc, US

1 - Enhanced Model Deployment and Solution in GAMS
Speaker: Steven Dirkse, GAMS Development, US, talk 628
The new capabilities recently added to GAMS make it easier than ever to develop, solve, and deploy models in nontraditional and powerful ways. Our cross-platform GAMS Studio provides a fresh look that will be especially welcomed by Mac users. Our embedded Python facility opens up a wealth of possibilities and makes data movement between GAMS and Python fast and painless, while providing a seamless union of Python code in a GAMS model. Finally, we have multiple ways to solve and deploy models to take advantage of parallel computing and opportunities to solve a group of similar models with only a single model generation. In this talk, we'll introduce these capabilities and demonstrate their use with a series of examples.

2 - Adding Functions to AMPL
Speaker: David Gay, AMPL Optimization Inc., US, talk 219
The AMPL modeling system for mathematical programming is demonstrably useful for dealing with a wide variety of mathematical programming problems (e.g., optimization and complementarity problems). While AMPL permits using imported functions, expressed in another language, the AMPL modeling language itself only allows stating algebraic expressions that entail finitely many operations. In some situations, functions expressed directly in AMPL would be useful. In particular, for solvers that allow callback functions (provided by the user) to affect the solver's algorithm, functions expressed directly in AMPL should be useful. This talk presents AMPL extensions that allow stating functions in AMPL, including functions that return tuples of values.

3 - Optimization Modeling in MATLAB
Speaker: Paul Kerr-Delworth, MathWorks, GB, talk 73
Co-Authors: *Aurèle Turnes*, *Steve Grikschat*, *Adam Hug*, *Mary Fenelon*, *Alan Weiss*, *Penny Anderson*,
The new problem-based workflow for optimization problems has made it much easier to model and solve linear and mixed-integer linear problems in MATLAB. Optimization variables are identified and defined as the first step. Next, objectives and constraints are defined via expressions of the optimization variables. The optimization solver is then selected automatically based on the type of constraints and objective. Large and complex optimization models can be expressed compactly using MATLAB arrays to index optimization variables and expressions. We will review design considerations, including extensions of familiar MATLAB objects in our implementation, and demonstrate with examples.

4 - Efficient model generation for decomposition methods in modeling languages
Speaker: Youngdae Kim, Univ. of Wisconsin-Madison, US, talk 1487
Co-Authors: *Michael Ferris*,
We introduce our model generation procedure that enables decomposition methods, such as Dantzig-Wolfe and Benders decomposition, for optimization problems and variational inequalities to be employed within modeling languages without requiring users to implement them by hand. Given structural information about coupling constraints and variables, our procedure incrementally generates a set of submodels amenable to the decomposition. We can choose a subsolver to use for each submodel so that a highly efficient procedure, possibly with parallel computations, can be employed tailored to a certain problem type. We especially focus on performance of submodel generation, and an efficient procedure is developed that avoids a model regeneration from scratch and utilizes any previously generated models as much as possible. Experimental results comparing performances between existing approach implementing the decomposition by hand and our implementation are demonstrated. We have implemented our procedure and our implementation is available within GAMS/EMP.

Optimal Control Problems with Discrete Switches

DISCRETE OPTIMIZATION & INTEGER PROGRAMMING
MINLP - Fr 9:00am-10:30am, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

INVITED SESSION 102
Organizer: Christian Kirches, TU Braunschweig, DE

1 - An Algorithm for Model-Predictive Control of Switched Nonlinear Dynamic Systems
Speaker: Adrian Bürger, Karlsruhe UAS, DE, talk 828
Co-Authors: *Angelika Altmann-Dieses*, *Moritz Diehl*, *Clemens Zeile*, *Sebastian Sager*,
We present an algorithm for model-predictive control of switched nonlinear dynamic systems capable of solving a Mixed-Integer Non-Linear Program (MINLP) arising from the discretization of a Mixed-Integer Optimal Control Problem on a timescale suitable for applications within energy systems and process control. The algorithm relies on decomposing the MINLP into a sequence of Non-Linear Programs and a Mixed-Integer Linear Program that is a Combinatorial Integral Approximation problem and can be solved efficiently using a tailored Branch-and-Bound method. Exemplary, we apply the algorithm to a model of a solar thermal system for building climate control that includes typical constraints such as limits on the number of machine switches, machine operation conditions etc. and test it within a simulation study. To facilitate realistic settings, forecasted values for thermal load, ambient temperature and solar irradiation are used for solving the MINLP and corresponding measured values for model simulation. Results and solution times are discussed and an overview on planned future developments is given.

2 - Approximation algorithms for MIOCPs with discontinuous switch costs
Speaker: Felix Bestehorn, TU Braunschweig, DE, talk 1043
Co-Authors: *Christian Kirches*,
Mixed integer optimal control problems (MIOCPs) with discontinuous switch costs arise in the context of optimizing production. The discrete switch cost controls whether a production unit is switched on at all, while the mixed integer control problem realizes the production process itself. Ignoring part of the given information through one of the two given controls, simple relaxation, or approximation of either of the two problems can result in arbitrarily bad controls, even if only a single time slice is considered. Therefore one of the major obstacles in MIOCPs with discontinuous switch costs is the combination of solutions from two different types of algorithms, needed to solve either the continuous problem (CT) or the resulting discrete problem (DC). We discuss an iterative approach for this problem and present an algorithm

to combine discrete and continuous controls.

3 - Numerical Modeling of Switched Systems with Jumps in Optimal Control Problems

Speaker: Matthias Schloeder, IAM Heidelberg University, DE, talk 570

Co-Authors: *Ekaterina Kostina*,

This talk deals with optimal control problems, constrained by ordinary differential equations with state-dependent switches including possible jumps in the states. Our aim is to model such problems so that we could apply state-of-the-art numerical optimal control methods. We follow a framework for the numerical solution of optimal control problems with switches recently developed by Meyer et al. Their framework however does not consider jumps. To model phase-wise dynamics and phase-wise holding inequality constraints, the original problem is again replaced by a one containing discrete decision variables and vanishing constraints. But now the reformulation includes a jump condition which is not useful in practice. We discretize the problem and reformulate the jump condition in a numerically useful manner by the use of additionally introduced variables. Finally, we obtain an enlarged and relaxed problem which can be treated with methods from continuous optimization. In the next stage, we plan to apply our approach to mechanical systems to assess its efficacy.

Machine Learning in State Estimation and Situational Awareness in Power Grids

Specific Models, Algorithms, and Software

Energy - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 134

Organizer: Deepjyoti Deka, Los Alamos National Lab, US

1 - Learning with end-users in distribution grids:Topology and parameter estimation

Speaker: Deepjyoti Deka, Los Alamos National Lab, US, talk 597

Co-Authors: *Scott Backhaus*, *Deepjyoti Deka*, *Michael Chertkov*,

Efficient operation of distribution grids in the smart-grid era is hindered by the limited presence of real-time nodal and line meters. In particular, this prevents easy estimation of grid topology and associated line parameters that are necessary for control and optimization efforts in the grid. We study problems of topology and parameter estimation in the limited observability regime where measurements are restricted to only the terminal nodes of the grid and all intermediate nodes are unobserved/hidden. To this end, we propose two algorithms for exact topology (and impedances) estimation that provably reconstruct topology using voltage and injection measured only at the end-users of the distribution grid. The first algorithm requires time stamped voltage samples, statistics of nodal power injections and permissible line impedances to recover the true topology. The second and improved algorithm requires only time-stamped voltage/complex power samples to recover both the true topology and impedances without any additional input (e.g.,number of grid nodes, statistics of injections at hidden nodes,permissible line impedances). We illustrate their performance through numerical experiments on the IEEE and custom power distribution models.

2 - Online Learning of Power Transmission Dynamics

Speaker: Marc Vuffray, Los Alamos National Laboratory, US, talk 490

Co-Authors: *Andrey Lokhov*, *Dmitry Shemetov*, *Deepjyoti Deka*, *Michael Chertkov*,

We consider the problem of reconstructing the dynamic state matrix of transmission power grids from time-stamped PMU measurements in the regime of ambient fluctuations. Using a maximum likelihood based approach, we construct a family of convex estimators that adapt to the structure of the problem depending on the available prior information. The proposed method is fully data-driven and does not assume any knowledge of system parameters. It can be implemented in near real-time and requires a small amount of data. Our learning algorithms can be used for model validation and calibration, and can also be applied to related problems of system stability, detection of forced oscillations, generation re-dispatch, as well as to the estimation of the system state.

3 - Machine learning with PMU signals

Speaker: Mauro Escobar, Columbia University, US, talk 596

Co-Authors: *Daniel Bienstock*, *Michael Chertkov*, *Apurv Shukla*,

We describe a set of tools and techniques used to analyze real-time PMU signals. Our work is guided by a 28-TB data set obtained from an industrial collaborator. Our tools are used to quickly identify regime changes and abnormal data deviations. Analysis of the data further reveals interesting statistical attributes of real-world PMU signals. We use these attributes to guide a defense mechanism against sophisticated "cyber-physical" attacks on power grids, which we will further detail in the talk if time permits.

4 - Convex polytope machine approach for transient stability assessment

Speaker: Dongchan Lee, MIT, US, talk 408

Co-Authors: *Konstantin Turitsyn*, *Yury Maximov*,

The transient stability assessment remains most time-consuming process in dynamic security assessment. In order to maintain reliability, power systems need to satisfy the N-1 security criterion, which ensures that the system will remain stable after failure of any individual component. Currently, this assessment is performed once every 15 minutes after the clearance of the market. However this approach may not be appropriate for future system subject to more fluctuations of renewable generation and faster redispatch based on fast online optimization and primal-dual type automatic generation control. In this talk an alternative approach will be presented based on the application of machine learning algorithms to determination of "secure" operating region, where the system is stable even after some pre-defined set of faults. We show that convex polytope machine based algorithm may be effective for learning the convex approximations of the security sets. These convex approximations can be precomputed offline and naturally integrated with online optimization schemes discussed in academic community. Performance of the algorithm will be illustrated on standard medium-sized IEEE examples.

Stochastic Optimization and Variational Inequalites

Continuous Optimization

Variat - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 149

Organizer: Hailin Sun, NJUST, CN

1 - Behavioural Function Equilibria and Approximation Schemes in Bayesian Games

Speaker: Huifu Xu, University of Southampton, GB, talk 679

Co-Authors: *Shaoyan Guo*, *Liwei Zhang*,

Meirowitz showed existence of continuous behavioural function equilibria for Bayesian games with non-finite type and action spaces. A key condition for the proof of the existence result is equi-continuity of behavioural functions which, according to Meirowitz, is likely to fail or difficult to verify. In this paper, we advance the research by presenting some verifiable conditions for the required equi-continuity, namely some growth conditions of the expected utility functions of each player at equilibria. In the case when the growth is of second order, we demonstrate that the condition is guaranteed by strong concavity of the utility function. Moreover, by using recent research on polynomial decision rules and optimal discretization approaches in stochastic and robust optimization, we propose some approximation schemes for the Bayesian equilibrium problem: first, by restricting the behavioural functions to polynomial functions of certain order over the space of types, we demonstrate that solving a Bayesian polynomial behavioural function equilibrium is down to solving a finite dimensional stochastic equilibrium problem; second, we apply the optimal quantization method to develop an effective discretization scheme for solving the latter. Error bounds are derived for the respective approximation schemes under moderate conditions and both academic examples and numerical results are presented to explain the Bayesian equilibrium problem and their approximation schemes.

2 - Inference of two stage stochastic programs using SVI techniques

Speaker: Shu Lu, UNC-Chapel Hill, US, talk 282

Co-Authors: *Yang Yu*,

In this talk, we discuss a method to conduct statistical inference for the true optimal solution of a two-stage stochastic program, given the solution to a sample average approximation problem. Our method is based on techniques for computing confidence regions and confidence intervals for the true solution of a stochastic variational inequality.

3 - Theory and algorithms for two-stage stochastic variational inequalities

Speaker: Xiaojun Chen, Hong Kong Polytechnic Univ., HK, talk 46

The two-stage stochastic variational inequality (SVI) provides a powerful modeling paradigm for many important applications in which uncertainties and equilibrium are present. The two-stage SVI is to find a pair: here-and-now solution and wait-and-see solution. The here-and-now solution represents now-decisions, while the wait-and-see solution depends on future events described by random variables. This talk reviews new developments in theory and algorithms for two-stage SVI, including joint work with Ting-kei Pong, Alexander Shapiro, Hailin Sun, Roger Wets and Huifu Xu.

4 - Sample average approximation of two-stage stochastic generalized equation

Speaker: Hailin Sun, NJUST, CN, talk 44

Co-Authors: *Xiaojun Chen*, *Alexander Shapiro*,

A solution of two-stage stochastic generalized equations is a pair: a first stage solution which is independent of realization of the random data and a second stage solution which is a function of random variables. This paper studies convergence of the sample average approximation of two-stage stochastic nonlinear generalized equations. In particular an exponential rate of the convergence is shown by using the perturbed partial linearization of functions. Moreover, sufficient conditions for the existence, uniqueness, continuity and regularity of solutions of two-stage stochastic generalized equations are presented under an assumption of monotonicity of the involved functions. These theoretical results are given without assuming relatively complete recourse, and are illustrated by two-stage stochastic non-cooperative games of two players.

Clustering.

Discrete Optimization & Integer Programming

APPROX - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 36 Building: B, Intermediate, Zone: 4

Invited Session 155

Organizer: Zac Friggstad, University of Alberta, CA

1 - A Near-Linear Approximation Scheme for Multicuts of Embedded Graphs

Speaker: Arnaud de Mesmay, CNRS, Gipsa-lab, FR, talk 857

Co-Authors: *Vincent Cohen-Addad*, *Éric Colin de Verdière*,

For an undirected edge-weighted graph G and a set R of pairs of vertices called pairs of *terminals*, a multicut is a set of edges such that removing these edges from G disconnects each pair in R. We provide an algorithm computing a $(1+\varepsilon)$-approximation of the minimum multicut of a graph G in time $(g+t)^{(O(g+t)^3)} \cdot (1/\varepsilon)^{O(g+t)} \cdot n \log n$, where g is the genus of G and t is the number of terminals. This is tight in several aspects, as the minimum multicut problem is both APX-hard and W[1]-hard (parameterized by the number of terminals), even on planar graphs (equivalently, when $g = 0$). Our result, in the field of fixed-parameter approximation algorithms, mostly relies on concepts borrowed from computational topology of graphs on surfaces. In particular, we use and extend various recent techniques concerning homotopy, homology, and covering spaces. Interestingly, such topological techniques seem necessary even for the planar case. We also exploit classical ideas stemming from approximation schemes for planar graphs and low-dimensional geometric inputs. A key insight towards our result is a novel characterization of a minimum multicut as the union of some Steiner trees in the universal cover of the surface in which G is embedded.

2 - On local search for clustering

Speaker: Vincent Cohen-Addad, CNRS and Sorbonne Université, FR, talk 689

We review recent results on local search techniques for solving clustering problem. We will go consider the classic k-means and k-median problems and show that the classic local search algorithm with neighborhood size of poly(k) achieves a 1+1/k approximation in many practical scenarios such as bounded doubling metrics, "beyond worst-case" instances, or planar graphs. Finally, we will show how to speed-up the classic local search heuristic for bounded doubling metrics.

3 - Approximation Schemes for Clustering With Outliers
Speaker: Zac Friggstad, University of Alberta, CA, talk 1146
Co-Authors: *Kamyar Khodamoradi*, *Mohsen Rezapour*, *Mohammad Salavatipour*,
Clustering problems are well-studied in a variety of fields such as data science, operations research, and computer science. Such problems include variants of centre location problems, k-Median, and k-Means to name a few. In some cases, not all data points need to be clustered; some may be discarded for various reasons. For instance, some points may arise from noise in a data set or one might be willing to discard a certain fraction of the points to avoid incurring unnecessary overhead in the cost of a clustering solution. We study some clustering problems with outliers: Uncapaciated Facility Location (UFL) with uniform opening costs, k-Median, and k-Means. Our main focus is when the metric is a doubling metric (including fixed dimensional Euclidean metrics) or is the shortest path metrics of a graph from a minor-closed family of graphs. For Uncapacitated Facility Location with outliers on such metrics we show a simple multiswap local search heuristic yields a PTAS. With a bit more work, we extend this to bicriteria approximations for k-Median and k-Means where, for any constant $\epsilon > 0$ we can find a solution using at most $(1+\epsilon)k$ centres whose cost is at most a $(1+\epsilon)$-factor of the optimum, while still only discarding the allowed number of outliers.

4 - Dynamic Facility Location via Exponential Clocks
Speaker: Ashkan Norouzi Fard, EPFL, CH, talk 514
Co-Authors: *Ola Svensson*, *Hyung-chan An*,
The *dynamic facility location problem* is a generalization of the classic facility location problem proposed by Eisenstat, Mathieu, and Schabanel to model the dynamics of evolving social/infrastructure networks. The generalization lies in that the distance metric between clients and facilities changes over time. This leads to a trade-off between optimizing the classic objective function and the "stability" of the solution: there is a switching cost charged every time a client changes the facility to which it is connected. While the standard linear program (LP) relaxation for the classic problem naturally extends to this problem, traditional LP-rounding techniques do not, as they are often sensitive to small changes in the metric resulting in frequent switches. We present a new LP-rounding algorithm for facility location problems, which yields the first constant approximation algorithm for the dynamic facility location problem. Our algorithm installs competing exponential clocks on the clients and facilities, and connect every client by the path that repeatedly follows the smallest clock in the neighborhood. The use of exponential clocks gives rise to several properties that distinguish our approach from previous LP-roundings for facility location problems. In particular, we use *no clustering* and we allow clients to connect through paths of *arbitrary lengths*. In fact, the clustering-free nature of our algorithm is crucial for applying our LP-rounding approach to the dynamic problem.

Hybrid Algorithms and Matheuristics for VRP

Specific Models, Algorithms, and Software
Logistics - Fr 8:30am-10:30am, Format: 4x30 min
Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 181
Organizer: Thibaut Vidal, PUC-Rio, BR

1 - Heuristics for vehicle routing problems: Sequence or set optimization?
Speaker: Thibaut Vidal, PUC-Rio, BR, talk 1261
Co-Authors: *Túlio Toffolo*, *Tony Wauters*,
We investigate a structural decomposition for the capacitated vehicle routing problem (CVRP) based on vehicle-to-customer "assignment" and visits "sequencing" decision variables. We show that an heuristic search focused on assignment decisions with a systematic optimal choice of sequences (using Concorde TSP solver) during each move evaluation is promising but requires a prohibitive computational effort. We therefore focus on an intermediate search space, based on the dynamic programming procedure of Balas and Simonetti, which finds a good compromise between intensification and computational efficiency. A variety of speed-up techniques are proposed for a fast exploration: neighborhood reductions, dynamic move filters, memory structures, and concatenation techniques. Finally, a tunneling strategy is designed to reshape the search space as the algorithm progresses. The combination of these techniques within a classical local search, as well as in the unified hybrid genetic search (UHGS) leads to significant improvements of solution accuracy. New best solutions are found for surprisingly small instances with as few as 256 customers. These solutions had not been attained up to now with classic neighborhoods. Overall, this research permits to better evaluate the respective impact of sequence and assignment optimization, proposes new ways of combining the optimization of these two decision sets, and opens promising research perspectives for the CVRP and its variants.

2 - Single Liner Service Design with Speed Optimization
Speaker: Dominique Feillet, Mines Saint-Etienne and LIMOS, FR, talk 1359
Co-Authors: *Nadjib Brahimi*, *Ali Cheaitou*, *Pierre Cariou*,
In this talk, we consider the design and operation of a liner shipping service. The problem consists in selecting the ports to include in the single liner service as well as their sequence of call, the sailing speed of vessels, the number of vessels to deploy in the service as well as the amounts of cargo to load and unload in each port included in the service. The objective is to maximize profit defined as the difference between generated revenue from accepted service calls and total cost composed of fuel costs, vessel daily fixed costs, and port and canal fees. The problem is modeled as a non-linear mixed integer programming formulation. Properties were identified and used to derive an exact algorithm which provides good heuristic solution if it is stopped before termination. The algorithm finds an optimal speed for a relaxed version of the problem. The resulting problem with fixed speed speed is a MILP strengthened with valid inequalities and solved using a commercial software. The resulting solution is an upper bound on the total profit. For each route identified at this step, the best feasible solution is calculated. The algorithm iterates between these two steps and identifies the optimum, the best feasible solution, when the latter is larger than the current

upper bound. The proposed valid inequalities contributed considerably to reducing the CPU time required to solve the MILP. The exact algorithm was tested on realistic data. It finds optimal solution in less than 1 minute for small size problems and in a few hours for some large size problems.

3 - Heuristic pricing for the shortest path problem with resource constraints

Speaker: Jean Bertran Gauthier, Johannes Gutenberg University, DE, talk 1026

Co-Authors: *Stefan Irnich*,

The shortest path problem with resource constraints (SPPRC), and its many variants, is the core component for tackling rich vehicle routing problems by column generation. While elementary routes are automatically obtained with respect to any optimal solution of such problems, requesting the pricing problem to also fulfill this condition makes the latter particularly challenging to solve. Fetching elementary routes directly from the pricing problem is interesting to better steer the search for an integer solution but we now face a *NP*-hard problem. One of the most popular method, called $ng - route$, balances the exposure to non-elementary routes using a memory system that must be handled while solving the SPPRC. Since calling upon this pricing problem is ultimately only necessary to certify optimality, we study alternative heuristic interventions to find improving routes for the restricted master problem. Following the footsteps of various researchers like Desaulniers et al. (2008), we relieve the burden on the exact pricer by modifying the current solution of the restricted master problem using primal local search heuristics. Literature benchmark instances are used to expose our ideas regarding the search of negative reduced cost routes.

4 - Garbage Collection Routing With Heterogeneous Fleet

Speaker: Pedro Diniz, PUC-Rio, BR, talk 1508

Co-Authors: *Rafael Martinelli*, *Marcus Poggi*, *Augusto Baffa*, *Thibaut Vidal*,

A large garbage collection company wants to optimize its operations by minimizing the overall routing time, cost and the number of heterogeneous-capacity deployed vehicles while also subject to many constraints such as the number of shifts, number of days, travel extent and many others. Current literature on the subject proposes solutions based on reductions to known classes of Routing Problems such as CARP, CVRP and MDCARP. While these solutions reported improved results, many addressed only fleet of homogeneous vehicles or had performance limitations when applied to instances of increased size. In this study, we introduce a method that mixes feasible routes from Metaheuristics and combines them using MIP formulations in order to solve the Routing Problem while also minimizing the cost of hiring vehicles, therefore identifying the best heterogeneous fleet capacity configuration. The model also considers the vehicles individually, allowing the balance of crew overtime cost and fleet size. Results achieved from real operational data improved the capacity usage to the company target of 80

Geometry in complexity analysis of non-smooth optimization methods

Continuous Optimization

NonSmooth - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle LC4 Building: L, Intermediate 1, Zone: 9

Invited Session 199

Organizer: Jalal Fadili, Normandie Univ-ENSICAEN, FR

1 - An ODE associated to the Nesterov acceleration scheme

Speaker: Charles Dossal, INSA de Toulouse, FR, talk 1551

Co-Authors: *J-F Aujol*, *Aude Rondepierre*,

In this talk we will give some new results about the convergence rate and the convergence of the trajectory of the solutions of the ODE associated to the Nesterov acceleration scheme.

2 - Structured sparsity in inverse problems and support recovery

Speaker: Guillaume Garrigos, ENS Paris, FR, talk 202

Co-Authors: *Lorenzo Rosasco*, *Silvia Villa*,

We consider inverse problems in separable Hilbert spaces where the prior on the data is an assumption of structured sparsity. We look at a class of regularizers for which the extended support of the original data remains stable to certain perturbations, and identifiable by minimization algorithms. This is a direct consequence of a more general identification theorem, involving the mirror stratifiability of the regularizer, a notion developped recently, and based on duality arguments. As a by-product, we derive improved rates of convergence for the minimization algorithms, like a new linear rate result for the soft-thresholding algorithm in $\ell^2(N)$ with no assumptions. We then provide necessary and sufficient conditions for norm regularizers to be mirror stratifiable, and show its tight relationship with the geometry of the corresponding unit ball. We apply this characterization result to show that norm regularizers inducing group sparsity with overlap are not mirror-stratifiable. We then discuss how to adapt the notion of mirror-stratifiability to treat these regularizers.

3 - Error Bound-Based Convergence Rate Analysis of Newton-Type Methods

Speaker: Anthony So, CUHK, HK, talk 1535

Co-Authors: *Man-Chung Yue*, *Zirui Zhou*,

Recently, there has been growing interest in applying Newton-type methods to solve structured optimization problems that arise in machine learning, signal processing, and statistics. Most existing superlinear convergence analyses of these methods require certain non-degeneracy assumptions at a solution, which are typically not satisfied by contemporary applications. In this talk, we will demonstrate how certain error bound property, which has been widely used to establish the linear convergence of first-order methods, can be exploited to yield superlinear convergence guarantees for various Newton-type methods. Consequently, we show that when applied to problems such as convex regularized loss minimization and non-convex matrix recovery and phase retrieval, which are known to possess the error bound property, those Newton-type methods will enjoy a superlinear rate of convergence. We will also discuss some directions for further study.

4 - Finite Activity Identification: Geometry and Algorithms

Speaker: Jalal Fadili, Normandie Univ-ENSICAEN, FR, talk 54

Co-Authors: *Jerome Malick*, *Gabriel Peyre*,

This talk will present a set of activity identification results for a class of convex functions with a strong geometric structure, that we coin “mirror-stratifiable”. These functions are such that there is a bijection between a primal and a dual stratification of the space into partitioning sets, called strata. This pairing is crucial to track the strata that are identifiable by iterates of nonsmooth convex optimization algorithms. This class of functions encompasses all regularizers routinely used in signal and image processing, machine learning, and statistics. We show that this "mirror-stratifiable" structure enjoys nice activity identification of first-order proximal splitting-type algorithms. Existing results in the literature typically assume that, under a non-degeneracy condition, the active set associated to a minimizer is identified in finite time by optimization schemes. In contrast, our results do not require any non-degeneracy assumption: in consequence, we are able to track precisely the set of identifiable strata. We show that these results have crucial implications when solving challenging ill-posed inverse problems via regularization, a typical scenario where the non-degeneracy condition is not fulfilled. Our theoretical results are illustrated by numerical simulations.

Recent Advances in Coordinate Descent and Constrained Problems

Continuous Optimization
RandomM - Fr 9:00am-10:30am, Format: 3x30 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Invited Session 208
Organizer: Ion Necoara, Univ. Politehnica Bucharest, RO

1 - Convergence Analysis of Inexact Randomized Iterative Methods
Speaker: Nicolas Loizou, University of Edinburgh, GB, talk 835
Co-Authors: *Peter Richtarik*,
In this work we study several classes of stochastic optimization algorithms enriched with inexact updates. Among the methods studied are: stochastic gradient descent, stochastic Newton, stochastic proximal point and stochastic dual subspace ascent. This is the first time inexact variants of several of these methods are studied. We choose to perform our analysis in a setting in which all of the above methods are equivalent. Numerical experiments illustrate the benefits of our approach.

2 - A Stochastic Penalty Model for Optimization with Many Convex Constraints
Speaker: Konstantin Mishchenko, KAUST, SA, talk 1264
Co-Authors: *Peter Richtarik*, *Ion Necoara*,
We study an inexact penalty reformulation for constraint optimization where the set of interest can be represented as intersection of a big number of convex sets. In this situation, one is naturally interested in avoiding expensive computations of projection onto the whole intersection. Instead, the considered penalty model allows applying stochastic algorithms that require only one of the sets to be involved at each iteration leading to a significant speed-up in convergence time. Unlike exact penalties, the one we analyzed does not lead to absolute feasibility, but the degree of constraints violation is guaranteed to be decently small. In this talk, we will cover upper and lower bounds on solution properties as well as computational aspects of this model.

3 - Random coordinate descent methods for linearly constrained convex optimization
Speaker: Ion Necoara, Univ. Politehnica Bucharest, RO, talk 809
Co-Authors: *Martin Takac*,
In this paper we consider large-scale smooth convex optimization problems with linear coupled constraints. Since we have multiple non-separable linear constraints in the problem, we devise random coordinate descent schemes that update at least two variables at each iteration. We first investigate sufficient conditions on the choice of the coordinates over which we minimize at each iteration in order to have well-defined algorithms. Based on these conditions we develop new random coordinate descent methods for solving our linearly constrained convex problem, in particular, random coordinate gradient and accelerated coordinate gradient methods. From our knowledge, this is the first analysis of accelerated random coordinate gradient type schemes on optimization problems with non-separable linear constraints. In the smooth case, we prove for both methods (random coordinate gradient and accelerated coordinate gradient) that we obtain in expectation an ϵ-accurate solution in at most $O(1/\epsilon)$ and $O(1/\sqrt{\epsilon})$ iterations, respectively, and thus sublinear convergence rates. For strongly convex functions the new random coordinate descent methods converge linearly. We also show that the random selection of coordinates produces better results than the deterministic selection of them. In special cases where complexity bounds are known (e.g., for convex optimization problems with a single linear coupled constraint), our theory recovers the best known bounds.

Recent advances in Integer Optimization

Discrete Optimization & Integer Programming
IPtheory - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 218
Organizer: Alberto Del Pia, UW-Madison, US

1 - Computational evaluation of new MIP models for tree ensembles optimization
Speaker: Jean-Philipp Richard, UF, US, talk 1141
Co-Authors: *Bijan Taslimi*, *Jongeun Kim*, *Mohit Tawarmalani*,
Tree ensemble models are widely used to predict the value of a dependent variable as a function of independent variables. When the independent variables are controllable, the problem of optimizing the value of the dependent variable by adjusting the values of the independent variables naturally arises. MIP models have recently been proposed for such tree ensembles optimization problems. In this talk, we introduce new MIP formulations for this problem and compare their computational characteristics.

2 - Strong duality for conic mixed-integer programs
Speaker: Diego Moran, UAI, CL, talk 1195
Co-Authors: *Burak Kocuk*, *Gustavo Angulo*,
It is known that the subadditive dual of a conic mixed-integer program is a strong dual under a strict feasibility requirement. In this talk, we present alternative sufficient conditions for strong duality. In particular, we show that the subadditive dual is a strong dual if the feasible region of the continuous relaxation of the primal problem satisfies a certain property related to Dirichlet's approximation theorem. Furthermore, we give a sufficient condition for a set to satisfy this property

and use it to show that bounded convex sets, rational polyhedra and strictly convex sets are among the sets satisfying it. Finally, we present some duality results for a different primal form of the conic mixed-integer program that use the concept of generator subadditive functions introduced by Klabjan (2007).

3 - An affine bounding method for two-stage stochastic integer programs
Speaker: Gustavo Angulo, Universidad Católica, CL, talk 1051
Co-Authors: *Merve Bodur*, *Diego Moran*,
For two-stage stochastic programs with mixed-integer recourse, we propose a decomposition method akin to Benders' decomposition. To approximate the second-stage value function, we iteratively partition the first-stage feasible set with affine lower-bounding functions derived from a Lagrangian relaxation, which is shown to be exact at the vertices of each element of the partition. Preliminary computational results are also presented.

4 - Aggregation-based cutting-planes for packing and covering integer programs
Speaker: Merve Bodur, University of Toronto, CA, talk 218
Co-Authors: *Alberto Del Pia*, *Santanu Dey*, *Marco Molinaro*, *Sebastian Pokutta*,
We study the strength of Chvatal-Gomory (CG) cuts and more generally aggregation cuts for packing and covering integer programs (IPs). Aggregation cuts are obtained as follows: Given an IP formulation, we first generate a single implied inequality using aggregation of the original constraints, then obtain the integer hull of the set defined by this single inequality with variable bounds, and finally use the inequalities describing the integer hull as cutting-planes. Our first main result is to show that for packing and covering IPs, the CG and aggregation closures can be 2-approximated by simply generating the respective closures for each of the original formulation constraints, without using any aggregations. On the other hand, we use computational experiments to show that aggregation cuts can be arbitrarily stronger than cuts from individual constraints for general IPs. Finally, we examine the strength of cuts based on k different aggregation inequalities simultaneously, the so-called multi-row cuts, and show that every packing or covering IP with a large integrality gap also has a large k-aggregation closure rank. In particular, this rank is always at least of the order of the logarithm of the integrality gap.

Recent progress in graph cut problems

Discrete Optimization & Integer Programming
COMB - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 41 Building: C, 3rd floor, Zone: 1

Invited Session 244
Organizer: Karthekeyan Chandrasekaran, UIUC, US

1 - Approximation of Linear 3-Cut and related problems
Speaker: Tamás Király, Eötvös University Budapest, HU, talk 125
In the linear 3-cut problem, the input is a node-weighted directed graph and three specified terminal nodes s, r, t, and the goal is to find a minimum weight subset of non-terminal nodes whose removal ensures that s cannot reach r and t, and r cannot reach t. This problem is approximation-equivalent to the following arborescence blocking problem: given a node-weighted directed graph with a specified root node r, remove a minimum weight subset of non-root nodes such that the remaining digraph has no in-arborescence and no out-arborescence rooted at r. Linear 3-cut contains undirected 3-way node cut as a special case, and can be reduced to directed 2-way cut (bicut). Under the Unique Games Conjecture, the best approximation ratios of these problems are $4/3$ and 2, respectively. We show that the linear 3-cut problem has a $\sqrt{2}$-approximation algorithm and this is tight under UGC. The proof involves showing that, somewhat surprisingly, the integrality gap of the natural LP-relaxation is $\sqrt{2}$. We also discuss some consequences for the bicut problem. Joint work with Kristóf Bérczi, Karthekeyan Chandrasekaran, and Vivek Madan.

2 - An FPT Algorithm Beating 2-Approximation for k-Cut
Speaker: Euiwoong Lee, New York University, US, talk 170
Co-Authors: *Anupam Gupta*, *Jason Li*,
In the k-cut problem, we are given an edge-weighted graph G and an integer k, and have to remove a set of edges with minimum total weight so that G has at least k connected components. Prior work on this problem gives, for all $h \in [2, k]$, a $(2 - h/k)$-approximation algorithm for k-cut that runs in time $n^{O(h)}$. Hence to get a $(2 - \epsilon)$-approximation algorithm for some absolute constant ϵ, the best runtime using prior techniques is $n^{O(k\epsilon)}$. Moreover, it was recently shown that getting a $(2 - \epsilon)$-approximation for general k is NP-hard, assuming the Small Set Expansion Hypothesis. If we use the size of the cut as the parameter, an FPT algorithm to find the exact k-cut is known, but solving the k-cut problem exactly is $W[1]$-hard if we parameterize only by the natural parameter of k. An immediate question is: can we approximate k-cut better in FPT-time, using k as the parameter? We answer this question positively. We show that for some absolute constant $\epsilon > 0$, there exists a $(2-\epsilon)$-approximation algorithm that runs in time $2^{O(k^6)} \cdot \widetilde{O}(n^4)$. This is the first FPT algorithm that is parameterized only by k and strictly improves the 2-approximation.

3 - An Integrality Gap for the Călinescu–Karloff–Rabani Relaxation for Multiway Cut
Speaker: Yury Makarychev, TTIC, US, talk 181
Co-Authors: *Haris Angelidakis*, *Pasin Manurangsi*,
We give a new lower bound on the integrality gap for the Calinescu-Karloff-Rabani linear programming relaxation of the Minimum Multiway Cut problem. We show that the gap is at least $6/(5 + 1/(k - 1))$ for k terminals. The result improves upon a long-standing lower bound of $8/(7 + 1/(k - 1))$ by Freund and Karloff (2000). Assuming the Unique Games Conjecture, our result implies that Minimum Multiway Cut is hard to approximate within a factor of $6/(5 + 1/(k - 1)) - \varepsilon$ for every $\varepsilon > 0$.

4 - Hypergraph k-cut in randomized polynomial time
Speaker: Karthekeyan Chandrasekaran, UIUC, US, talk 196
Co-Authors: *Chao Xu*, *Xilin Yu*,
In the hypergraph k-cut problem, the input is a hypergraph and a constant k and the goal is to find a smallest subset of hyperedges whose removal ensures that the remaining hypergraph has at least k connected components. The graph k-cut problem is solvable efficiently (Goldschmidt and Hochbaum, 1994) while the complexity of the hypergraph k-cut problem

is open. In this talk, I will present a randomized polynomial-time algorithm to solve the hypergraph k-cut problem.

Theoreticals and practicals aspects of decomposition algorithms for multi-stage stochastic problems: 3

Optimization under Uncertainty
Stoch - Fr 8:30am-10:30am, Format: 4x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 245
Organizer: Vincent Leclère, ENPC, FR

1 - Distributionally Robust Dual Dynamic Programming
Speaker: David Morton, Northwestern University, US, talk 435
Co-Authors: *Daniel Duque*,
We consider a multi-stage stochastic linear program that lends itself to solution by stochastic dual dynamic programming (SDDP). In this context, we consider a distributionally robust variant of the model, inspired by work of Philpott, de Matos, and Kapelevich (2017). The specific realizations in each stage are fixed, and distributional robustness is with respect to the probability mass function governing those realizations. We describe a computationally tractable variant of SDDP to handle this model.

2 - Stochastic dual dynamic integer programming
Speaker: Andy Sun, Georgia Institute of Technolog, US, talk 943
Co-Authors: *Shabbir Ahmed*, *Jikai Zou*,
Multistage stochastic integer programming (MSIP) combines the difficulty of uncertainty, dynamics, and non-convexity, and constitutes a class of extremely challenging problems. A common formulation for these problems is a dynamic programming formulation involving nested cost-to-go functions. In the linear setting, the cost-to-go functions are convex polyhedral, and decomposition algorithms, such as nested Benders' decomposition and its stochastic variant, stochastic dual dynamic programming (SDDP), which proceed by iteratively approximating these functions by cuts or linear inequalities, have been established as effective approaches. However, it is difficult to directly adapt these algorithms to MSIP due to the nonconvexity of integer programming value functions. In this paper we propose an extension to SDDP – called stochastic dual dynamic integer programming (SDDiP) – for solving MSIP problems with binary state variables. The crucial component of the algorithm is a new reformulation of the subproblems in each stage and a new class of cuts, termed Lagrangian cuts, derived from a Lagrangian relaxation of a specific reformulation of the subproblems in each stage, where local copies of state variables are introduced. We show that the Lagrangian cuts satisfy a tightness condition and provide a rigorous proof of the finite convergence of SDDiP with probability one. Extensive computational experiments show that the proposed methodology is very effective in solving large-scale multistage stochastic integer optimization problems.

3 - A deterministic algorithm for solving stochastic minimax dynamic programmes
Speaker: Regan Baucke, University of Auckland, NZ, talk 900
Co-Authors: *Anthony Downward*, *Golbon Zakeri*,
In this talk, we will present an algorithm for solving stochastic minimax dynamic programmes where state and action sets are convex and compact. A feature of the formulations we will discuss is the simultaneous non- rectangularity of both 'min' and 'max' feasibility sets. We begin by presenting convex programming upper and lower bound representations of saddle functions – extending outer representations from traditional convex cutting plane algorithms. Our algorithm is similar in spirit to existing stochastic dual dynamic programming (SDDP) type algorithms; bounding functions are iteratively updated in order to compute cost-to-go functions. However, special consideration must be taken in ensuring the validity of the cost-to-go bounding functions (now saddle functions) over the domain. Another feature of our algorithm is the ability to achieve deterministic convergence, even in the case where our formulation is stochastic. This is achieved by making use of the both the lower and upper bounds, and during the sampling phase of our procedure, choosing the next realisation of data that gives the greatest bound closure for the given state.

4 - Exact converging bounds for Stochastic Dual Dynamic Programming
Speaker: Vincent Leclère, ENPC, FR, talk 349
Co-Authors: *François Pacaud*, *Arnaud Lenoir*, *Jean-Philipp Chancelier*, *Carpentier Pierre*,
The Stochastic Dual Dynamic Programming (SDDP) algorithm has become one of the main tools to address convex multistage stochastic optimal control problem. Recently a large amount of work has been devoted to improve the convergence speed of the algorithm through cut-selection and regularization, or to extend the field of applications to non-linear, integer or risk-averse problems. However one of the main downsides of the algorithm remains the difficulty to give an upper bound of the optimal value, usually estimated through Monte Carlo methods and therefore difficult to use in the algorithm stopping criterion. We present a dual SDDP algorithm, based on Fenchel conjugacy, that yields a converging exact upper bound for the optimal value of the optimization problem. Incidentally we show how to compute an alternative control policy based on an inner approximation of Bellman value functions instead of the outer approximation given by the standard SDDP algorithm. We illustrate the efficiency of the approach on an energy production problem.

Algorithmic aspects of connectivity in network design

Discrete Optimization & Integer Programming
COMB - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Invited Session 264
Organizer: Neil Olver, Vrije Universiteit Amsterdam, NL

1 - Beyond Metric Embedding: Approximating Group Steiner on Bounded Treewidth Graphs
Speaker: Bundit Laekhanukit, MPI-INF, DE, talk 190
Co-Authors: *Syamantac Das*, *Daniel Vaz*, *Parinya Chalermsook*,

The Group Steiner Tree (GST) problem is a classical problem in combinatorial optimization and theoretical computer science. In the Edge-Weighted Group Steiner Tree (EW-GST) problem, we are given an undirected graph $G = (V, E)$ on n vertices with edge costs $c : E \to \mathbb{R}_{\geq 0}$, a source vertex s and a collection of subsets of vertices, called groups, $S_1, \ldots, S_k \subseteq V$. The goal is to find a minimum-cost tree $H \subseteq G$ that connects s to some vertex from each group S_i, for all $i = 1, 2, \ldots, k$. The Node-Weighted Group Steiner Tree (NW-GST) problem has the same setting, but the costs are associated with nodes. The goal is to find a minimum-cost node set $X \subseteq V$ such that $G[X]$ connects every group to the source. In this talk, we present $O(\log n \cdot \log k)$ approximation algorithms that run in time $n^{O(w \log w)}$ for both NW-GST and EW-GST, where w denotes the treewidth of an input graph G. The key to both results is tree-embedding that is different from the standard metric-tree embedding. It produces a tree of much bigger size but does not cause any loss in the approximation factor. Our embedding is obtained by embedding (discrete) dynamic program table into a tree. We remark that GST is NP-hard on trees, and our results cannot be obtained via a metric-tree embedding because even embedding a graph of treewidth 2 to a tree incurs a factor $\Omega(\log n)$ loss in the approximation ratio. This is a joint work with Parinya Chalermsook, Syamantac Das and Daniel Vaz based on the paper published in SODA'201

2 - Approximating Node-Weighted k-MST on Planar Graphs

Speaker: Mateusz Lewandowski, University of Wroclaw, PL, talk 189

Co-Authors: *Jaroslaw Byrka*, *Joachim Spoerhase*,

We study the problem of finding a minimum weight connected subgraph spanning at least k vertices on planar, node-weighted graphs. We give a $(4 + \epsilon)$-approximation algorithm for this problem. We achieve this by utilizing the recent LMP primal-dual 3-approximation for the node-weighted prize-collecting Steiner tree problem by Byrka et al (SWAT'16) and adopting an approach by Chudak et al. (Math. Prog. '04) regarding Lagrangian relaxation for the edge- weighted variant. In particular, we improve the procedure of picking additional vertices (tree merging procedure) given by Sadeghian (2013) by taking a constant number of recursive steps and utilizing the limited guessing procedure of Arora and Karakostas (Math. Prog. '06). More generally, our approach readily gives a $(4/3 \cdot r + \epsilon)$-approximation on any graph class where the algorithm of Byrka et al. for the prize-collecting version gives an r-approximation. We argue that this can be interpreted as a generalization of an analogous result by Konemann et al. (Algorithmica '11) for partial cover problems. Together with a lower bound construction by Mestre (STACS'08) for partial cover this implies that our bound is essentially best possible among algorithms that utilize an LMP algorithm for the Lagrangian relaxation as a black box. In addition to that, we argue by a more involved lower bound construction that even using the LMP algorithm by Byrka et al. in a non-black-box fashion could not beat the factor $4/3 \cdot r$ when the tree merging step relies only on the solutions output by the LMP algorithm.

3 - Improved Algorithms for MST and Metric-TSP Interdiction

Speaker: Andre Linhares, University of Waterloo, CA, talk 206

Co-Authors: *Chaitanya Swamy*,

We consider the MST-interdiction problem: given a multigraph $G = (V, E)$, edge weights $\{w_e \geq 0\}_{e \in E}$, interdiction costs $\{c_e \geq 0\}_{e \in E}$, and an interdiction budget $B \geq 0$, the goal is to remove a set $R \subseteq E$ of edges of total interdiction cost at most B so as to maximize the w-weight of an MST of $G - R := (V, E \setminus R)$. Our main result is a 4-approximation algorithm for this problem. This improves upon the previous-best 14-approximation by Zenklusen [Zen15]. Notably, our analysis is also significantly simpler and cleaner than the one in [Zen15]. Whereas [Zen15] uses a greedy algorithm with an involved analysis to extract a good interdiction set from an over-budget set, we utilize a generalization of knapsack called the tree knapsack problem that nicely captures the key combinatorial aspects of this "extraction problem." We prove a simple, yet strong, LP-relative approximation bound for tree knapsack, which leads to our improved guarantees for MST interdiction. Our algorithm and analysis are nearly tight, as we show that one cannot achieve an approximation ratio better than 3 relative to the upper bound used in our analysis (and the one in [Zen15]). Our guarantee for MST-interdiction yields an 8-approximation for metric-TSP interdiction (improving over the 28-approximation in [Zen15]). We also show that the maximum-spanning-tree interdiction problem is at least as hard to approximate as the minimization version of densest-k-subgraph.

4 - On the Integrality Gap of the Prize-Collecting Steiner Forest LP

Speaker: Kanstantsin Pashkovich, University of Waterloo, CA, talk 103

Co-Authors: *Jochen Koenemann*, *Neil Olver*, *Chaitanya Swamy*, *Ramamoorthi Ravi*, *Jens Vygen*,

In the prize-collecting Steiner forest (PCSF) problem, we are given an undirected graph $G = (V, E)$, edge costs $\{c_e \geq 0\}_{e \in E}$, terminal pairs $\{(s_i, t_i)\}_{i=1}^k$, and penalties $\{\pi_i\}_{i=1}^k$ for each terminal pair; the goal is to find a forest F to minimize $c(F) + \sum_{i:(s_i,t_i) \text{ not connected in } F} \pi_i$. The Steiner forest problem can be viewed as the special case where $\pi_i = \infty$ for all i. It was widely believed that the integrality gap of the natural (and well-studied) linear-programming (LP) relaxation for PCSF is at most 2. We dispel this belief by showing that the integrality gap of this LP is at least $9/4$. This holds even for planar graphs. We also show that using this LP, one cannot devise a Lagrangian-multiplier-preserving (LMP) algorithm with approximation guarantee better than 4. Our results thus show a separation between the integrality gaps of the LP-relaxations for prize-collecting and non-prize-collecting (i.e., standard) Steiner forest, as well as the approximation ratios achievable relative to the optimal LP solution by LMP- and non-LMP-approximation algorithms for PCSF. For the special case of prize-collecting Steiner tree (PCST), we prove that the natural LP relaxation admits basic feasible solutions with all coordinates of value at most $1/3$ and all edge variables positive. Thus, we rule out the possibility of approximating PCST with guarantee better than 3 using a direct iterative rounding method.

Mixed Integer Programming Representability

DISCRETE OPTIMIZATION & INTEGER PROGRAMMING

IPTHEORY - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 35 Building: B, Intermediate, Zone: 4

Invited Session 275
Organizer: Juan Pablo Vielma, MIT, US

1 - Mixed-integer linear representability, disjunctions, and Chvátal functions
Speaker: Chris Ryan, University of Chicago, US, talk 760
Co-Authors: *Amitabh Basu*, *Kipp Martin*, *Guanyi Wang*,
Jeroslow and Lowe give an exact geometric characterization of projections of mixed-integer linear sets, also known as MILP-representable or MILP-R sets. We give an alternate algebraic characterization by showing that a set is MILP-R if and only if it is the intersection of finitely many affine Chvátal inequalites in continuous variables (termed AC sets). Unlike the case for linear inequalities, allowing for integer variables and projection does not enhance modeling power. We show that the MILP-R sets are still precisely those sets that are modeled as affine Chvátal inequalites with integer variables. Furthermore, the projection of a set defined by affine Chvátal inequalites with integer variables is still an MILP-R set. We give a sequential variable elimination scheme that, when applied to a MILP-R sets, yields the AC set characterization. This is related to the elimination scheme of Williams and Williams-Hooker, who describe projections of integer sets using disjunctions of affine Chvátal systems. We show that disjunctions are unnecessary by showing how to find the affine Chvátal inequalities that cannot be discovered by the Williams-Hooker scheme. This answers a long-standing open question due to Ryan (1991) on designing an elimination scheme to represent finitely-generated integral monoids as a system of Chvátal inequalities without disjunctions. Finally, our work can be seen as a generalization of the approach of Blair and Jeroslow and Schrijver for constructing consistency testers for integer programs to general AC sets.

2 - A mixed-integer branching approach for very small formulations
Speaker: Joey Huchette, MIT, US, talk 781
Co-Authors: *Juan Pablo Vielma*,
Motivated by lower bounds on the number of integer variables required by traditional mixed-integer programming (MIP) formulations, we present a more general mixed-integer branching formulation framework. We generalize some of the most computationally effective formulations for piecewise linear functions and other disjunctive constraints, while maintaining favorable algorithmic properties of traditional MIP formulations: in particular, amenability to branch-and-bound and branch-and-cut algorithms. Our framework allows us to produce strong formulations for any disjunctive constraint that use only two integer variables and a linear number of constraints. We sharpen this result for univariate piecewise linear functions and annulus constraints arising in power systems and robotics, producing strong formulations that use only two integer variables and a constant (at most 6) number of general inequality constraints. Along the way, we produce strong logarithmic-sized traditional MIP formulations for the annulus constraint using our main technical result, illustrating its broader utility in the traditional MIP setting.

3 - On the Size of Integer Programs with Sparse Constraints or Bounded Coefficients
Speaker: Marc Pfetsch, TU Darmstadt, DE, talk 766
Co-Authors: *Christopher Hojny*, *Hendrik Lüthen*,
Given a set of integer points and an objective function, we consider formulations of the corresponding optimization problem as a small integer program. Since there are many such possibilities, we investigate different characteristics, including sparsity and the size of the coefficients of the formulation. For ternary coefficients, we show lower bounds on the size of integer programs for the knapsack problem. For sparse formulations, we provide a characterization of the minimal size. Furthermore, we investigate conditions for which a general objective function can be handled in a mixed integer program.

4 - Mixed-integer convex representability
Speaker: Juan Pablo Vielma, MIT, US, talk 699
Co-Authors: *Miles Lubin*, *Ilias Zadik*,
We consider the question of which nonconvex sets can be represented exactly as the feasible sets of mixed-integer convex optimization problems (MICP). We first show a complete characterization for the case when the number of possible integer assignments is finite. We then further study the characterization for the more general case of unbounded integer variables and introduce a simple necessary condition for representability. This condition can be used to show that the set of prime numbers is not MICP representable, even though it can be represented using polynomial equations and integrality constraints. While the result for the prime numbers suggests certain regularity of MICP representable sets, we show that even for subsets of the natural numbers, MICP representable sets can be significantly more irregular than rational mixed integer linear programming representable sets. Inspired by these irregular MICP representable sets we introduce a notion of rational MICP representability and show how this notion imposes regularity to MICP representable subsets of the natural numbers, for compact convex sets and the graphs and epigraphs of certain functions. Finally, we study other notions of regularity associated to infinite unions of convex sets with the same volume.

Integer Programming and Crew Scheduling

Discrete Optimization & Integer Programming
IPpractice - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Invited Session 292
Organizer: Francois Soumis, Polytechnique, CA

1 - Dynamic Constraints Aggregation for Crew Scheduling Problem
Speaker: Francois Soumis, Polytechnique, CA, talk 1173
The crew pairing problem, which forms groups of flights into pairings, is generally modeled as a set partitioning problem. A pairing is a sequence that starts at a crew base, covers a series of flights over a few days, and finishes at the same base. For large-scale problems the first difficulty is the exponential number of feasible pairings (variables), and this can be handled via column generation. However, solving a master problem of 50 000 constraints for thousands of column-generation iterations takes too much time. To reduce the solution time some airlines use a rolling-horizon (RH) heuristic that divides the overall period into overlapping time slices, e.g., slices of two days with an overlap of one day. Two-day slices lead to 30 problems of 3000 flights; this takes too long to solve and the solution quality is poor because the optimization is

too myopic (the slices are narrow). The dynamic constraint aggregation method (DCA) developed by Elhallaoui et al. (2005) speeds up the master problem by reducing the degeneracy. This method also produces better dual variables and reduces the number of column-generation iterations. Furthermore, the LP solution is less fractional, which reduces the number of nodes to explore in the branch and bound. DCA can solve a weekly problem with 14 000 flights in a few hours, and the RH heuristic with slices of a week reduces the salary cost by up to 5**2 - Integrated Crew Pairing and Personalized Crew Assignment Problems**

Speaker: Vahid Zeighami, Polytechnique Montreal, CA, talk 1575

Co-Authors: *Francois Soumis*,

The airline crew scheduling problem, because of its size and complexity, is usually solved in two phases: the crew pairing problem and the crew assignment problem. A pairing is a sequence of flights, connections, and rests starting and ending at the same crew base. The crew pairing problem consists of determining a minimum-cost set of feasible pairings such that each flight is covered exactly once. In the crew assignment problem, the goal is to construct monthly schedules from these pairings for a given set of pilots and copilots independently, while respecting all the safety and collective agreement rules. However, this sequential approach may lead to significantly suboptimal solutions since it does not take into account the crew assignment constraints and objective during the building of the pairings. In this paper, first, we propose an extension of the crew pairing problem that incorporates pilot and copilot vacation requests at the crew pairing stage. Second, we introduce a model that completely integrates the crew pairing and crew assignment problems simultaneously for pilots and copilots. To solve this integrated problem, we develop a method that combines Benders decomposition and column generation. We conduct computational experiments with real-world data from a major US carrier.

3 - Considering preferences and language skills in the airline crew pairings problem

Speaker: Frédéric Quesnel, École Polytechnique Montréal, CA, talk 1388

Co-Authors: *Francois Soumis*, *Guy Desaulniers*,

Airline crew scheduling is usually divided in two steps : the crew pairing problem (CPP) and the crew rostering problems (CRP). While the goal of the CPP is to find feasible pairings at minimum cost, the CRP aims at finding a feasible schedule that satisfy as many employee preferences as possible and respects a set of flight language constraints (some flights require cabin crew proficient in a specific language). The main challenge with this two-phase approach is that the pairings generated by the CPP are often unsuitable for the objective of the CRP. In this talk, we propose two CPP variants that tackle this issue by considering crew information at the pairing level. Both variants are solved using a column generation algorithm in which new pairings are generated by solving subproblems consisting of constrained shortest path problems. The first takes into account crew preferences by rewarding pairings that contain specific features that are beneficial for the CRP, related to those preferences. We introduce a new type of path resources designed to handle complex features and we adapt the dominance rules accordingly. The second takes into account flight languages requirements in order to group flights with similar language requirements in the same pairings. This is done by creating specialised subproblems for each language. We provide some results for real-world instances.

4 - Alternate Lagrangian Decomposition for Integrated Crew Scheduling Problem

Speaker: Mohammed Saddoune, Polytechnique Montréal, CA, talk 1555

Co-Authors: *Vahid Zeighami*,

The airline crew scheduling problem consists of determining crew schedules for airline crew members such that all the scheduled flights over a planning horizon (usually a month) are covered and the constraints are satisfied. Because of its size and complexity, this problem is usually solved sequentially in two main steps: the crew pairing and the crew assignment. This sequential approach, however, may lead to solutions that are far from global optimal as the constraints and the objective of the crew assignment are not taken into account in building the pairings. In this paper, we consider the pilot and copilot crew scheduling problems in a personalized context where each (co)pilot requests a set of preferences for specific flights (PFs) and vacations (VRs) per month. We propose an integrated crew scheduling model to generate personalized monthly schedules for pilots and copilots simultaneously in a single optimization step where we keep the pairings in the two problems as similar as possible so the propagation of the perturbations during the operation is reduced. To solve this integrated model, we develop a method that combines Lagrangian relaxation, column generation, and dynamic constraint aggregation. The solution process iterates between the integrated pilot model and the integrated copilot model by estimating the effects of decisions in the first problem on the second problem. We conduct computational experiments on a set of real instances from a major US carrier.

Graphical Optimization Model 2

Discrete Optimization & Integer Programming

CP - Fr 8:30am-10:30am, Format: 4x30 min

Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 297

Organizer: Maria Restrepo, Polytechnique Montreal, CA

1 - Recent algorithmic advances for combinatorial optimization in graphical models

Speaker: Simon de Givry, INRA, FR, talk 1524

Co-Authors: *Thomas Schiex*, *David Allouche*, *George Katsirelos*, *Abdelkader Ouali*, *Matthias Zytnicki*,

By representing the constraints and objective function in factorized form, graphical models can concisely define various NP-hard combinatorial optimization problems. They are therefore extensively used in several areas of computer science and artificial intelligence. Graphical models can be deterministic or stochastic, optimize a sum or product of local functions, defining a joint cost or probability distribution. Simple transformations exist between these two types of models, but also with MaxSAT and integer programming. During the past ten years, we have been developing a graphical model solver called toulbar2 and we report on a large comparison of exact solvers which are all state-of-the-art for their own target language. We present recent algorithmic advances in toulbar2 including generalized clique cuts and parallel variable neighborhood search methods that make the solver very competitive on several benchmarks coming from probabilistic inference, computer vision and pattern recognition, weighted MaxSAT, and weighted MaxCSP competitions. All 3026 instances are made publicly available in five different formats (uai, lp, wcnf, wcsp, mzn) and seven formulations. To our knowledge, this is the first evaluation that encompasses such a large set of related NP-hard optimization frameworks, despite their tight connections. Solver toulbar2 and benchmarks are available at https://github.com/toulbar2/toulbar2 and http://genoweb.toulouse.inra.fr/ degivry/evalgm.

2 - Learning and using Graphical models to design new molecules

Speaker: Thomas Schiex, INRA, FR, talk 1587

Co-Authors: *Sophie Barbe*, *David Simoncini*, *Jelena Vucinic*, *Manon Ruffini*,

Graphical models (GMs) define a family of mathematical models that describe a joint function on many variables as the combination of small functions. With discrete variables and a conjonction of boolean functions, a GM is a Constraint Network (Constraint Satisfaction Problem), at the core of Constraint Programming. By substituting additive functions to boolean functions, we get a general family of models that covers deterministic "Cost Function Networks" (and the Weighted Constraint Satisfaction Problem) but also stochastic models such as "Bayesian networks" or "Markov Random Fields" (MRFs, and the Maximum A Posteriori" - MAP - problem). The advantage of the stochastic interpretation is that it enables learning from data using eg. L1/L2 regularized log(pseudo)likelihood (convex) optimization. In the context of Computational Protein Design, Markov Random Fields are ideal to represent the energy of a protein. Biophysicists have spent decades tuning pairwise decomposable force fields to capture the stability of a protein in a solvant. In the end, designing a protein can be reduced to a MAP problem on an MRF. However, these force fields are still inaccurate and protein design remains uncertain. To include more information in the process, it is possible to extract information from the history of protein evolution. An MRF that abstracts this information can be first estimated from data and then consistently integrated in the original MRF so that a MAP query is still capable to answer the original design question, with more information and hopefully, an increased design success.

3 - Integrated staffing and scheduling for home healthcare

Speaker: Maria Restrepo, Polytechnique Montreal, CA, talk 1027

Co-Authors: *Louis-Martin Rousseau*,

Workforce planning for home healthcare represents an important and challenging task involving complex factors associated with labor regulations, caregivers' preferences, and demand uncertainties. This task is done manually by most home care agencies, resulting in long planning times and suboptimal decisions that usually fail to meet the health needs of the population, to minimize operating costs, and to retain current caregivers. Motivated by these challenges, we present a two-stage stochastic programming model for employee staffing and scheduling in home health care. In this model, first-stage decisions correspond to the staffing and scheduling of caregivers at each geographic district. Second-stage decisions are related to the temporary reallocation of caregivers to neighboring districts, to contact caregivers to work on a day-off, and to allow under-staffing and over-staffing. The proposed model is tested on real-world instances, where we evaluate the impact in costs, caregiver utilization, and service level, by using different scheduling policies and recourse actions. Results show that when compared with a deterministic model, the two-stage stochastic model leads to significant cost savings, as staff dimensioning and staff scheduling decisions are more robust to accommodate changes in demand. Moreover, these results suggest that flexibility in terms of the use of recourse actions is highly valuable, as it helps to further improve costs, service level, and caregiver utilization.

4 - Solving parallel machine scheduling problems with B and P and decision diagrams

Speaker: Daniel Kowalczyk, KU Leuven, BE, talk 736

Co-Authors: *Roel Leus*,

We study the parallel machine scheduling problem to minimize the sum of the weighted completion times of the jobs to be scheduled. We use a set covering formulation for this problem, and we improve the computational performance of a branch-and-price (B and P) algorithm by a number of techniques, including a generic branching scheme, zero-suppressed binary decision diagrams (ZDDs) to solve the pricing problem, dual-price smoothing as a stabilization method, and Farkas pricing to handle infeasibilities. We report computational results that show the effectiveness of the algorithmic enhancements, which depends on the characteristics of the instances. To the best of our knowledge, we are also the first to use ZDDs to solve the pricing problem in a B and P algorithm for a scheduling problem.

Optimal Control in Engineering Applications

Continuous Optimization

Control - Fr 9:00am-10:30am, Format: 3x30 min

Room: Salle AURIAC Building: G, 1st floor, Zone: 6

Contributed Session 310

Chair: Maxime Grangereau, EDF, FR

1 - A Priori Error Estimates for a Linearized Fracture Control Problem

Speaker: Masoumeh Mohammadi, TU Darmstadt, DE, talk 824

Co-Authors: *Winnifried Wollner*,

A linearized control model for fracture propagation is considered. The problem is discretized by a conforming finite element method. The a priori error estimate is discussed for the discretization scheme. First, a quasi-best approximation result is proved for the lower level optimization problem concerning the fracture propagation such that the total energy is minimized. Next, a convergence result for the upper level optimization model, in which the vector valued displacement field is controlled to approach as close as possible to the desired state, is presented. The theoretical results are verified with numerical experiments.

2 - Stochastic optimal control of a battery : resolution with McKean-FBSDE

Speaker: Maxime Grangereau, EDF, FR, talk 984

Co-Authors: *Emmanuel Gobet*,

In the context of energy management, we study the problem of the optimal control of a battery in order to reduce the operating costs of a provider of network electricity. Unlike previous works related to micro-grid management, we consider a system connected to the network and aim at limiting both the power peaks and the fluctuations of the power supplied by the network. We propose a general framework, which allows to account for the aging of the battery as well, for instance. This results in a stochastic optimal control problem with McKean interaction: the cost involves the law of the control and state variables. We derive necessary and sufficient optimality conditions, using the stochastic Pontryagyn principle. This gives rise to a particular Mc-Kean-Forward Backward Stochastic Differential Equation (FBSDE). We prove existence and uniqueness of solutions to the control problem in a small time horizon to this problem in a general framework, using a fixed-point argument. A particular focus is given to the Linear Quadratic case, where we can prove existence and uniqueness of a solution for arbitrary time horizons. The affine-linearity of the underlying FBSDE allows to derive a closed-loop feedback formula for the optimal control. This formula involves the solutions of two backward Riccati Ordinary Differential Equations and two affine-linear Backward Stochastic Differential Equations. Some numerical results are given to demonstrate the performance of the approach.

3 - Adaptive Multilevel Optimization of Fluid-Structure Interaction

Speaker: Johanna Biehl, TU Darmstadt, DE, talk 740

Co-Authors: *Stefan Ulbrich*,

The interaction of fluid flows with elastic materials is part of many applications, for example in medicine, civil engineering or aerodynamics. Therefore it is of interest to control flow and the corresponding deformation of the structure. In this talk, we introduce an adaptive, derivative based multilevel optimization algorithm for fluid-structure interaction problems of incompressible flows and hyperelastic structures in a laminar regime. Since the corresponding monolithic finite element discretization is nonlinear and high dimensional, we use adaptive grid refinement techniques and introduce a reduced order model based on proper orthogonal decomposition to reduce the cost of the optimization process. The existence and stability of solutions of the resulting saddle point problem is ensured with help of supremizers, which guarantee that the inf-sup condition is satisfied. For the optimization we use an SQP method for PDE-constrained problems with adjoint based derivative computation and a posteriori error estimators for the finite element discretization and reduced order model. The presented method is applied to a benchmark problem proposed by Turek and Hron. Acknowledgement. This work is supported by the 'Excellence Initiative' of the German Federal and State Governments and the Graduate School of Computational Engineering at Technische Universität Darmstadt.

Dimensionality reduction tools for learning: A sketchy session

Specific Models, Algorithms, and Software

Learning - Fr 9:00am-10:30am, Format: 3x30 min

Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 313

Organizer: Robert Gower, Telecom Paristech, FR

1 - Sketched Learning with Random Feature Moments

Speaker: Nicolas Keriven, ENS, FR, talk 991

Co-Authors: *Rémi Gribonval*, *Gabriel Peyre*, *Gilles Blanchard*, *Clarice Poon*, *Yann Traonmilin*,

Learning parameters from voluminous data can be prohibitive in terms of memory and computational requirements. Furthermore, modern architectures often ask for learning methods to be amenable to streaming or distributed computing. In this context, a popular approach is to first compress the database into a representation called a linear sketch, then learn the desired information using only this sketch. In this talk, we introduce a methodology to fit a mixture of probability distributions on the data, using only a sketch of the database. The sketch is defined by combining two notions from the reproducing kernel literature, kernel mean embedding and random features. It is seen to correspond to linear measurements of the probability distribution of the data, and the problem is thus analyzed under the lens of Compressive Sensing (CS), in which a signal is randomly measured and recovered. We analyze the problem using two classical approaches in CS: first a Restricted Isometry Property in the Banach space of finite signed measures, from which we obtain strong recovery guarantees however with an intractable non-convex minimization problem, and second with a dual certificate analysis, from which we show that total-variation regularization yields a convex minimization problem that in some cases recovers exactly the number of components of a gaussian mixture model. We also briefly describe a flexible heuristic greedy algorithm to estimate mixture models from a sketch, and apply it on synthetic and real data.

2 - Stochastic Subsampling for Factorizing Huge Matrices

Speaker: Arthur Mensch, Inria, FR, talk 1481

Co-Authors: *Julien Mairal*, *Bertrand Thirion*, *Gaël Varoquaux*,

We present a matrix-factorization algorithm that scales to input matrices with both huge number of rows and columns. Learned factors may be sparse or dense and/or non-negative, which makes our algorithm suitable for dictionary learning, sparse component analysis, and non-negative matrix factorization. Our algorithm streams matrix columns while subsampling them to iteratively learn the matrix factors. At each iteration, the row dimension of a new sample is reduced by subsampling, resulting in lower time complexity compared to a simple streaming algorithm. Our method comes with convergence guarantees to reach a stationary point of the matrix-factorization problem. We demonstrate its efficiency on massive functional Magnetic Resonance Imaging data (2 TB), and on patches extracted from hyperspectral images (103 GB). For both problems, which involve different penalties on rows and columns, we obtain significant speed-ups compared to state-of-the-art algorithms.

3 - Optimal kernel methods for large scale machine learning

Speaker: Alessandro Rudi, INRIA and ENS, FR, talk 730

Kernel methods provide a principled way to perform non linear, nonparametric learning. They rely on solid functional analytic foundations and enjoy optimal statistical properties. However, at least in their basic form, they have limited applicability in large scale scenarios because of stringent computational requirements in terms of time and especially memory. In this talk, we take a substantial step in scaling up kernel methods, proposing FALKON, a novel algorithm that allows to efficiently process millions of points. FALKON is derived combining several algorithmic principles, namely stochastic subsampling, iterative solvers and preconditioning. Our theoretical analysis shows that optimal statistical accuracy is achieved requiring essentially $O(n)$ memory and $O(n\sqrt{n})$ time. An extensive experimental analysis on large scale datasets shows that, even with a single machine, FALKON outperforms previous state of the art solutions, which exploit parallel/distributed architectures.

Telecommunications

Specific Models, Algorithms, and Software
Network - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 18 Building: I, 1st floor, Zone: 7

Invited Session 361
Organizer: Edoardo Amaldi, Politecnico di Milano, IT

1 - An Optimization Model for Quadratic Flow Thinning
Speaker: Michal Pioro, Warsaw Univ. of Techn., PL, talk 161
Co-Authors: *Ilya Kalesnikau*, *Michael Poss*,
Flow thinning (FT) is a traffic protection mechanism applicable to communication networks with variable link capacities, for example wireless networks. With FT, end-to-end traffic demands are equipped with dedicated logical tunnels (for example MPLS tunnels), whose nominal capacity is subject to thinning in order to follow the current availability of link capacities (that are fluctuating below their maximum levels). In effect, instantaneous traffic realized between the end-nodes of each demand can be adapted to the current total capacity available on the demand's dedicated tunnels, so that the network is always capable of carrying traffic admitted to the tunnels. We present an efficient, implementable version of FT, referred to as QFT (quadratic flow thinning). With QFT, the capacity of each tunnel is adjusted according to an optimized, tunnel-specific quadratic (or affine as a special case) flow thinning function, whose arguments are the fractions of available link capacities (in relation to the maximum link capacities) on a pre-specified, tunnel-dependent subset of links. By deriving relevant mixed-integer pricing problems for basic variants of QFT, we show how the corresponding network cost minimization problems can be treated by a path generation algorithm. Results of a numerical study illustrate tractability of the cost minimization problems, and assess cost efficiency of QFT in comparison with original FT.

2 - Approximating the Virtual Network Embedding Problem: Theory and Practice
Speaker: Matthias Rost, TU Berlin, DE, talk 1218
Co-Authors: *Stefan Schmid*,
Many resource allocation problems in the cloud can be described as a basic Virtual Network Embedding Problem (VNEP): finding mappings of request graphs (describing the workloads) onto a substrate graph (describing the physical infrastructure). Obeying substrate capacities, the goal is either to maximize the profit by embedding a subset of requests or to minimize the embedding costs of all requests. Despite being studied for more than a decade, the underlying algorithmic problem is hardly understood. We present the first approximation algorithms for the VNEP. Our results are based on the randomized rounding of solutions to a novel strong Linear Programming (LP) formulation. In fact, we show that strong LP formulations need to take the requests' structure into account: there cannot exist a polynomially-sized formulation for general request graphs. Accordingly, we introduce the graph-theoretic notions of extraction orders and extraction width and show that our formulation's size is exponential in the extraction width. As cactus request graphs have bounded extraction width, we obtain the first polynomial-time approximations for this request class. For general requests, we obtain fixed-parameter tractable approximations. Complementing our theory we present an extensive computational study for approximating the profit of embedding cactus request graphs.

3 - DDRA: Distributed Detection and Recovery Algorithm for Wireless Sensor Networks
Speaker: Chafiq Titouna, University of Batna2, DZ, talk 1544
A wireless sensor network (WSN) is a network formed by a large number of sensor nodes where each node is equipped with a sensor to detect physical phenomena such as light, heat, pressure, etc. In many applications, the network is deployed in harsh environments such as battlefield where the nodes are susceptible to damage. In addition, nodes may fail due to energy depletion and breakdown in the onboard electronics. So failures are inevitable in WSN, and it is important to establish a fault-tolerant mechanism. Given the resource-constrained setup, this mechanism should impose the least overhead and performance impact. This paper focuses on recovery process after a fault detection phase in WSNs. We present an algorithm to recover faulty node called Distributed Detection and Recovery Algorithm (DDRA).The performance evaluation is tested through simulation to evaluate some factors such as: Packet delivery ratio, control overhead, memory overhead and fault recovery delay. We compared our results with referenced algorithm: Fault Detection in Wireless Sensor Networks (FDWSN), and found that our DDRA performance outperforms that of FDWSN.

4 - On the Virtual Network Embedding problem with substrate network expansion
Speaker: Edoardo Amaldi, Politecnico di Milano, IT, talk 1485
Co-Authors: *Antonio Capone*, *Alessandro Cimbelli*,
Network virtualization is an important paradigm which has been attracting considerable attention in recent years. We investigate a new Virtual Network Embedding problem variant arising in the field of telecommunications, where the point of view of the Infrastructure Provider is adopted. Given a substrate (physical) network with arc capacities and a set of star-shaped virtual networks with node-to-node traffic demands, the problem is to decide how to expand the substrate network capacities in order to be able to map all the virtual network requests onto the substrate network (virtual nodes onto substrate nodes and virtual arcs onto substrate paths), and to determine fair prices for the virtual networks in order to cover the total expansion cost. After discussing complexity issues and structural properties, we present a Mixed Integer Linear Programming (MILP) formulation, a MILP-based heuristic and a column generation method to derive tight dual bounds.

Variational Analysis 3

Continuous Optimization
Variat - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Invited Session 369

Organizer: Johanna Burtscheidt, University of Duisburg-Essen, DE

1 - Stability and Small Application of a Risk Averse CP under Uncertainty

Speaker: Johanna Burtscheidt, University of Duisburg-Essen, DE, talk 543

In most of the literature on complementarity problems (CP) full knowledge of the data is indispensable. However, the importance of including data uncertainty has become more and more apparent in recent years. We present a deterministic, risk averse formulation for complementarity problems (CP) under stochastic uncertainty inspired by the expected residual minimization (ERM) model. The approach consists in a stability analysis in addition to some notes on the structure of the problem type. In particular, qualitative stability of the optimal values under perturbation of the underlying Borel probability measure will be investigated with respect to weak convergence of probability measures. Following that we formulate a risk averse complementarity problem for a special game of dice where a participant has to choose one of three strategies to maximize its score. In doing so he has to make his decision without knowing the outcome of some dice.

2 - Variable selection with heredity principles by nonconvex optimization

Speaker: Hongbo Dong, Washington State University, US, talk 1540

We consider variable selection in statistical learning with heredity principles (or hierarchical constraints). Such conditions are faithfully modeled by affine sparsity constraints. A study of the closure representation of the feasible set leads to a rigorous derivation of penalized estimation related to a previous approach proposed by Bien, Taylor, and Tibshirani (where a lasso-type, hence convex, estimator is proposed). We propose nonconvex optimization based estimators by approximating each binary indicator functions with a class of difference-of-convex (dc) functions. We prove the epi-convergence of such approximations, and propose a majorization-minimization algorithm to compute the d(rectional)-stationary points. Simulated and real data sets are used to evaluate the finite-sample performance of the proposed approach.

3 - Adaptive Full Newton-step Infeasible Interior-Point Method for Sufficient HLCP

Speaker: Goran Lesaja, Georgia Southern University, US, talk 1046

Co-Authors: *Florian Potra*,

An adaptive full Newton-step infeasible-interior-point method for solving sufficient horizontal linear complementarity problems is analyzed and sufficient conditions are given for the superlinear convergence of the sequence of iterates. The main feature of the method is that the parameter defining the Newton-step is adaptively chosen at each iteration, in contrast with previous full-Newton step methods where this parameter is kept fixed at all iterations. We mention that no superlinear convergence results are known for the latter methods. The theoretical complexity of our method matches the best known results in the literature. In the first algorithm we assume that an upper bound for the handicap of the problem is known. The second algorithm does not depend on the handicap of the problem, so that it can readily be applied to any horizontal linear complementarity problem.

4 - Application of Optimization over the Pareto set in Machine Learning

Speaker: Henri Bonnel, University of New Caledonia, NC, talk 1660

Co-Authors: *Christopher Schneider*,

We will present an important application of the problem of optimizing a scalar valued function over a Pareto set associated to a convex multiobjective optimization program. So, we will deal with the optimum choice of weights for the elastic net regularization method (used in the fitting of linear regression models) which use a convex combination of L_1 and L_2 norms. An algorithm for computing the optimal path using the linear complementarity problem is proposed.

Algorithmic Game Theory II

Optimization under Uncertainty

Game - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 372

Chair: Margarida Carvalho, Polytechnique Montréal, CA

1 - Efficient Black-Box Reductions for Separable Cost Sharing

Speaker: Anja Huber, Augsburg University, DE, talk 961

In cost-sharing games with delays, a set of agents jointly allocates a subset of resources. Each resource has a fixed cost that has to be shared by the players, and each agent has a non-shareable player-specific delay for each resource. A separable cost-sharing protocol determines cost shares that are budget-balanced, separable and guarantee existence of pure Nash equilibria (PNE). We provide black-box reductions reducing the design of such a protocol to the design of an approximation algorithm for the underlying cost-minimization problem. In this way, we obtain separable cost-sharing protocols in matroid games, single-source connection games, and connection games on n-series-parallel graphs. All these reductions are efficiently computable - given an initial allocation profile, we obtain a cheaper profile and separable cost shares turning the profile into a PNE. Hence, in these domains any approximation algorithm yields a separable cost-sharing protocol with price of stability bounded by the approximation factor. Joint work with Tobias Harks, Martin Hoefer and Manuel Surek.

2 - Finding and verifying the nucleolus of cooperative games

Speaker: Marton Benedek, University of Southampton, GB, talk 1343

Co-Authors: *Tri-Dung Nguyen*, *Joerg Fliege*,

In cooperative games payers allowed to enter into binding agreements, i.e. forming a coalition with other players. For these games various solution concepts exist, among which the nucleolus offers a stable payoff allocation by lexicographically minimising the regret of all possible coalitions. Computing this solution is desired thanks to its numerous attractive properties: it exists and is unique, it lies in all (non-empty) ε-cores, etc. Although computing the nucleolus is very challenging, the Kohlberg criterion offers a powerful method for verifying whether a solution is the nucleolus in relatively small games (the number of players $n \leq 20$). However, this becomes more challenging for larger games because of the need to form and check the balancedness of possibly exponentially many collections of coalitions, each collection could be of an exponentially large size. We develop a simplifying set of the Kohlberg criteria that involves checking the balancedness of at most $(n-1)$ sets of coalitions. We also provide a method for reducing the size of these sets. Moreover, based on the established results, we are able to formulate a new constructive algorithm computing the Nucleolus of a general cooperative game. Numerical results show that our algorithm outperforms both classical nested linear programming approaches and state-of-the-art pivoting algorithms.

3 - Perfect d-Proper Equilibrium and Its Determination

Speaker: Chuangyin Dang, City University of Hong Kong, HK, talk 798

As a strict refinement of perfect equilibrium, the introduction of proper equilibrium has significantly advanced the development of game theory and its applications. Nevertheless, the notion of proper equilibrium can lead to a severe numerical problem when one intends to compute such an equilibrium. To remedy this deficiency, this paper proposes a perfect d-proper equilibrium, which is also a strict refinement of perfect equilibrium. In the notion, the positive number d measures the degree of properness of an equilibrium. The smaller the value of d, the higher the degree of properness. It is shown that a strategic game always has a perfect d-proper equilibrium. A significant feature is that such an equilibrium is numerically much easier to compute than a proper equilibrium. For a given game, as d is sufficiently small, a perfect d-proper equilibrium is always a proper equilibrium. A differentiable homotopy method is developed to compute a perfect d-proper equilibrium.

4 - Kidney Exchange Game

Speaker: Margarida Carvalho, Polytechnique Montréal, CA, talk 1035

Co-Authors: *Andrea Lodi*,

Kidney exchange programs are an invaluable alternative for patients suffering from renal failure. Thus, it is essential that their design leads to optimal social outcomes. We analyze strategic behaviors in a kidney exchange program that involves patient-donor pairs of more than one entity (e.g., hospitals or countries). This setting can be represented as a cardinality matching game in a graph. We review known Nash equilibria results of this game and we present computational experiments that enable the comparison between Nash equilibria and the optimal social welfare. Afterwards, motivated by the introduction of machine learning predictions of graft quality, we propose a modified game and we address its computational complexity, equilibria existence and the game expected social welfare.

Advances in theory of dynamic programming

Optimization under Uncertainty

Markov - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 31 Building: B, Ground Floor, Zone: 5

Contributed Session 385

Chair: Stephane Gaubert, INRIA, FR

1 - On controllability of Markov chains: A Markov Decision Processes approach

Speaker: Mauricio Junca, Universidad de los Andes, CO, talk 601

Co-Authors: *Daniel Avila*,

We consider a Markov control model in discrete time with countable both state space and action space. Using the value function of a suitable long-run average reward problem, we study various reachability/controllability problems. First, we characterize the domain of attraction and escape set of the system, and a generalization called p-domain of attraction, using the aforementioned value function. Next, we solve the problem of maximizing the probability of reaching a set A while avoiding a set B. Finally, we consider a constraied version of the previous problem, where we ask for the probability of reaching the set B to be bounded. In the finite case, we use linear programming formulations to compute the previous solutions.

2 - Stochastic Convex Optimization and Regret Bounds for Apprenticeship Learning

Speaker: Angeliki Kamoutsi, ETH ZURICH, CH, talk 1490

Co-Authors: *John Lygeros*,

While in forward discrete-time Markov decision processes (MDPs) it is typically assumed that the cost function is given, in many cases one can not specify directly the cost of a task, but instead can observe an optimal behavior. In this talk, we consider large scale MDPs and address the problem of apprenticeship learning under the assumption that the true cost function can be represented as a linear combination of some basis functions. We forgo learning a cost function and we propose a method that directly learns a policy from expert demonstrations by formulating the problem as a single convex optimization problem over occupation measures. To this aim, we use the linear programming (LP) formulation of the MDP, the bijective relationship between occupation measures and policies and tools from stochastic convex optimization. In particular, the objective is to minimize the l_2-distance between the feature expectations of the expert and the learner, subject to linear constraints ensuring that the optimization variable is an occupation measure generated by a policy. We control the complexity by limiting our search to the linear subspace defined by a small number of features. We then convert the initial program to an unconstrained convex optimization problem. In this way, we are able to provide high-confidence regret bounds showing that the performance of our algorithm approaches the best achievable by any policy in the comparison class. The computational complexity does not depend on the size of the state-action spaces.

3 - Randomized Dimension Reduction for Monte Carlo Simulations

Speaker: Nabil Kahale, ESCP Europe, FR, talk 574

We present a new unbiased algorithm that estimates the expected value of $f(U)$ via Monte Carlo simulation, where U is a vector of d independent random variables, and f is a function of d variables that does not depend equally on all its arguments. Our algorithm simulates at each iteration a random subset of arguments of f, and reuses the remaining arguments from the previous iteration. In order to optimize the tradeoff between the statistical error and the running time, we use a new geometric algorithm that solves in $O(d)$ time a d-dimensional optimization problem. Under certain conditions we prove that, for the same computational cost, the variance of our estimator is lower than the variance of the standard Monte Carlo estimator by a factor of order d. Applications to Markov chains simulation are presented.

Numerical experiments show that our algorithm dramatically improves upon the standard Monte Carlo method for large values of d, and is highly resilient to discontinuities.

4 - Dynamic programming over noncommutative spaces applied to switched systems

Speaker: Nikolas Stott, INRIA - Ecole Polytechnique, FR, talk 1676

Co-Authors: *Stephane Gaubert*,

Kraus maps (completely positive trace preserving maps) arise classically in quantum information, as they describe the evolution of non-commutative probability measures. We introduce tropical analogues of Kraus maps, obtained by replacing the addition of positive semidefinite matrices by a multivalued supremum with respect to the Loewner order. We show that non-linear eigenvectors of tropical Kraus maps determine piecewise quadratic approximations of the value functions of switched optimal control problems. This leads to a new scheme to approximate the joint spectral radius of a family of matrices, relying on the solution of a non-linear eigenvalue problem.We report experiments on large scale instances.

Finance and Portfolio Optimization

Specific Models, Algorithms, and Software

Sciences - Fr 9:00am-10:30am, Format: 3x30 min

Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 395

Organizer: Asaf Shupo, TD Bank, CA

1 - Auction under ROI constraints

Speaker: Benjamin Heymann, Criteo R & D, FR, talk 652

Auction theory envisions a group of buyers competing for some items. Each buyer associates a private value to each item, and its bid is thus a function of the private value and the competition. A standard result for example is that bidding truthfully in second price auctions is a weakly dominant strategy, or, in the context of digital advertising, "eCPM equals CTR multiplied by CPC". However this statement is not true if the buyers are subject to ROI constraints. This is what I propose to discuss in a simplified, symmetric setting.

2 - Time Consistency of the Mean-Risk Problem

Speaker: Gabriela Kovacova, Wirtschaftsuniversität Wien, AT, talk 273

Co-Authors: *Birgit Rudloff*,

The mean-risk problem is a well known and extensively studied problem in Mathematical Finance. Its aim is to identify portfolios that maximize the expected terminal value and at the same time minimize the risk. The usual approach in the literature is to combine the two to obtain a problem with a single objective. This scalarization, however, comes at the cost of time inconsistency. In this work we show that these difficulties disappear by considering the problem in its natural form, that is, as a vector optimization problem. As such the mean-risk problem can be shown to satisfy under mild assumptions an appropriate notion of time consistency. Additionally, the upper images, whose boundaries are the efficient frontiers, recurse backwards in time. We argue that this represents a Bellman's principle appropriate for a vector optimization problem: a set-valued Bellman's principle. Furthermore, we provide conditions under which this recursion can be directly used to compute the efficient frontiers backwards in time.

3 - Building Optimal Strategies Using Multi-Objective Optimization

Speaker: Asaf Shupo, TD Bank, CA, talk 664

Co-Authors: *Daniel Ivan*,

In many organizations retaining customers, being profitable, achieving competitive advantage, and considering conflicting views of risk, provide good motivation for using multiple-objective optimization (MOO). Allocating their products across various segments of customers is another indication where MOO models can be used. Our work consists on building optimal strategies by using MOO techniques to obtain a range of optimal Pareto solutions. Also a solution that considers an acceptable tradeoff amongst the objectives is provided.

Decomposition Methods

Continuous Optimization

NLP - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 9 Building: N, 4th floor, Zone: 12

Contributed Session 431

Chair: Roger Behling, UFSC, BR

1 - Circumcentering the Douglas–Rachford method

Speaker: Roger Behling, UFSC, BR, talk 6

Co-Authors: *José Bello Cruz*, *Luiz Santos*,

We introduce and study a geometric modification of the Douglas–Rachford method called the Circumcentered–Douglas–Rachford method. This method iterates by taking the intersection of bisectors of reflection steps for solving certain classes of feasibility problems. The convergence analysis is established for best approximation problems involving two (affine) subspaces and both our theoretical and numerical results compare favorably to the original Douglas–Rachford method. Under suitable conditions, it is shown that the linear rate of convergence of the Circumcentered–Douglas–Rachford method is at least the cosine of the Friedrichs angle between the (affine) subspaces, which is known to be the sharp rate for the Douglas–Rachford method. We also present a preliminary discussion on the Circumcentered–Douglas–Rachford method applied to the many set case and to examples featuring non-affine convex sets.

2 - On the linear convergence of the circumcentered–reflection method

Speaker: Luiz-Rafael Santos, UFSC, BR, talk 91

Co-Authors: *Yunier Bello-Cruz*, *Roger Behling*,

In order to accelerate the Douglas–Rachford method we recently developed the circumcentered-reflection method, which provides the closest iterate to the solution among all points relying on successive reflections, for the best approximation problem related to two affine subspaces. We now prove that this is still the case when considering a family of finitely many affine subspaces. This property yields linear convergence and incites embedding of circumcenters within classical reflection and projection based methods for more general feasibility problems. Our method present good numerical results when compared to other projection/reflection methods.

3 - Alternating Direction Method of Multipliers for k-means Clustering

Speaker: Yuan Shen, Nanjing University of Finance, CN, talk

259
Co-Authors: *Xin Liu*,
The k-means clustering problem is widely used in various fields such as machine learning, biometric, and etc. For its importance, it has been studied extensively in the past few decades, and there have been a bunch of efficient algorithms for solving it. However, most algorithms are based on heuristic method which could be lack of theory. In this talk, we propose a new algorithm for solving this problem. It is based on a non-convex optimization model and the popular alternating direction method of multipliers. We analyze its theoretical property based on the Kurdyka-Łojasiewicz theory. This is a contribution to both optimization theory and algorithm.

4 - A Nonomonotone Decomposition Framework: convergence analysis and applications
Speaker: Leonardo Galli, Università di Firenze, IT, talk 1031
Co-Authors: *Alessandro Galligari*, *Marco Sciandrone*,
In this work we propose a general framework that provides a unified convergence analysis for nonmonotone decomposition algorithms. In particular, we show that the monotone assumption is not required to obtain convergence. Some existing and some revised nonmontone line searches are proved to fit in the proposed framework. In the second part of the work, we design a numerical decomposition scheme that, under certain assumptions, leads to a remarkable reduction of function calls and (in the nonmonotone case) a crucial gain in terms of significant digits. Numerical results, performed on a set of large scale Net Equilibrium Problems, show the advantages of nonmonotone strategies over their monotone counterparts. A final comparison highlights the importance of employing the proposed numerical decomposition scheme for solving large scale problems.

New Horizons in Robust Optimization

Optimization under Uncertainty
Robust - Fr 9:00am-10:30am, Format: 3x30 min
Room: Salle 33 Building: B, Ground Floor, Zone: 5

Invited Session 447
Organizer: Angelos Georghiou, McGill University, CA

1 - Data-driven Chance Constrained Programs over Wasserstein Balls
Speaker: Zhi Chen, Imperial College London, GB, talk 918
Co-Authors: *Daniel Kuhn*, *Wolfram Wiesemann*,
We provide an exact deterministic reformulation for data-driven chance constrained programs over Wasserstein balls. For individual chance constraints as well as joint chance constraints with right-hand side uncertainty, our reformulation amounts to a mixed-integer conic program. In the special case of a Wasserstein ball with 1-norm or ∞-norm, the cone is the nonnegative orthant, which implies that the chance constrained program can be represented as a mixed-integer linear program. Using our reformulation, we show that two popular approximation schemes based on the conditional-value-at-risk and the Bonferroni inequality can perform poorly in practice.

2 - Cardinality-Constrained Clustering and Outlier Detection via Conic Optimization
Speaker: Kilian Schindler, EPFL, CH, talk 974
Co-Authors: *Napat Rujeerapaiboon*, *Daniel Kuhn*, *Wolfram Wiesemann*,
Plain vanilla K-means clustering is prone to produce unbalanced clusters and suffers from outlier sensitivity. To robustify this popular approach against both shortcomings, we formulate a joint outlier detection and clustering problem, which assigns a prescribed number of datapoints to an auxiliary outlier cluster and performs cardinality-constrained K-means clustering on the residual dataset. We cast this problem as a mixed-integer linear program (MILP) that admits tractable semidefinite and linear programming relaxations. We propose deterministic rounding schemes that transform the relaxed solutions to feasible solutions for the MILP and prove that these solutions are optimal in the MILP if a cluster separation condition holds. Finally, we illustrate the effectiveness of the suggested approach in numerical experiments

3 - A robust optimization prospective to decentralized decision making
Speaker: Angelos Georghiou, McGill University, CA, talk 1423
Co-Authors: *Georgios Darivianakis*, *John Lygeros*,
Designing policies for a network of agents is typically been done by formulating an optimization problem where each agent has access to state measurements of all the other agents in the network. Such a policy design with centralized information exchange results in optimization problems that are typically hard to solve, requires to establish substantial communication links, and does not promote privacy since all information is shared among the agents. In this work, we propose an optimization framework for decentralized policy designs. In contrast to the centralized information exchange, our approach requires only local communication among the neighboring agents. Using robust optimization techniques, we formulate a convex optimization problem with separable structure that can be solved efficiently, while the proposed policy structure addresses potential privacy concerns.

Dealing with non-convexity

Specific Models, Algorithms, and Software
Learning - Fr 8:30am-10:30am, Format: 4x30 min
Room: Salle 16 Building: I, 2nd floor, Zone: 7

Contributed Session 473
Chair: Damek Davis, Cornell University, US

1 - Smoothing Piecewise Linear Loss Functions for Deep Learning
Speaker: Leonard Berrada, University of Oxford, GB, talk 1294
Co-Authors: *Pawan Kumar*, *Andrew Zisserman*,
Deep neural networks (DNN) are powerful and versatile models that are applicable to a wide range of machine learning tasks. In theory, DNNs allow practitioners to employ any loss function based on the task at hand. However, in practice, it has been observed that their performance suffers significantly when using a piecewise linear loss function (for example, the hinge loss or its generalizations that are commonly used in empirical risk minimization). We illustrate the difficulty of training DNNs with piecewise linear loss functions using two computer vision tasks: top-k error minimization and multi-

label classification. In both cases, we show that (i) smoothing the loss function is necessary for accurate optimization; and (ii) the complexity of computing the gradient of the smoothed loss function can be drastically reduced through a connection to polynomial algebra.

2 - Convergence rates of stochastic methods for nonsmooth nonconvex problems

Speaker: Damek Davis, Cornell University, US, talk 910

Co-Authors: *Dmitriy Drusvyatskiy*,

We prove that the proximal stochastic subgradient method, applied to a weakly convex problem (i.e. differences of convex functions and quadratics), drives the gradient of the Moreau envelope to zero at the rate $O(k^{-1/4})$. This class of problems captures a variety of nonsmooth nonconvex formulations, now widespread in data science. As a consequence, we obtain the long-sought convergence rate of the standard projected stochastic gradient method for minimizing a smooth nonconvex function on a closed convex set. In the talk, I will also highlight other stochastic methods for which we can establish similar guarantees.

3 - Implicit Regularization in Nonconvex Statistical Estimation

Speaker: Cong Ma, Princeton University, US, talk 258

Co-Authors: *Kaizheng Wang*, *Yuxin Chen*, *Yuejie Chi*,

Recent years have seen a flurry of activities in designing provably efficient nonconvex procedures for solving statistical estimation problems. Due to the highly nonconvex nature of the empirical loss, state-of-the-art procedures often require proper regularization (e.g. trimming, regularized cost, projection) in order to guarantee fast convergence. For vanilla procedures such as gradient descent, however, prior theory either recommends highly conservative learning rates to avoid overshooting, or completely lacks performance guarantees. This paper uncovers a striking phenomenon in nonconvex optimization: even in the absence of explicit regularization, gradient descent enforces proper regularization implicitly under various statistical models. In fact, gradient descent follows a trajectory staying within a basin that enjoys nice geometry, consisting of points incoherent with the sampling mechanism. This "implicit regularization" feature allows gradient descent to proceed in a far more aggressive fashion without overshooting, which in turn results in substantial computational savings. Focusing on three fundamental statistical estimation problems, i.e. phase retrieval, low-rank matrix completion, and blind deconvolution, we establish that gradient descent achieves near-optimal statistical and computational guarantees without explicit regularization. In particular, by marrying statistical modeling with generic optimization theory, we develop a general recipe for analyzing the trajectories of iterative algorithms via a leave-one-out perturbation argument.

4 - Provable Convex Minimization under Non-convex Submodular-structured Sparsity

Speaker: Naoki Marumo, NTT, JP, talk 1193

Co-Authors: *Tomoharu Iwata*,

We propose a gradient descent-style algorithm for solving convex minimization over a non-convex submodular-structured sparse set, $\{x \in \mathbf{R}^n \mid (\exists S \subseteq \{1,\ldots,n\})\ g(S) \leq c,\ \mathrm{supp}(x) \subseteq S\}$, where $g : 2^{\{1,\ldots,n\}} \to \mathbf{R}$ is a submodular function and $\mathrm{supp}(x)$ denotes the nonzero indices set of x. Under a mild assumption, we prove that the proposed method converges linearly to a nearly optimal solution and derive the estimation error bound with two standard machine learning settings: linear and logistic regression. We determine the sample size that is sufficient to meet the assumption with the linear regression setting. Our method does not require the NP-hard projection onto the feasible region and our analysis does not require the restricted condition number of the loss function to be small. The experimental results show that the proposed method converges significantly faster, achieves a higher accuracy and selects nonzero variables more properly than the state-of-the-art methods.

New methods for stochastic optimization and variational inequalities

Optimization under Uncertainty

Stoch - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Contributed Session 491

Chair: Yunxiao Deng, Dept of ISE, USC, US

1 - Extragradient method for pseudomonotone stochastic variational inequalities

Speaker: Alfredo Iusem, IMPA, BR, talk 192

Co-Authors: *Philip Thompson*, *Alejandro Jofre*,

We consider stochastic variational inequalities with monotone operators. The operator F defining the variational inequality depends both on a variable in the finite dimensional Euclidean space and on a random variable. We are interested in finding solutions for the deterministic variational inequality problem whose operator T is defined as the expected value of F, but we do not assume that T is explicitly available; rather we propose a Stochastic Approximation procedure, meaning that at each iteration, a step similar to some variant of the deterministic projection method is taken after sampling the random variable, choosing thus a specific realization of the operator. Our method uses non-vanishing step-sizes and our convergence results require only pseudo-monotonicity of the operator. We provide convergence and complexity analysis, allowing for an unbounded feasible set, unbounded operator, non-uniform variance of the oracle and, also, we do not require any regularization procedures. In the stochastic approximation procedure, we employ an iterative variance reduction procedure, consisting of taking, in iteration k, not just the value of the operator at one one sample of the random variable, but the average of the operator values at m(k) samples. We attain the optimal oracle complexity (up to a logarithmic term). The generated sequence also enjoys a new feature: the sequence is bounded in Lp if the stochastic error has finite p-moment. Explicit estimates for the convergence rate, the complexity and the p-moments are given depending on problem parameters.

2 - An Accelerated Randomized Method for Smooth Stochastic Convex Optimization

Speaker: Eduard Gorbunov, MIPT, RU, talk 1287

Co-Authors: *Pavel Dvurechensky*, *Alexander Gasnikov*,

We consider smooth stochastic convex optimization problems in the context of algorithms which are based on directional derivatives of the objective function. This context can be considered as an intermediate one between derivative-free optimization and gradient-based optimization. We assume that at any given point and for any given direction, a stochastic approximation for the directional derivative of the objective function at this point and in this direction is available with some additive noise. The noise is assumed to be of an unknown nature, but bounded in the absolute value. We underline that we consider directional derivatives in *any* direction, as opposed to coordinate descent methods which use only derivatives in coordinate directions. For this setting, we propose a non-accelerated and an accelerated directional derivative method and provide their complexity bounds. Our non-accelerated algorithm has a complexity bound which is similar to the gradient-based algorithm, that is, without any dimension-dependent factor. Our accelerated algorithm has a complexity bound which coincides with the complexity bound of the accelerated gradient-based algorithm up to a factor of square root of the problem dimension. We extend these results to strongly convex problems.

3 - Stochastic Analogues to Deterministic Optimization Methods

Speaker: Mihai Anitescu, Argonne National Laboratory, US, talk 215

Stochastic optimization—those problems that involve random variables—is a fundamental challenge in many disciplines. Unfortunately, current solvers for stochastic optimization restrictively require finiteness by either replacing the original problem with a sample average surrogate, or by having complete knowledge of a finite population. To help alleviate this restriction, we state a general, novel framework that generates practical, robust numerical methods to solve the actual stochastic optimization problem iteratively. Our key insight is to treat the objective and its gradient as a sequential estimation problem that is solved by integrating statistical filters and deterministic optimizers. We demonstrate the framework by generating a Kalman Filtering-based gradient descent method with line search or trust region to solve a challenging stochastic optimization problem in statistics, machine learning, and control.

4 - Convex Stochastic Decomposition and Applications to Machine Learning

Speaker: Yunxiao Deng, Dept of ISE, USC, US, talk 1657

Co-Authors: *Suvrajeet Sen*,

In this talk, we present a stochastic proximal point algorithm named convex stochastic decomposition (Convex SD) to allow general convex stochastic programs. As in standard stochastic decomposition algorithm, convex SD works in an online manner, which increases the sample by a small number of additional samples at each iteration. During each iteration sample average subgradient approximation (SASA) functions will be updated by solving the proximal problem. Asymptotic convergence of this algorithm is proved by imposing the assumptions similar to the standard SD algorithm. In addition, we also present computational results of several applications in machine learning which can be solved and validated by this algorithm.

Stability and scaling in conic programming

CONTINUOUS OPTIMIZATION

SDP - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

CONTRIBUTED SESSION 498

Chair: Diego Cifuentes, Max Planck Institute MPI MiS, DE

1 - Scaling points and reach for non-self-scaled barriers

Speaker: Roland Hildebrand, LJK CNRS, FR, talk 496

The theory of interior-point algorithms is most developed for the class of symmetric cones, which include the orthant, the Lorentz cone, and the semi-definite matrix cone, leading to the classes of linear programs, second-order cone programs, and semi-definite programs, respectively. Its success relies on the property of these cones to possess a self-scaled barrier. In particular, for every primal-dual pair of points in the product of the cone with its dual, there exists a so-called scaling point, which is used by primal-dual interior-point algorithms on symmetric cones to compute a descent direction for the next iteration. In this contribution we give a geometric interpretation of the scaling point in terms of an orthogonal projection onto a Lagrangian submanifold in the primal-dual product space. This approach allows to extend the notion of scaling point to arbitrary self-concordant barriers and convex cones. We show that there exists a tube of primal-dual pairs of points of positive thickness around the submanifold for which scaling points exist. In geometric terms this means that the submanifold has positive reach. The thickness of the tube is a monotone function of the barrier parameter.

2 - Stability Analysis for Parameterized Conic Programs

Speaker: Hector Ramirez, Universidad de Chile, CL, talk 1623

In this talk we visit several results characterizing wel-known stability properties (such as Aubin property, isolated calmness, etc.) for critical maps of parameterized conic programs. These characterizations are typically carried out via the computation of second order generalized derivatives. We need the constraint set is defined over a convex cone satisfying a reducibility assumption. So, our approach covers seminal examples such as (nonlinear) SDP and SOCP.

3 - An improved projection and rescaling algorithm for conic feasible problems

Speaker: Wei Zhang, The logistics Institute NUS, SG, talk 288

Co-Authors: *Kees Roos*, *Yanqin Bai*,

Motivated by Chubanov's projection-based method for linear feasibility problems, a projection and rescaling algorithm for the conic feasibility problems

$$find\ x \in L \bigcap \Omega,$$

is proposed by Pena and Soheili, where L and Ω are respectively a linear subspace and the interior of a symmetric cone in a finite dimensional vector space V. When V is the Euclidean space R^n, L is the null space of a matrix and Ω is R^n_{++}, the problem reduces to the linear feasibility problem. In Pena and Soheili's method for the general case, the condition measure $\delta(L \bigcap \Omega)$ is adopted to bound the iteration complexity. In this paper, we utilize another condition measure $\delta_\infty(L \bigcap \Omega)$, which is based on the L_∞ norm of the vectors. Besides, in each basic iteration, the stopping criterion is determined by the projection to the space $L^\perp$ instead of onto L. Based on this, we can reduce the number of iterations for a Von-Neumann type basic procedure and a smoothed perceptron basic procedure by $O(r)$ and $O(r^{\frac{1}{2}})$ respectively, where r is the Jordan algebra rank of V. Besides, the prox-mirror method is also customized as a basic procedure, which can achieve the same iteration complexity of the smoothed perceptron method. Moreover, by carefully examining the fast and slow iterations, we can further reduce the total iteration complexity of the Von-Neumann type basic procedure.

4 - On the local stability of semidefinite relaxations

Speaker: Diego Cifuentes, Max Planck Institute MPI MiS, DE, talk 1671

We consider a parametric family of polynomial optimization problems over algebraic sets. Although these problems are typically nonconvex, tractable convex relaxations via semidefinite programming (SDP) have been proposed. Often times in applications there is a natural value of the parameters for which the relaxation will solve the problem exactly. We study conditions under which the relaxation will continue to be exact as the parameter moves in a small neighborhood of the original one. Our framework captures several estimation problems such as low rank approximation, camera triangulation, rotation synchronization and approximate matrix completion. Our results guarantee that the SDP relaxation will continue to solve the problem in the low noise regime.

Scheduling Applications

Specific Models, Algorithms, and Software

Scheduling - Fr 9:00am-10:30am, Format: 3x30 min

Room: Salle 23 Building: G, 3rd floor, Zone: 6

Contributed Session 526

Chair: Mauricio de Souza, UFMG, BR

1 - Generating many optimal solutions in nurse scheduling

Speaker: Atsuko Ikegami, Seikei University, JP, talk 997

Co-Authors: *Wei Wu*, *Masaya Hasebe*, *Koji Nonobe*,

The nurse scheduling problem must be solved in hospitals in order to main the quality of health care. This problem, which is typically formulated as an optimization problem, has been studied by many researchers, particularly in the past two decades. Nowadays, it is possible to find optimal or near-optimal schedules in a reasonable amount of time. Nevertheless, optimization algorithms and techniques are seldom used in Japanese hospitals. To improve this situation, in this paper, we propose an approach that provides schedulers (decision-makers), with an optimal solution together with information that can be used to modify a solution without losing optimality. In order to generate this information, we generate many optimal solutions and analyze their features. To demonstrate our approach, we show some computational results from a benchmark instance.

2 - Mixed Integer Programming Based Merge Search for Open Pit Block Scheduling

Speaker: Davaatseren Baatar, Monash University, AU, talk 702

Co-Authors: *Dhananjay Thiruvady*, *Andreas Ernst*, *Angus Kenny*, *Mohan Krishnamoorthy*, *Gaurav Singh*,

Open-pit mine scheduling is a challenging optimisation problem in the mining industry. It tries to create the best possible open-cut mine plan in order to maximise the net present value of an ore body. This leads to very large mixed integer programming problems that have a strong network structure which can be exploited to obtain a solution to the linear programming relaxation by repeatedly solving maximum flow problems. We investigate mixed integer programming based methods to tackle this problem, starting with some ideas on preprocessing and alternative maximum flow algorithms that can be used to speed up the solution process. We then propose a novel method called *merge search*, which combines parts of existing solutions to generate improvements. We find that merge search is able to provide better quality solutions than those available in the literature and a parallel branch and bound search improves upon the best known upper (relaxed) bounds known to date. Furthermore, we investigate parallel implementations of merge search show empirically that this heuristic approach can efficiently make use of parallel processes to obtain good solutions more rapidly.

3 - Surgical scheduling under uncertainty by approximate dynamic programming

Speaker: Mauricio de Souza, UFMG, BR, talk 1024

Co-Authors: *Thiago Silva*,

Surgical scheduling consists of selecting surgeries to be performed within a day, while jointly assigning operating rooms, starting times and the required resources. Patients can be elective or emergency/urgent. The scheduling of surgeries in an operating theatre with common resources to emergency/ urgent and elective cases are highly subject to uncertainties on the duration of an intervention and on the arrival of emergency/urgent cases. A stochastic process is associated to each clinic determining the probability of arrival, the expected duration and a time window the surgery must start. The day is divided into decision stages. Due to the dynamic nature of the problem, at the beginning of each stage the planner can make decisions taking into account the new information available. Decisions can be to schedule arriving surgeries, and to reschedule or cancel surgeries not started yet. The objective is to minimize the expected costs of refusing arriving surgeries, canceling scheduled surgeries, and starting surgeries out of their time window. We address the problem with an approximate dynamic programming approach embedding an integer programming formulation to support decision making. We propose a dynamic model and an approximate policy iteration algorithm making use of basis functions with coefficients estimated with recursive least squares to capture the impact of decisions to the future stages. Computational experiments on instances based on observed data in practice have shown the proposed algorithm to perform better than a lookhead approach with statistical significance.

Convergence analysis for non smooth optimization

Continuous Optimization

NonSmooth - Fr 8:30am-10:30am, Format: 4x30 min

Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 557

Organizer: Robert Csetnek, University of Vienna, AT

1 - ADMM for monotone operators: convergence analysis and rates

Speaker: Robert Csetnek, University of Vienna, AT, talk 1012

Co-Authors: *Radu Ioan Bot*,

We propose a unifying scheme for several algorithms from the literature dedicated to the solving of monotone inclusion problems involving compositions with linear continuous operators in infinite dimensional Hilbert spaces. We show that a number of primal-dual algorithms for monotone inclusions and also the classical ADMM numerical scheme for convex optimization problems, along with some of its variants, can be embedded in this unifying scheme. While in the first part of the talk convergence results for the iterates are reported, the second part is devoted to the derivation of convergence rates obtained by combining variable metric techniques with strategies based on suitable choice of dynamical step sizes.

2 - Optimal Convergence Rates for Generalized Alternating Projections

Speaker: Mattias Fält, Lund University, SE, talk 1334
Co-Authors: *Pontus Giselsson*,
Generalized alternating projections is an algorithm that alternates relaxed projections onto a finite number of sets to find a point in their intersection. We consider the special case of two linear subspaces, for which the algorithm reduces to a matrix iteration. For convergent matrix iterations, the asymptotic rate is linear and decided by the magnitude of the subdominant eigenvalue. We show how to select the three relaxation-parameters to optimize this magnitude, and hence the asymptotic convergence rate. The obtained rate depends on the Friedrichs angle between the subspaces and is considerably better than known rates for other methods such as alternating projections and Douglas-Rachford splitting. We also present an adaptive scheme that, online, estimates the Friedrichs angle and updates the algorithm parameters based on this estimate. A numerical example is provided, which supports our theoretical claims and shows very good performance for the adaptive method. The results can be used to improve convergence rates for general convex feasibility problems, and opens up for interesting applications to solving huge-scale linear systems.

3 - Newton method for bilevel optimization: Theory+extensive numerical experiments

Speaker: Alain Zemkoho, University of Southampton, GB, talk 1434
We consider the optimistic bilevel optimization problem involving twice continuously differentiable functions. Using the *lower-level optimal value function*, we reformulate the problem into a single-level optimization problem. To construct a tractable Newton method to solve the latter problem, we start by introducing a new stationarity concept, namely, the *KN-I-stationarity conditions*. A detailed analysis of these conditions shows that they lead to standard ones under mild assumptions. The KN-I-type stationarity conditions allow us to design a simple, yet powerful Newton scheme to solve the bilevel optimization problem. From numerical experiments conducted on 126 nonlinear bilevel optimization examples from the literature, our method is able to compute, just within a few seconds, the *true/best known or better solutions* for all the problems with an existing record on their results, i.e., for 114 out of the 126 problems. To the best of our knowledge, this is the first time in the literature where experiments on a method for nonlinear bilevel optimization are conducted at such a scale, and possibly with such a level of success. To achieve this success, appropriate choices had to be made for the exact penalization parameter, usually needed to mitigate the negative effects of the *value function constraint*. By so doing, we also provide a first benchmark study on the selection of this parameter. We will present these results in this talk, including second order sufficient conditions for bilevel optimization.

4 - Inducing strong convergence into the asymptotic behaviour of proximal splitting

Speaker: Dennis Meier, University of Vienna, AT, talk 581
Co-Authors: *Radu Ioan Bot*, *Robert Csetnek*,
Proximal splitting algorithms for monotone inclusions (and convex optimization problems) in Hilbert spaces share the common feature to guarantee for the generated sequences in general weak convergence to a solution. In order to achieve strong convergence, one usually needs to impose more restrictive properties for the involved operators, like strong monotonicity (respectively, strong convexity for optimization problems). In this talk, we propose a modified Krasnoselskii-Mann algorithm in connection with the determination of a fixed point of a nonexpansive mapping and show strong convergence of the iteratively generated sequence to the minimal norm solution of the problem. Relying on this, we derive a forward-backward and a Douglas-Rachford algorithm, both endowed with Tikhonov regularization terms, which generate iterates that strongly converge to the minimal norm solution of the set of zeros of the sum of two maximally monotone operators. Furthermore, we formulate strong convergent primal-dual algorithms of forward-backward and Douglas-Rachford-type for highly structured monotone inclusion problems involving parallel-sums and compositions with linear operators. The resulting iterative schemes are particularized to the solving of convex minimization problems.

Majority judgment

Invited Talks
KEYNOTE - Fr 11:00am-12:00am, Format: 1x60 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 535
Organizer: Martine Labbé, Université Libre de Bruxelles, BE

1 - Majority judgment

Speaker: Michel Balinski, CNRS and Ecole Polytechnique, FR, talk 1576
Every well-known voting procedure in use today hides important vices that can deny the will of the electorate including majority vote with only two candidates (the domination paradox), approval voting, and all methods that ask voters to rank-order candidates. The reason: voters cannot adequately express their opinions. Majority judgment asks voters to express their opinions by evaluating every candidate in a common language of ordinal grades such as: Great, Good, Average, Poor, or Terrible. Majorities determine the electorate's evaluation of each candidate and the ranking between every pair of candidates (necessarily transitive), with the first-placed among them the winner. Majority judgment is described together with real examples of its use. It was specifically designed to (1) permit voters to express their opinions, (2) be meaningful in the sense of measurement theory, (3) guarantee a transitive order-of-finish (avoiding Condorcet's paradox), (4) avoid Arrow's paradox (when the order-of-finish of two candidates depends on the presence/absence of another candidate), (5) combat strategic manipulation and encourage the honest expression of opinions. References M. Balinski and R. Laraki, Majority Judgment: Measuring, Ranking, and Electing, M.I.T. Press 2011. – and –, "Judge: Don't Vote!" Operations Research 62 (2014) 483-511.

and C solver for mixed-integer quadratic problems.

Submodularity in mixed-integer quadratic and conic quadratic optimization

Invited Talks
KEYNOTE - Fr 11:00am-12:00am, Format: 1x60 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 540
Organizer: Daniel Bienstock, Columbia University, US

1 - Submodularity in mixed-integer quadratic and conic quadratic optimization
Speaker: Alper Atamturk, UC Berkeley, US, talk 1667
Submodularity plays an important role in developing effective methods for numerous combinatorial optimization problems. However, its use beyond 0-1 optimization, especially for problems with continuous variables, has been limited. In this talk, we review the recent progress in exploiting submodularity or partial submodularity in mixed 0-1 quadratic and conic quadratic optimization for deriving strong formulations and effective algorithms.

Modern Branch-and-Cut Implementation

Invited Talks
KEYNOTE - Fr 11:00am-12:00am, Format: 1x60 min
Room: BROCA Building: W, 3rd floor, Zone: 0

Invited Session 542
Organizer: Marc Pfetsch, TU Darmstadt, DE

1 - Modern Branch-and-Cut Implementation
Speaker: Matteo Fischetti, University of Padua, IT, talk 1574
The Branch and Cut (B and C) method was proposed in 1990's by Manfred Padberg and Giovanni Rinaldi, and is nowadays the method of choice for the exact solution of Mixed-Integer Linear Programs (MILPs). A typical use of the MILP technology consists in writing a computer program (in any high-level programming language such as C/C++, Python, Matlab, etc.) that reads the input data, internally generates the model of interest, and solves it by invoking appropriate functions provided by the solver. Open-source and commercial MILP solvers provide a wide set of parameters to control its execution. In some cases, however, one is interested in customizing the solver even further, by exploiting some problem-specific knowledge. To this end, modern MILP codes provide so-called "callback functions" that are automatically invoked by the solver at some critical points of its execution. By default, the callbacks are not installed, meaning that they are not active and the solver uses its own default solution strategy. By installing her own callbacks, an advanced user can then take control of the solution algorithm and fully customize it. In the talk we will quickly describe the most-used callback functions for a generic B and C solver for MILPs. As an example of application, we will show how callback functions can be used to allow a given MILP solver to handle (nonconvex) bilinear terms of the form $z_i = x_i y_i$, thus producing a fully-general B

Tseng Memorial Lectureship in Continuous Optimization

Invited Talks
SEMI - Fr 11:00am-12:00am, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 549
Organizer: Yaxiang Yuan, Chinese Academy of Sciences, CN

Bounds for quantum graph parameters by conic and polynomial optimization

Invited Talks
PLENARY - Fr 1:30pm-2:30pm, Format: 1x60 min
Room: Auditorium Building: Symph H, Gambetta, Zone: 0

Invited Session 553
Organizer: Frank Vallentin, University of Cologne, DE

1 - Bounds for quantum graph parameters by conic and polynomial optimization
Speaker: Monique Laurent, CWI and Tilburg University, NL, talk 311
Co-Authors: *Sander Gribling*, *David de Laat*, *Sabine Burgdorf*, *Teresa Piovesan*,
Quantum information is a rich source of challenging optimization problems. In particular, the study of quantum correlations, which are used to model the effect of quantum entanglement, leads to hard optimization problems where the variables may be instantiated to positive semidefinite matrices of arbitrary size (instead of nonnegative scalars in the classical case). This also leads to natural quantum analogues of classical graph parameters like minimum graph coloring and maximum stable sets. We will introduce the relevant concepts and discuss how to model and bound these quantum graph parameters, and other problems over quantum correlations, using tools from conic, semidefinite and noncommutative polynomial optimization.

Estimation and Learning for Power Systems

Specific Models, Algorithms, and Software
Energy - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle DENUCE Building: Q, Ground Floor, Zone: 8

Invited Session 25
Organizer: Javad Lavaei, UC Berkeley, US

1 - Performance Bound for Power System State Estimation via Conic Relaxations

Speaker: Yu Zhang, UC Santa Cruz, US, talk 113

Co-Authors: *Ramtin Madani*,

This talk deals with the non-convex power system state estimation (PSSE) problem, which is vital to the monitoring and operation of electric power grids. Given a set of noisy measurements, PSSE aims at estimating the complex voltage at each bus of the system. We propose a novel convexification framework for the PSSE problem by using semidefinite programming (SDP) and second-order cone programming (SOCP) relaxations. We first study a related power flow problem as the noiseless counterpart. We show that both conic relaxations recover the true solution as long as the voltage angle difference across each line of the network is not too large. By capitalizing on this result, penalized SDP and SOCP problems are designed to solve the PSSE, where a penalty based on the weighted least absolute value is added to fit noisy measurements with possible bad data. Strong theoretical results are given to quantify the optimal solution of the penalized SDP, which is shown to possess a dominant rank-one component formed by lifting the true voltage vector. An upper bound on the estimation error is derived as a function of the noise power, which decreases exponentially fast as the number of measurements increases. Numerical results on benchmark systems corroborate the merits of the proposed approaches.

2 - Spurious Critical Points in Power System State Estimation

Speaker: Richard Zhang, UC Berkeley, US, talk 128

The power systems state estimation problem computes the set of complex voltage phasors given quadratic measurements using nonlinear least squares. This is a nonconvex optimization problem, so even in the absence of measurement errors, local search algorithms like Newton/Gauss-Newton can become "stuck" at local minima, which correspond to nonsensical estimations. In this talk, we observe that local minima cease to be an issue as redundant measurements are added. Posing state estimation as an instance of the quadratic recovery problem, we derive a bound for the distance between the true solution and the nearest spurious local minimum. We use the bound to show that critical points of the nonconvex least squares objective become increasing rare and far-away from the true solution with the addition of redundant information.

3 - Vulnerability analysis and robustification of power grid state estimation

Speaker: Ming Jin, UC Berkeley, US, talk 119

The integration of sensing and information technology renders the power grid vulnerable to cyber-attacks. To understand how robust state estimators are, we study their behavior under worst attacks possible. Three types of data injection attacks are formulated in an optimization with “unobservability” and “sparse attack” constraints. A novel treatment of the continuous nonconvexity and discrete nonlinearity of the problem is proposed based on semidefinite programming (SDP) relaxation with a sparsity penalty, where a rank-1 and sparse solution exists under mild conditions. In light of the analysis, we discuss measures to improve the robustness of power grid, and how this method can be used to strengthen the current bad data detection scheme.

Interior Point Methods in Engineering Applications I

CONTINUOUS OPTIMIZATION

NLP - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: GINTRAC Building: Q, Ground Floor, Zone: 8

INVITED SESSION 60

Organizer: Jacek Gondzio, University of Edinburgh, GB

1 - A (non)convex interior-point implementation tuned for radiotherapy optimisation

Speaker: Sebastiaan Breedveld, Erasmus MC, NL, talk 516

Co-Authors: *Rens van Haveren*, *Ben Heijmen*,

Radiotherapy is used to treat patients suffering from cancer. Prior to treatment, a treatment plan has to be generated that describes how the radiation dose is distributed inside the patient, aiming for a high dose to the tumour while maximally sparing surrounding tissues. Since both short solution times and optimality of the solution are important for this application, we developed an interior-point implementation tuned specifically for this. Typical of the application-specific large-scale problem is the mixture of sparse and dense data matrices, which we permute and tile to exploit the problem structure and reduce the time per iteration, making it 2.2 times faster than the naive method. The tiling also improves scalability on multiprocessor systems, with a factor 9.8 on 16 threads compared to 7.7 for the naive method. Among other application-specific elements, we can also assume a limited set of predefined cost-functions for which the first and second order derivatives have a computationally-efficient canonical form, simplifying the implementation.

2 - Refined planning tools for external radiotherapy using interior point methods

Speaker: Lovisa Engberg, KTH, SE, talk 540

Co-Authors: *Anders Forsgren*,

In radiotherapy treatment planning, the planner utilizes optimization tools in a treatment planning software to create a plan that meets the clinical goals. The goals are to minimize or maximize (for tumors) multiple “partial-volume doses”, i.e., doses received at certain percentiles of structures of interest. A financial analogue is to optimize the intractable value-at-risk (VaR) measure. The current planning tools model the clinical goals implicitly by penalty-based objective functions. We suggest an explicit approach to strengthen the correlation between tools and clinical goals, aiming at facilitating the planning process. A convex formulation is achieved by approximating partial-volume dose by mean tail-dose (conditional VaR). The resulting formulation is in fact a linear program, but its size is of large scale compared to the conventional penalty-based formulation. Applying a primal-dual interior point method allows us to exploit the problem structure and significantly reduce the size of the associated system of linear equations. Higher-order techniques are employed to handle the fact that the reduced system is relatively expensive to form. A parallel advantage of applying the interior method is the opportunity to interpret the dual gap optimality tolerance as a dose tolerance, owing to the explicit objective functions being interpretable as dose. While usually relating to machine precision, the optimality tolerance in our application can be chosen less conservative: pushing the method much further than to a certain dose tolerance is not expected to be meaningful.

3 - Computational Study of a Primal-Dual Penalty-

Interior-Point Algorithm
Speaker: Renke Kuhlmann, Universität Bremen, DE, talk 79
Co-Authors: *Christof Büskens*,
Interior-point methods have been shown to be very efficient for large-scale nonlinear programming. The combination with penalty methods increases their robustness due to the regularization of the constraints caused by the penalty term and have enjoyed an increased popularity recently. A special class of these are penalty-interior-point algorithms, where neither the penalty nor the barrier parameter have to converge to zero. This avoids the ill-conditioning of the linear equation system near the optimal solution which is a valuable property for a post-optimality parametric sensitivity analysis. In this talk we would like to present a practical implementation of such a method in the nonlinear programming solver WORHP and study the application of adaptive barrier and penalty updates. The numerical performance is compared to the classic log-barrier interior-point algorithm of WORHP and IPOPT on the CUTEst test set.

Advances in the first-order methods for convex optimization

Continuous Optimization
NonSmooth - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 8 Building: N, 4th floor, Zone: 12

Invited Session 73
Organizer: Angelia Nedich, ASU, US

1 - Accelerated curvature-aided incremental aggregated gradient method
Speaker: Hoi To Wai, Arizona State University, US, talk 310
Co-Authors: *Wei Shi*, *Cesar Uribe*, *Angelia Nedich*, *Anna Scaglione*,
This paper proposes an accelerated curvature-aided incremental aggregated gradient (A-CIAG) method for solving strongly convex optimization problems arising in large-scale learning problems. The proposed method utilizes a new curvature-aided gradient tracking technique to produce accurate gradient estimations with the aids of Hessian information during the computation. To compute an ϵ-optimal solution, we show that the A-CIAG method requires only $O(\sqrt{\kappa(F)}\log(1/\epsilon))$ *incremental* steps, where $\kappa(F)$ is the problem's condition number, i.e., the same number of steps involved in full gradient computation for the Nesterov's accelerated method, provided that the initialization is close to an optimal solution. Thus, A-CIAG achieves the optimal rate for first order methods using just incremental updates. Numerical experiments on synthetic and real data confirm our findings.

2 - Fast Incremental Gradient Method for Optimization with Linear Constraints
Speaker: Tatiana Tatarenko, TU Darmstadt, DE, talk 322
Co-Authors: *Angelia Nedich*,
In this work we prove applicability of a fast incremental gradient method, which has been recently presented in the literature on unconstrained composite convex optimization, to convex optimization problems with a large number of linear inequality constraints. For this purpose we present a novel approach based on inexact but smooth penalty functions. This approach provides a reformulation of initial constrained optimization problems in terms of unconstrained optimization with the guarantees that the resulting penalized unconstrained problem has a feasible solution within a predefined neighborhood of the initial problem solution set. Such reformulation allows us to use the incremental gradient method that at each iteration requires only one inequality constraint observation. Moreover, the presented algorithm converges to a predefined neighborhood of some solution with optimal rates in both cases of convex and strongly convex optimization.

3 - Efficient Methods For Edge-weighted TV Models with Sphere Constraints
Speaker: Maryam Yashtini, Georgetown University, US, talk 377
Co-Authors: *Sung Ha Kang*, *Wei Zhu*,
Alternating minimization algorithms are developed to solve variational models for image colorization based on chromaticity and brightness color system. The proposed methods are based on operator splitting, augmented Lagrangian and alternating direction method for multipliers. Some analytic results as well as numerical results will be presented.

Outer Convexification and Mixed-Integer Optimal Control

Discrete Optimization & Integer Programming
MINLP - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Invited Session 103
Organizer: Sebastian Sager, University Magdeburg, DE

1 - Improved Regularity Assumptions for Partial Outer Convexification of MIPDECOs
Speaker: Paul Manns, TU Braunschweig, DE, talk 833
Co-Authors: *Christian Kirches*,
Partial outer convexification is a relaxation technique for Mixed-Integer Optimal Control Problems being constrained by time-dependent differential equations. Sum-Up-Rounding algorithms allow to approximate feasible points of the relaxed, convexified continuous problem with binary ones that are feasible up to an arbitrarily small $\delta > 0$. We show that this approximation property holds for ODEs and semilinear PDEs under mild regularity assumptions on the nonlinearity and the solution trajectory of the PDE. In particular, we are able to show that we can give up all requirements of differentiability and uniformly bounded derivatives of the involved functions that have been imposed in previous work.

2 - Combinatorial Integral Approximation Decompositions for Mixed-Integer Control
Speaker: Clemens Zeile, University of Magdeburg, DE, talk 505
Co-Authors: *Tobias Weber*, *Sebastian Sager*,
Decomposing the nonlinear and the integer part in mixed-integer nonlinear programs (MINLPs) seems promising from a computational point of view. In general, however, no bounds on the objective value gap can be guaranteed and iterative procedures with potentially many subproblems are necessary. The situation is different for mixed-integer optimal control problems with binary choices that switch over time. Here, a priori bounds were derived for a decomposition into one continuous nonlinear control problem and one mixed-integer linear program, the combinatorial integral approximation (CIA) problem. We generalize and extend the decomposition idea.

First, we derive different de- compositions and analyze the implied a priori bounds. Second, we propose several strategies to generate promising candidate solutions for the binary control functions in the original problem. We discuss numerical results of the algorithm applied to a collection of benchmark problems.

3 - Global optimization of ODE constrained network problems

Speaker: Oliver Habeck, TU Darmstadt, DE, talk 376

Co-Authors: *Marc Pfetsch*, *Stefan Ulbrich*,

We present a new approach for finding global solutions of mixed-integer nonlinear optimization problems with ordinary differential equation constraints on networks. Throughout the talk, we will illustrate our approach on the example of stationary gas transport. Instead of using a first discretize then optimize approach, we combine spatial and variable branching with appropriate discretizations of the differential equations to derive relaxations of the original problem. To construct the relaxations we first define under- and overestimators for the ODE solution operator, i.e., the mapping from initial values to end values, by using numerical discretization schemes. From this we derive under certain conditions convex under- and concave overestimators, such that we can define a convex relaxation of the original problem. Thereby, we make use of the underlying network structure, where the solutions of the ODEs only need to be known at the nodes. This property enables us to introduce the relaxation without adding new variables to the problem. Futhermore, this allows us to adaptively refine the discretization and the relaxation. The incorporation into a spatial branch-and-bound process yields an algorithm, which can find ε-optimal solutions or decide infeasibility and terminates finitely under some natural assumptions. We provide some computational examples and show how the relaxations can be improved by representing physical conditions with binary variables.

Relative Entropy Optimization I

Continuous Optimization

SDP - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle LC5 Building: L, Intermediate 1, Zone: 10

Invited Session 111

Organizer: Venkat Chandrasekaran, Caltech, US

1 - Exactness of Relative Entropy Relaxations for Signomial Programs

Speaker: Riley Murray, Caltech, US, talk 1685

Signomial programs are typically non-convex, and include NP-Hard problems as special cases. A number of engineering design problems (particularly in aerospace and chemical engineering) can be encoded as signomial programs. In this talk discuss exactness of convex relative entropy relaxations for signomial programs.

2 - Certificates of nonnegativity via conic lifts

Speaker: Hamza Fawzi, University of Cambridge, GB, talk 257

I will discuss a generic way to obtain relaxations for nonconvex problems via certain lifting maps to a convex cone. Many existing relaxations based on LP, SDP, geometric programming, or relative entropy programming correspond to a specific choice of a lifting map. I will explain how this point of view can be used to design new relaxations for nonconvex optimization problems involving entropy-like functionals, and will discuss some applications in information theory.

3 - Exponential cone in MOSEK: overview and applications

Speaker: Michal Adamaszek, MOSEK ApS, DK, talk 152

There are two major additions to the conic optimization capabilities in upcoming version 9 of MOSEK: the exponential cone and the power cone. I will discuss the techniques used for optimizing over the exponential cone $x \geq y \exp(z/y)$ and present sample applications of MOSEK for problems involving constraints of this type.

Advances in DFO IV

Continuous Optimization

DerFree - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 125

Chair: Katya Scheinberg, Lehigh University, US

1 - New methods for blackbox optimization via structured gradient estimation

Speaker: Krzysztof Choromanski, Google Brain Robotics, US, talk 599

Co-Authors: *Mark Rowland*, *Vikas Sindhwani*, *Richard Turner*, *Adrian Weller*,

In this talk we present new methods for conducting high-dimensional blackbox optimization in the setting where gradients of function F under consideration are not directly available, but F can be queried (possibly in a noisy environment where output values are perturbed by noise). A standard approach to conduct optimization in such a setting is finite difference method that finds approximate values of the coordinates of the gradient vector in the standard canonical basis via small perturbations of a blackbox function along the directions of the canonical basis and finite difference measurements. Our new approach is based on using rows of structured orthogonal pseudo-random matrices as directions of gradient sensing. As a result, we propose new Monte Carlo estimators of the gradients of Gaussian smoothings that provide stronger concentration guarantees that standard baselines. We provide theoretical justification of the superiority of random orthogonal mechanism over state-of-the-art and show that it leads to more efficient blackbox optimization on the example of learning high-dimensional policies for robotics tasks encoded by fully connected neural networks. Our mechanism is also much more robust to noise than a standard one. As a byproduct, not only do we propose more accurate optimization algorithms, but faster ones. Our computational gains come from the exploration of properties of certain structured constructions under consideration, in particular Hadamard random matrices and random orthogonal matrices obtained via the so-called Kac's random walks.

2 - Scaling up and Randomizing Derivative Free Optimization for Machine Learning

Speaker: Katya Scheinberg, Lehigh University, US, talk 1079

Co-Authors: *Liyuan Cao*, *Hiva Ghanbari*,

We will introduce several black-box optimization problems arising in machine learning and reinforcement learning and discuss what challenges and opportunities these new applications present for the current algorithms. In particular for these applications the derivative-free methods need to scale up to thousands of variables, but on the other hand, can utilize parallel computations effectively and can benefit from randomized techniques. We will introduce several new and existing algorithms from this new perspective and compare their theoretical and numerical behavior.

3 - Globally Convergent Simulation-Based Optimization with Integer Variables

Speaker: Prashant Palkar, IIT Bombay, IN, talk 1463

Co-Authors: *Jeffrey Larson*, *Sven Leyffer*, *Stefan Wild*,

We present an iterative method for optimizing computationally expensive functions involving integer variables. We assume that the objective function is convex, its gradients are unavailable, and it can not be evaluated at nonintegral values of certain variables. Our method constructs secants that interpolate the objective function at previously evaluated points. These secant functions underestimate the objective in certain truncated polyhedral cones in the feasible region. We derive 'conditional' cuts using these secants, which collectively yield a nonconvex piecewise linear underestimator model of the objective function over the entire feasible region. We study two approaches for minimizing this model over a bounded integer lattice in order to generate iterates. In the first approach, we solve a sequence of integer programs to tighten the lower bound on the objective function. In the second approach, we heuristically evaluate the model values. We show that our method converges to a global minimizer under mild conditions and present some numerical results demonstrating the same.

Algorithms for optimization and variational problems with possibly nonisolated solutions II

Continuous Optimization

Variat - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 153

Organizer: Alexey Izmailov, Moscow State University, RU

1 - A globally convergent LP-Newton method for piecewise smooth constrained equation

Speaker: Mikhail Solodov, IMPA, BR, talk 236

Co-Authors: *Andreas Fischer*, *Alexey Izmailov*, *Markus Herrich*, *Wladimir Scheck*,

The LP-Newton method for constrained equations, introduced some years ago, has powerful properties of local superlinear convergence, covering both possibly nonisolated solutions and possibly nonsmooth equation mappings. We develop a related globally convergent algorithm, based on the LP-Newton subproblems and linesearch for the equation's infinity-norm residual. In the case of smooth equations, global convergence of this algorithm to B-stationary points of the residual over the constraint set is shown, which is a natural result: nothing better should generally be expected in variational settings. However, for the piecewise smooth case only a property weaker than B-stationarity can be guaranteed in general. We then develop an additional procedure for piecewise smooth equations that avoids undesirable accumulation points, thus achieving the intended property of B-stationarity.

2 - Some Developments on Multiplier Methods in Cone-Constrained Optimization

Speaker: Daniel Steck, University of Wuerzburg, DE, talk 185

Co-Authors: *Christian Kanzow*,

The augmented Lagrangian method (ALM) is a classical technique for nonlinear programming which has strong connections to convex analysis. In this talk, we discuss some recent developments on ALMs in finite dimensions, including applications to arbitrary cone-constrained problems and the use of safeguarded multiplier sequences. In addition, global and local convergence results are presented under varying assumptions such as constraint qualifications, second-order conditions, or local error bounds.

3 - On the second order augmented Lagrangian method for MPCC

Speaker: Paulo Silva, University of Campinas, BR, talk 101

Co-Authors: *Roberto Andreani*, *Leonardo Secchin*,

In this talk we will study the behavior of the augmented Lagrangian method when applied to solve mathematical programs with complementarity constraints (MPCC). Even though MPCC do not satisfy the majority of the usual constraint qualifications (CQs) for standard nonlinear optimization, Izmailov, Solodov and Uskov proved that the augmented Lagrangian method, under MPCC Linear Independence Constraint Qualification (MPCC-LICQ), converge to strongly stationary (S-stationary) points, if the multiplier sequence is bounded. If the multiplier sequence is not bounded it only recovers Clarke stationary (C-Stationary) points. We will show that this last result can be improved in two ways. First, for the case of bounded multipliers, we are able to weaken the qualification condition to the much more general MPCC-Relaxed Positive Linear Dependence condition (MPCC-RCLPD). For the case of unbounded multipliers, we show that using a second-order variation of the method it is possible to ensure convergence to at least Mordukhovich stationary (M-stationary) points. However, the stringent MPCC-LICQ condition is still needed. Finally, we present some numerical experiments that confirms our findings.

Submodular Maximization.

Discrete Optimization & Integer Programming

APPROX - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 179

Organizer: Justin Ward, QMUL, GB

1 - Robust Maximization of Submodular Objs. in the Presence of Adversarial Removals

Speaker: Ilija Bogunovic, EPFL, CH, talk 306

Co-Authors: *Slobodan Mitrovic*, *Volkan Cevher*, *Junyao Zhao*, *Jonathan Scarlett*,

We consider the problem of maximizing a monotone submodular set function subject to a cardinality constraint k in the setting where some number of elements τ is deleted from the returned set. The focus of this work is on the worst-case adversarial setting. We provide efficient algorithms that achieve constant factor approximation guarantees in both the centralized and streaming setting. Our algorithms exhibit a high-level of robustness, in some cases, even allowing for any number of removals. We also prove the first constant-factor approximation guarantees for a wider class of non-submodular objectives. Finally, we numerically demonstrate the robust performance of our algorithms on various real-world datasets.

2 - Robust submodular maximization under matroid constraints

Speaker: Alfredo Torrico, Georgia Tech, US, talk 708

Co-Authors: *Mohit Singh*, *Sebastian Pokutta*, *Nika Haghtalab*, *Nima Anari*, *Seffi Naor*,

We consider the robust submodular maximization problem subject to a matroid constraint in the offline as well as online setting. In the offline version we are given a collection of k monotone submodular functions and a matroid on a ground set of size n. The goal is to select one independent set that maximizes the minimum of the submodular functions. This problem is known to be NP-hard to approximate to any polynomial factor. We design a bi-criteria approximation algorithm that returns a set S with (nearly) optimal value and such that it is the union of few independent sets. In the online version of the problem, we receive a new collection of functions at each time step and aim to pick an independent set in every stage. We measure the performance of the algorithm in the regret setting where the goal is to give a solution that compares well to picking a single set for all stages. Again, we give a bi-criteria approximation algorithm which has a (nearly) optimal approximation as well as sub-linear regret bounds.

3 - Submodular Optimization: From Discrete to Continuous and Back

Speaker: Amin Karbasi, Yale, US, talk 1509

Many procedures in statistics and artificial intelligence require solving non-convex problems. Historically, the focus has been to convexify the non-convex objectives. In recent years, however, there has been significant progress to optimize non-convex functions directly. This direct approach has led to provably good guarantees for specific problem instances such as latent variable models, non-negative matrix factorization, robust PCA, matrix completion, etc. Unfortunately, there is no free lunch and it is well known that in general finding the global optimum of a non-convex optimization problem is NP-hard. This computational barrier has mainly shifted the goal of non-convex optimization towards two directions: a) finding an approximate local minimum by avoiding saddle points or b) characterizing general conditions under which the underlying non-convex optimization is tractable. In this talk, I will consider a broad class of non-convex optimization problems that possess special combinatorial structures. More specifically, I will focus on maximization of stochastic continuous submodular functions that demonstrate diminishing returns. Despite the apparent lack of convexity in such functions, we will see that first order methods can indeed provide strong approximation guarantees.

Intersection cuts, disjunctions, and valid inequalities

Discrete Optimization & Integer Programming

MINLP - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 180

Organizer: Eli Towle, University of Wisconsin, US

1 - Outer-product-free Sets for Polynomial Optimization

Speaker: Daniel Bienstock, Columbia University, US, talk 149

Co-Authors: *Chen Chen*, *Gonzalo Muñoz*,

Polynomial optimization may be represented (after lifting) as a problem of minimizing a linear objective function over $S \cap P$, where $S := \{X \in \mathbb{S}^{n \times n} | X = xx^T, x \in \mathbb{R}^n\}$, and P is a polyhedron. We apply the S-free approach to polynomial optimization, and so consider outer-product-free sets: closed convex sets in $\mathbb{S}^{n \times n}$ with interiors that do not intersect with S. We identify families of (inclusion-wise) maximal outer-product-free sets, and discuss how to generate (and implement) intersection cuts from such sets.

2 - Synthetizing branch-and-bound information into cutting planes

Speaker: Egon Balas, Carnegie Mellon University, US, talk 1323

Co-Authors: *Aleksandr Kazachkov*,

Valid cutting planes for mixed integer programs can be derived from any disjunction implied by the integrality constraints. However, some such disjunctions, and hence the resulting cuts, are stronger than others, and the differences are instance-dependent. We discuss a method for deriving cuts from instance-specific disjunctions, i.e. disjunctions that are chosen by using information generated by a partial branch and bond procedure. The cuts are derived from a V-polyhedral representation of the disjunction, whose H-polyhedral counterpart corresponds to a certain class of lift-and- project cuts.

3 - Intersection disjunctions for reverse convex sets

Speaker: Eli Towle, University of Wisconsin, US, talk 691

Co-Authors: *Jim Luedtke*,

We present a framework to obtain valid inequalities for non-convex optimization problems. Specifically, we derive inequalities valid for a reverse convex set, which is defined as the set of points in a polyhedron that lie outside a given open convex set. Reverse convex sets can be used to model certain bilevel programs. Additionally, constraints involving any function representable as the difference of convex functions, which includes all twice continuously differentiable functions, can be reformulated with one convex and one reverse convex constraint. In general, reverse convex sets are non-convex and disconnected. Intersection cuts are a well-known method for generating valid inequalities for reverse convex sets. Intersection cuts are generated from a basic solution that lies within the convex set. Our contribution is a disjunctive framework that uses basic solutions that lie outside the convex set to generate valid inequalities. We begin by proposing an extension to intersection cuts that defines a two-term disjunction for a reverse convex set. Next, we generalize this analysis to a multi-term disjunction by considering the convex set's recession directions. We present a polyhedral relaxation for each term of the disjunction, allowing the approach to be used to generate disjunctive cuts.

Risk-aware decision making

Optimization under Uncertainty

Stoch - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 32 Building: B, Ground Floor, Zone: 5

Invited Session 251
Organizer: Minseok Ryu, University of Michigan, US

1 - Medical Homecare Delivery with Time-dependent Stochastic Travel Time
Speaker: Hideaki Nakao, University of Michigan, US, talk 1048
Co-Authors: *Siqian Shen*,
We formulate a variant of stochastic vehicle routing problem for medical home care delivery, in which we consider multiple vehicles being dispatched from multiple depots to serve patients having soft time windows. The travel time between patients are random and the distributions are known but differ over time due to peak hour congestion. We also consider stochastic service time at patients' locations. We formulate a two-stage stochastic mixed-integer linear program, in which we decide routes and schedules in the first stage to minimize the total vehicle traveling cost plus the second-stage expected penalty cost of patient waiting and overtime use of vehicles and medical staff. We propose two approaches: One uses modified Benders cuts based on reformulation linearization technique (RLT) and the other uses scenario decomposition. Via numerical studies, we compare the CPU time of the two approaches and measure the performance of solutions in both in-sample and out-of-sample tests under different parameter settings, especially when statistics of the travel time vary significantly over time.

2 - A stochastic programming approach for optimization of latent disease detection
Speaker: Zheng Zhang, University of Michigan, US, talk 1178
Co-Authors: *Brian Denton*,
Latent diseases, such as cancer, can develop undetected over time. Many diagnostic tests have been developed in recent years, motivating the need to optimize clinical decisions for whether and when to test patients in a way that detects the disease early and limits harm from unnecessary testing. Most approaches have focused on dynamic models and the use of partially observable Markov decision processes. In this talk, we present a new approach based on the use of a stochastic programming formulation. We present a general latent disease detection problem in which patients vary on the basis of personalized risk factors, and there are multiple types of diagnostic tests, and multiple strategies for performing the tests The decision variables include the binary assignment of patients to strategies, when and how frequently the tests are performed in each strategy, and patient-specific recourse decisions including the detected probability for each patient over time, the missed probability of detection, and the total use of testing. We present several objective functions that apply to different decision-makers including expected cost, the delay time until detection and quality of life measures of patients. We develop a decomposition-based algorithm as a solution method for the model. We describe a method for strengthening the formulation and ways to customize the optimality cuts based on the structure of the problem. We also provide insights based on the application of this model to optimize strategies for active surveillance of prostate cancer.

3 - Nurse staffing under uncertain demand and absenteeism
Speaker: Minseok Ryu, University of Michigan, US, talk 1123
Co-Authors: *Ruiwei Jiang*,
This paper describes a data-driven approach for nurse staffing decision under uncertain demand and absenteeism. We propose a distributionally robust nurse staffing (DRNS) model with both exogenous (stemming from demand uncertainty) and endogenous uncertainty (stemming from nurse absenteeism). We provide a separation approach to solve the DRNS model with general nurse pool structures. Also, we identify several classes of nurse pool structures that often arise in practice and show how the DRNS model in each of these structures can be reformulated as a monolithic mixed-integer linear program (MILP) that facilitates off-the-shelf commercial software. Built upon the DRNS model, furthermore, we propose an optimal nurse pool design model, which produces an optimal pool structure that minimizes the number of cross-training while achieving the target staffing cost.

Combinatorial aspects of Linear Programming

Discrete Optimization & Integer Programming
COMB - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2

Invited Session 259
Organizer: Daniel Dadush, CWI, NL

1 - A Friendly Smoothed Analysis of the Simplex Method
Speaker: Sophie Huiberts, CWI, NL, talk 158
Co-Authors: *Daniel Dadush*,
The simplex method for linear programming is known for its good performance in practice, although the theoretical worst-case performance is exponential in the input size. The smoothed analysis framework of Spielman and Teng (2001) aims to explain the good practical performance. In our work, we improve on all previous smoothed complexity results for the simplex algorithm on all parameter regimes using with a substantially simpler and more general proof.

2 - Geometric Rescaling Algorithms for Submodular Function Minimization
Speaker: Giacomo Zambelli, London School of Economics, GB, talk 373
Co-Authors: *Daniel Dadush*, *Laszlo Vegh*,
We present a new class of polynomial-time algorithms for submodular function minimization (SFM), as well as a unified framework to obtain strongly polynomial SFM algorithms. Our new algorithms are based on simple iterative methods for the minimum-norm problem, such as the conditional gradient and the Fujishige-Wolfe algorithms. We exhibit two techniques to turn simple iterative methods into polynomial-time algorithms. Firstly, we use the geometric rescaling technique, which has recently gained attention in linear programming. We adapt this technique to SFM and obtain a weakly polynomial bound $O((n^4EO + n^5)\log(nL))$. Secondly, we exhibit a general combinatorial black-box approach to turn any strongly polynomial εL-approximate SFM oracle into a strongly polynomial exact SFM algorithm. This framework can be applied to a wide range of combinatorial and continuous algorithms, including pseudo-polynomial ones. In particular, we can obtain strongly polynomial algo-

rithms by a repeated application of the conditional gradient or of the Fujishige-Wolfe algorithm. Combined with the geometric rescaling technique, the black-box approach provides a $O((n^5 EO + n^6)\log^2 n)$ algorithm. Finally, we show that one of the techniques we develop in the paper, “sliding”, can also be combined with the cutting-plane method of Lee, Sidford, and Wong, yielding a simplified variant of their $O(n^3 \log^2 nEO + n^4 \log^{O(1)} n)$ algorithm.

3 - A Simpler and Faster Strongly Polynomial Algorithm for Generalized Max-Flow

Speaker: Neil Olver, Vrije Universiteit Amsterdam, NL, talk 99

Co-Authors: *Laszlo Vegh*,

We present a new strongly polynomial algorithm for generalized flow maximization. The first strongly polynomial algorithm for this problem was given [Vegh ’16]; our new algorithm is much simpler, and much faster. The complexity bound $O((m + n \log n)mn \log(n^2/m))$ improves on the previous estimate by Vegh by almost a factor $O(n^2)$. The key new technical idea is relaxing primal feasibility conditions. This allows us to work almost exclusively with integral flows, in contrast to all previous algorithms for the problem.

Computational Integer Programming I

Specific Models, Algorithms, and Software

Algo - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 273

Organizer: Domenico Salvagnin, University of Padova, IT

1 - Exploiting Degeneracy in MIP

Speaker: Tobias Achterberg, Gurobi, DE, talk 412

Co-Authors: *Zonghao Gu*, *Edward Rothberg*,

Mixed integer programs arising from practical applications typically feature highly degenerate solutions to their LP relaxation. Consequently, these LPs have multiple optimal solutions, often both in the primal and the dual space. This degeneracy is arguably the main reason for performance variability of LP based MIP solvers. In recent years, various authors have investigated different aspects of LP degeneracy in MIP solving. One line of research is to try to exploit degeneracy in order to improve the performance of MIP solvers or to reduce the solvers’ variability. Examples are Zanette’s, Fischetti’s, and Balas’ work on using the lexicographic simplex for Gomory cuts, the "pump reduce" step in CPLEX, or the "degenerate reduced cost fixing" implemented in the SAS/OR solver. Most recently, Bajgiran, Cire, and Rousseau presented a more systematic way to pick dual optimal LP solutions in order to improve reduced cost fixing. This talk explains some of the methods in Gurobi to exploit LP degeneracy for MIP solving. Computational results assess the practical impact of the various techniques.

2 - Online Estimation of the Size of the Branch and Bound Tree in MIP Solvers

Speaker: Pierre Le Bodic, Monash University, AU, talk 197

We present an online method that estimates the final size of the branch-and-bound tree in Mixed-Integer Programming solvers. This in turn allows to estimate the total running time. The method combines an old sampling method due to Knuth (1975) and recent work on branching by Le Bodic and Nemhauser (2017). This method is implemented in the MIP solver SCIP and its results are displayed as an extra column.

3 - Multi-Row Intersection Cuts based on the Infinity Norm

Speaker: Alinson Xavier, Argonne National Laboratory, US, talk 858

Co-Authors: *Ricardo Fukasawa*, *Laurent Poirrier*,

When generating multi-row intersection cuts for Mixed-Integer Linear Programming, an important practical question is to decide which intersection cuts to use. Even when restricted to cuts that are facet-defining for the corner relaxation, the number of potential candidates is still very large. In this talk, we introduce a subset of intersection cuts based on the infinity norm that is very small, works for relaxations with arbitrary number of rows, and, unlike many subclasses studied in the literature, takes into account the entire data from the simplex tableau. We perform computational experiments to evaluate their practical effectiveness in real-world instances and conclude that they yield, in terms of gap closure, around 50

Branch-and-cut techniques

Discrete Optimization & Integer Programming

MINLP - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 35 Building: B, Intermediate, Zone: 4

Invited Session 277

Organizer: Teodora Dan, Université de Montréal, CA

1 - A branch-and-bound algorithm for a bilevel location-allocation model

Speaker: Teodora Dan, Université de Montréal, CA, talk 1039

Co-Authors: *Andrea Lodi*, *Patrice Marcotte*,

We propose an exact branch-and-bound framework for determining the optimal locations and service levels associated with facilities, incorporating congestion and competition. A salient feature of our model is that user behavior is explicitly taken into account. Users patronize the facility that minimizes their individual disutility, expressed as the sum of travel time and queueing delay. This situation can be modeled as a highly nonlinear bilevel program that involves discrete and continuous variables, where the leader’s objective function integrates the equilibrium resulting from the choice of locations and the associated service levels. The piecewise linear approximation that we created for the lower level nonlinear terms guarantee a valid upper bound for this problem, that we further reduce to a MILP. Whenever an integer solution is achieved, a lower bound is computed by solving the follower’s mathematical program. We also propose a recipe for computing tighter valid upper bounds at some nodes of the branch-and-bound tree. Numerical results will be presented and discussed.

2 - Improving branching for disjunctive models via approximate convex decompositions

Speaker: Lovis Anderson, Zuse Institute Berlin, DE, talk 1229

Co-Authors: *Benjamin Hiller*, *Tom Walther*,

Disjunctive sets arise in a variety of optimization models and much research has been devoted to obtain strong relaxations for them. We argue that in certain cases the branching possibilities (i.e. binary variables) of the usual formulations are unsuitable to obtain strong bounds early in the search process as they do not capture the overall shape of the entire disjunctive set. As a remedy, this paper proposes to exploit the shape of the disjunctive set via a hierarchy of approximate convex decompositions (ACDs). We introduce a method to compute such a hierarchy that yields tighter relaxations on each level. The main ingredient is a sweep-plane algorithm to analyze the geometric structure of the non-convex body and to find cuts which separate the disjunction into two parts that are closer to their respective convex hulls. We show how to use an ACD hierarchy to extend the optimization model to obtain improved branching behavior.

3 - Learning with Cutting Planes
Speaker: Tu Nguyen, Johns Hopkins University, US, talk 638
Co-Authors: *Amitabh Basu*, *Marco Molinaro*, *Sriram Sankaranarayanan*,
Traditionally, optimization algorithms have been used in machine learning algorithms, in particular during the training phase. There has now been a coming wave of interest in doing the inverse: applying learning to solve optimization problems. In this project, we attempt to use learning in cutting plane methods. Nowadays, most, if not all, of the commercial MILP solvers utilize Gomory mixed integer cuts (GMI) to reduce the feasible region. However, through computational experiments, we found out that there are certain classes of problems where using multi-row Gomory cuts outperforms GMI. We then strive to train a classifier to help us decide whether a certain problem is good for applying multi-row Gomory cuts just by looking at the problem in standard form.

Polyhedral theory in practice

Discrete Optimization & Integer Programming
IPtheory - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 309
Organizer: Mourad Baiou, CNRS, FR

1 - The Stop Number Minimization Problem: polyhedral analysis
Speaker: Rafael Colares, LIMOS UCA, FR, talk 1438
Co-Authors: *Mourad Baiou*, *Hervé Kerivin*,
Stop Number Minimization Problem (SNMP) arises in the management of a dial-a-ride system with autonomous vehicles. A fleet of capacitated vehicles travels along a circuit with predefined stations in a clockwise direction and clients demand for a ride between stations. SNMP consists of assigning requests to vehicles such that no vehicle gets overloaded and the number of stops is minimized. Formally, let $V = \{1, \ldots, n\}$ be the set of stations sequentially ordered as they appear in the circuit and $E = \{e_1, \ldots, e_m\}$ be the set of demands such that each demand $e \in E$ is specified by an origin $o_e \in V$ and a destination $d_e \in V$. Also, let K be the set of available vehicles each with capacity C. Let $\Delta_E(v) = \{e \in E : o_e \leq v \text{ and } d_e \geq v+1\}$ be the set of demands that cross or starts at station v. Then a feasible solution to SNMP is a partition of E into $|K|$ subsets $\{E_1, \ldots, E_{|K|}\}$, such that $|\Delta_{E_i}(v)| \leq C$ for any $i \in K$ and $v \in V$. Given a feasible solution $\{E_1, \ldots, E_{|K|}\}$, vehicle $i \in K$ stops in every station of $V(E_i)$. Thus, the cost of a solution is $\sum_{i=1}^{|K|} |V(E_i)|$. SNMP is to find a feasible solution of minimum cost. We explore the relations between SNMP and matching problems. Indeed, we may use maximum matching problem to solve a special case of SNMP. In this way, we abuse of Edmonds blossom inequalities in order to derive new valid inequalities for the SNMP. We give necessary and sufficient conditions for which inequalities are facet-defining and derive an efficient branch-and-cut algorithm.

2 - On the nucleolus of shortest path and network disconnection games
Speaker: Francisco Barahona, IBM Research, US, talk 1431
Co-Authors: *Mourad Baiou*,
We study two cooperative games in networks, namely the "Shortest Path Game" and "Network Disconnection Game." We give polynomial combinatorial algorithms for testing membership to the core, and to compute the nucleolus.

3 - On some network security games
Speaker: Mourad Baiou, CNRS, FR, talk 1329
Co-Authors: *Francisco Barahona*,
Given a matroid M defi ned by an independence oracle on a ground set E, the Matroid Base Game is played by two players: the defender chooses a basis B and (simultaneously) the attacker chooses an element $e \in E$. The attacker incurs a cost $c(e)$ for choosing an element e, and if $e \in B$ then there is a probability $p(e)$ that the attacker will detect the defender. The defender has to fi nd a bases-selection strategy that minimizes the average probability of being detected. The attacker has to fi nd a probabilistic selection strategy that maximizes the average detection probability minus its average cost. An algorithm to compute Nash-equilibrium mixed strategies was given by D. Szeszler (2016). Its time complexity is $O(|E|^{10} IO)$, where IO is the time that it takes one call to the independence oracle. Here we present an algorithm that requires $O(|E|^6 IO)$ time. For graphic matroids, i.e., when the defender chooses a spanning tree in a graph $G = (V, E)$, and the attacker chooses an edge, we give an algorithm that takes $O(|V|^5)$ time. This type of game is extended to common bases of two matroids. For this case we give a strongly polynomial algorithm, settling a question that was left open by D. Szeszler (2016). We also treat the case when the defender chooses a rooted arborescence in a directed graph $D = (V, A)$, and the attacker chooses an arc, we use this structure to give an algorithm that requires $O(|V||A|^3 log(|V|^2/|A|) log|A|)$ time.

Submodular and Incremental Maximization

Discrete Optimization & Integer Programming
APPROX - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 340
Organizer: Martin Gross, RWTH Aachen, DE

1 - Multi-objective Maximization of Monotone Submodular Functions
Speaker: Rajan Udwani, MIT, US, talk 1089
We consider the problem of multi-objective maximization of monotone submodular functions subject to cardinality constraint, often formulated as $\max_{|A|=k} \min_{i \in \{1,\ldots,m\}} f_i(A)$. It is known that greedy methods work well for a single objective, however the problem becomes much harder with multiple ob-

jectives. In particular, Krause et al. (2008) showed that when the number of objectives m grows as the cardinality k i.e., $m = \Omega(k)$, the problem is inapproximable (unless $P = NP$). On the other hand, Chekuri et al. (2010) showed that when m is constant, there is a randomized $(1 - 1/e) - \epsilon$ approximation for the far more general case of matroid constriant, with runtime (number of queries to function oracle) n^{m/ϵ^3}. We focus on finding a fast and practical algorithm that also works when m is super constant. First, we modify the algorithm of Chekuri et al. (2010) to achieve a $(1 - 1/e)$ approximation for $m = o(\frac{k}{\log^3 k})$, demonstrating a steep transition from constant factor approximability to inapproximability around $\Omega(k)$. More importantly, using Multiplicative-Weight-Updates we next give a much faster $\widetilde{O}(n/\delta^3)$ time, $(1-1/e)^2-\delta$ approximation. While the above results are all randomized, we also give a simple deterministic $(1-1/e)-\epsilon$ approximation with runtime n^{m/ϵ^4} by characterizing the variation in optimal solution value as a function of the cardinality k.

2 - A New Approximation Guarantee for Submodular Maximization via Discrete Convexity

Speaker: Tasuku Soma, The university of Tokyo, JP, talk 1198

Co-Authors: *Yuichi Yoshida*,

In monotone submodular function maximization, approximation guarantees based on the curvature of the objective function have been extensively studied in the literature. However, the notion of curvature is often pessimistic, and we rarely obtain improved approximation guarantees, even for very simple objective functions. In this talk, we provide a novel approximation guarantee by extracting an M-concave function h, a notion in discrete convex analysis, from the objective function f.

3 - General Bounds for Incremental Maximization

Speaker: Martin Gross, RWTH Aachen, DE, talk 1324

Co-Authors: *Aaron Bernstein*, *Yann Disser*,

We propose a theoretical framework to capture incremental solutions to cardinality constrained maximization problems. The defining characteristic of our framework is that the cardinality/support of the solution is bounded by a discrete value k that grows over time, and we allow the solution to be extended one element at a time. We investigate the best-possible competitive ratio of such an incremental solution, i.e., the worst ratio over all k between the incremental solution after k steps and an optimum solution of cardinality k. We define a large class of problems that contains many important cardinality constrained maximization problems like maximum matching, knapsack, and packing/covering problems. We provide a general 2.618-competitive incremental algorithm for this class of problems, and show that no algorithm can have competitive ratio below 2.18 in general. In the second part of the paper, we focus on the inherently incremental greedy algorithm that increases the objective value as much as possible in each step. This algorithm is known to be 1.58-competitive for submodular objective functions, but it has unbounded competitive ratio for the class of incremental problems mentioned above. We define a relaxed submodularity condition for the objective function, capturing problems like maximum (weighted) (b-)matching and a variant of the maximum flow problem. We show that the greedy algorithm has competitive ratio (exactly) 2.313 for the class of problems that satisfy this relaxed submodularity condition.

Distributionally Robust Optimization: Models and Applications

Optimization under Uncertainty

Robust - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 33 Building: B, Ground Floor, Zone: 5

Invited Session 355

Organizer: Selin Ahipasaoglu, SUTD, SG

1 - Heavy tails in a moment-constrained robust newsvendor model

Speaker: Bikramjit Das, Singapore University of Techno, SG, talk 1197

Co-Authors: *Karthik Natarajan*, *Anulekha Dhara*,

In his seminal work, Scarf (1958) provided a solution to the newsvendor problem with ambiguity in the demand distribution. The optimal order quantity in this problem is computed for the worst possible distribution from a set of demand distributions that is characterized by partial information, such as moments. A simple observation indicates that the optimal order quantity when only the mean and variance (the first two moments) of the distribution are known, the model is also optimal for a censored student-t distribution with infinite variance. In this paper, we generalize this "heavy tail optimality" property of the distributionally robust newsvendor to the case when information on the first and the n-th moment is known for any $n > 1$ (not necessarily an integer). Unlike the mean-variance setting, this problem does not appear to be solvable in a simple closed form manner. We show that for high critical values, the optimal order quantity for the distributionally robust newsvendor is also optimal for a regularly varying distribution with parameter indexed by n.

2 - Robust Extreme Event Analysis

Speaker: Henry Lam, Columbia University, US, talk 913

Co-Authors: *Clementine Mottet*, *Xinyu Zhang*,

One bottleneck of extreme event analysis is that, by its own definition, tail data is often scarce. Conventional approaches fit data using well-chosen parametric distributions, but the inherent bias-variance tradeoff can hinder the estimation reliability. We discuss approaches using robust optimization as a nonparametric alternative. Our framework uses optimization, imposed over probability distributions, to compute confidence bounds on extremal performance measures, under constraints on the belief of tail geometry and other easily calibrated quantities. We discuss how this approach can mitigate the statistical challenge of conventional approaches with a different conservativeness-variance tradeoff. We also present some results on the geometric representation of multivariate monotone distributions that are useful for our analysis.

3 - Concentration versus Diversification in Portfolio Selection

Speaker: Selin Ahipasaoglu, SUTD, SG, talk 795

In this paper, we extend the classical mean-variance framework by incorporating an ellipsoidal uncertainty set and fixed transaction costs. In particular, we show that the optimal portfolio can be approximated by a linear combination of three benchmark portfolios: the mean-variance portfolio, the minimum-variance portfolio, and a portfolio induced by transaction costs. Moreover, for a simple model we explicitly characterize how the number of traded assets changes with respect to the level of uncertainty on model parameters. Our analytical results take us one step closer to understanding and resolving the so-called diversification paradox, the common belief that it is necessary to increase the number of assets to obtain a robust portfolio.

Nash equilibrium and Games 2

Continuous Optimization
Variat - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8

Invited Session 366
Organizer: Giancarlo Bigi, Università di Pisa, IT

1 - Numerically tractable optimistic bilevel problems
Speaker: Lorenzo Lampariello, Roma Tre University, IT, talk 1122
Co-Authors: *Simone Sagratella*,
We consider a class of optimistic bilevel problems. Specifically, we address bilevel problems in which the lower level objective function is fully convex. We show that this nontrivial class of mathematical programs is sufficiently broad to encompass significant real-world applications and proves to be numerically tractable. From this respect, we establish that the critical points for a relaxation of the original problem can be obtained addressing a suitable generalized Nash equilibrium problem. The latter game is proven to be convex and with a nonempty solution set. Leveraging this correspondence, we provide a provably convergent, easily implementable scheme to calculate critical points of the relaxed bilevel program. As witnessed by some numerical experiments on an application in economics, this algorithm turns out to be numerically viable also for big dimensional problems.
2 - Polyhedral complementarity algorithms for equilibrium problems
Speaker: Vadim Shmyrev, Sobolev Institute, RU, talk 262
An original approach to the equilibrium problem in linear exchange model and its variations is presented..The conceptual base of this approach is the scheme of polyhedral complementarity. For the model with fixed budgets (Fisher's model) the proposed approach makes it possible to reduce the equilibrium problem to two optimization problems on the price simplex, which are in duality similarly to dual linear programming problems. This reduction of Fisher's model differs from the well-known one given by E. Eisenberg and D. Gale and allows us to develop the finite algorithms for searching equilibrium prices of the model. The generalized exchange model with firms producing the commodities can be studied in this way as well too. Here we present the new conceptual full consideration of the approach including the generalized Fisher's model and the explicit form of optimization problems. The obtained finite algorithms can be used to get iterative algorithms for more complicated models (variable budgets, nonlinear preferences, some linear Arrow-Debreu models) . A reduction of the model with variable budgets to optimization problem is also obtained Key words:exchange model, economic equilibrium, fixed point, polyhedral complementarity, optimization problem, conjugate function, algorithm.
3 - Semi-infinite programming via two player generalized Nash games and saddlepoints
Speaker: Giancarlo Bigi, Università di Pisa, IT, talk 967
Co-Authors: *Simone Sagratella*,
Semi-infinite programs (SIPs) and Generalized Nash games (GNEPs) share similarities that lead to meaningful connections. These connections are analysed and exploited to solve SIPs through algorithms for GNEPs. Indeed, SIPs can be reformulated as GNEPs with a peculiar structure. Pairing this structure with penalization techniques for GNEPs leads to a class of solution methods for SIPs that are based on a sequence of saddlepoint problems. Any converging algorithm for the saddlepoint problem provides the basic iteration of the penalty scheme. In particular, a projected subgradient method for nonsmooth optimization and a subgradient method for saddlepoints are adapted to our framework and the convergence of the resulting algorithms is shown. A comparison between the two algorithms is outlined as well.

Scalarization, representation and the comparison of methods in Multiobjective Optimization

Optimization under Uncertainty
Game - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 378
Chair: Tyler Perini, Georgia Tech, US

1 - New scalarization technique for solving multi-objective problems
Speaker: Kenza Oufaska, TIC Lab - ELIT - UIR, MA, talk 1336
Co-Authors: *Khalid El Yassini*, *Mustapha Oudani*, *Tarik Zouadi*,
Often the optimization problems encountered are multi-objective: several contradictory or conflicting objective functions must be satisfied. Multi-objective optimization has been used more and more in recent decades, and its application in real-world problems continues to grow significantly. In this work, we propose a new scalarization technique to solve multi-objective problems. The approach consists of transforming the original problem (P) of multi-objective nature into a set of mono-objective sub-problems (Pi) where i = 1,2,..., k and k denotes the number of objective functions of the initial problem. During the process of solving each sub-problem (Pi), a particular focus is made to determine and characterize the evolution of all objective functions of the problem (Pi). The analysis of the behavior of the various objective functions and their values at the feasible solutions generated over the single-objective resolutions made makes it possible to guide the deduction of adapted and adjusted weighting weights on the basis of the importance given to the proximity of the different values taken by any objective function relative to the optimal value of the associated mono-objective sub-problem. The determined weights can be used, subsequently, to trigger the approach of solving the original problem via the weighting method in its classic version and thus deduce a compromise solution that can better satisfy the preferences of the decision maker concerned.
2 - Approximation of the frontier for a biobjective MIP: comparison between methods
Speaker: Tyler Perini, Georgia Tech, US, talk 1620
Co-Authors: *Diego Pecin*, *Natashia Boland*, *Martin Savels-*

bergh,
Computing the full nondominated frontier for a multiobjective optimization problem is often computationally impractical; therefore, we are interested in providing a representative approximation of the frontier. There exist many metrics in the literature for approximations of the frontier of a biobjective IP. However, there exist no such metrics in the literature for biobjective MIPs. The nondominated frontiers of biobjective MIPs are complex, including open, half-open, and closed line segments, and unlike biobjective IPs, many points of the frontier may share the same integer-part solution. We summarize and discuss the performance of 4 existing methods (ϵ-Tabu Constraint Method and 3 variants of the Boxed Line Method) on 3 classes of instances in terms of our approximation metrics.

3 - Multi-Objective Optimization for the Compiler of Hard Real-Time Systems
Speaker: Kateryna Muts, TU Hamburg, DE, talk 834
Co-Authors: *Arno Luppold*, *Heiko Falk*,
With the growing complexity of embedded systems software, high code quality can only be achieved using a compiler. Sophisticated compilers provide various optimizations to improve code aggressively w.r.t. different objective functions, e.g., worst-case execution time (WCET) and code size, which usually contradict each other. In order to find a suitable trade-off between these objectives, evolutionary multi-objective algorithms identifying Pareto optimal solutions are exploited. The third version of the Generalized Differential Evolution (GDE3) is currently one of the most suitable multi-objective evolutionary algorithms. However, the standard GDE3 cannot be used for solving the binary-coded optimization problems directly. A binary generalized differential evolution algorithm (BGDE) is inspired by the novel modified binary differential evolution algorithm (NMBDE) for single-objective optimization problems and GDE3. The formulas of the standard GDE3, including the mutation, crossover and selection operators, are reserved in BGDE. The probability estimation operator proposed in NMBDE is used to map real-coded vectors, generated by GDE3, to binary-coded vectors. The BGDE and multi-objective binary probability optimization algorithm (MBPOA), which is developed for binary-coded problems, are implemented in a compiler framework for hard real-time systems to perform an automatic minimization of the code size and WCET for the well-known compiler optimization function inlining. A comparison is performed that helps to determine the most suitable multi-objective optimizer.

Discrete stochastic dynamic programming

Optimization under Uncertainty
Markov - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 31 Building: B, Ground Floor, Zone: 5

Contributed Session 384
Chair: Adam Narkiewicz, Simiade, PL

1 - MILP formulations for discrete stochastic optimization (LIMIDs)
Speaker: Victor Cohen, Ecole des Ponts Paristech, FR, talk 1387
Co-Authors: *Axel Parmentier*, *Vincent Leclère*, *Guillaume Obozinski*, *Joseph Salmon*,
Limited Memory Influence Diagrams (LIMIDs) are a flexible tool to represent discrete stochastic optimization problems, including Markov Decision Process (MDP) and Partially Observable MDP as standard examples. More precisely, given random variables considered as vertices of an acyclic digraph, a probabilistic graphical model defines a joint distribution via the conditional distributions of vertices given their parents. In LIMIDs, the random variables are represented by a probabilistic graphical model whose vertices are partitioned into three types : chance, decision and utility vertices. The user chooses the distribution of the decision vertices conditionally to their parents in order to maximize the expected utility. Leveraging the notion of strong junction tree, we present a mixed integer linear formulation for solving a LIMID, as well as valid inequalities, which lead to a computationally efficient algorithm. We also show that the linear relaxation yields an optimal integer solution for instances that can be solved by the "single policy update", the default algorithm for addressing LIMIDs.

2 - LP relaxations for discrete stochastic optimization with variational inference
Speaker: Axel Parmentier, Ecole des Ponts Paristech, FR, talk 1384
Co-Authors: *Victor Cohen*, *Vincent Leclère*, *Guillaume Obozinski*, *Joseph Salmon*,
Sampling is arguably the most frequent approximation used in stochastic optimization when exact policy evaluation is intractable. Variational inference has become a popular alternative to sampling for approximating probability computations in the probabilistic graphical model community, but is still rarely used in stochastic optimization. We propose a variational inference approximation for Limited Memory Influence Diagrams (LIMIDs), which are a flexible probabilistic graphical model framework to express stochastic optimization problems, such as Markov Decision Processes (MDP) and partially observable MDP. Our approximation turns the initial problem into a linear relaxation of tractable size, whose resolution yields a lower bound on the value of the initial (minimization) problem as well as a heuristic solution. Our method provides a variational framework to interpret several approximations in the stochastic optimization literature, such as fluid approximations. Numerical experiments show the tractability of the LPs and the quality of the bounds and heuristic solutions.

3 - A sequential decision process with stochastic action sets
Speaker: Adam Narkiewicz, Simiade, PL, talk 26
The article proposes a normative model of dynamic choice in which an agent must sequentially choose actions in order to maximize her performance. Unlike in traditional models, the action sets are random. That is, for a given state history, instead of a known action set, there is a known probability distribution over action sets. For example, given the asset prices and portfolio history up to n-th period, the specific distributions of returns for the assets in the n+1-th period are known only after the n-th period. I prove that an optimal decision policy requires an agent to follow the maximum expected performance principle and that an optimal decision policy can be expressed as a function over state space, whose expected value the agent ought to maximize. I find necessary

conditions for optimality in the general case, in a Markovian environment, and in a stationary environment. I also prove existence, uniqueness, and sufficient conditions for optimality under certain circumstances. I then apply these results to solve numerically three problems. The first is a portfolio allocation problem in which a future pensioner tries to maximize probability of having a certain portfolio value at the time of retirement or tries to obtain this value as quickly as possible. The second is an optimal-foraging problem. The third is a problem in which an artificial agent is trying to find the quickest route in a dynamically changing graph.

Industrial dynamics and Environmental policy

Specific Models, Algorithms, and Software
Sciences - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 392
Organizer: Inmaculada Garcia Fernandez, Universidad de Malaga, ES

1 - Dynamics of Environmental Policy
Speaker: Adriana Piazza, Universidad Adolfo Ibanez, CL, talk 840
Co-Authors: *Hulya Eraslan*,
We consider a dynamic political economy model in discrete time with infinite horizon in which two parties decide environmental policy in each period. The parties disagree about the optimal policy. One party is a consumerist who advocates current consumption, and the other is an environmentalist who advocates protecting the environment at the cost of reduced current consumption. The party in power can unilaterally change environmental policy by increasing or decreasing the existing environmental stock. The cost of changing environmental policy is asymmetric. In particular, decreasing the environmental stock is costless, but increasing it involves a cost for both the party in power, and the party out of power. We characterize the set of stationary Markov perfect equilibria and compare the equilibrium policies to Pareto optimal policies. We also study the variation in equilibrium environmental policy with respect to patience of the parties, political turnover, costs of changing the environmental policy and polarization of the parties.
2 - Challenges in Nutrient Recycling and Biogas Plant Localization
Speaker: Nils-Hassan Quttineh, Linköping University, SE, talk 1290
Co-Authors: *Genevieve Metson*, *Uno Wennergren*, *Usman Akram*,
Nutrient management, particularly with respect to nitrogen (N) and phosphorus (P), is crucial for a sustainable food system. In order to increase crop yields, it is common practice to apply synthetic fertilizers to areas with crop nutrient needs. However, synthetic fertilizers can be costly, and losses of nutrients from croplands, animal rearing, and sewage systems can lead to water quality degradation; prompting many countries to revisit how organic waste which is high in N and P can be better managed. Issues of over- and under-abundance of nutrients often co-exist in the same country because of agricultural specialization. Reconnecting areas with crop nutrient needs and areas with higher concentrations of human and animal organic waste through recycling can thus potentially help countries meet both food security and environmental goals. The recycling of bio-supply (animal manure and human excreta) is currently low, hence there is a great potential to increase this recycling in order to meet crop needs, and at the same time decrease the use of synthetic fertilizers. A quantitative analysis for Sweden and Pakistan is presented. Other recycling technologies, such as biogas plants, are also studied, and we present a mathematical model selecting biogas plant locations (basically a Facility Location Problem) which minimize transport distances associated with transporting and transforming all manure and then redistributing the nutrients to meet crop demand.
3 - Use of dynamic programming in inventory control for perishable products
Speaker: Inmaculada Garcia Fernandez, Universidad de Malaga, ES, talk 428
Co-Authors: *Eligius Hendrix*, *Gloria Ortega*,
One third of world food production is thrown away every year. Adequate inventory control of retailers keeping track of the age distribution of the inventory of the perishable food products may help to reduce food waste. We illustrate how dynamic programming may help to derive optimal control rules and to reduce waste. This research has been funded by national project TIN2015-66680 in part financed by the European Regional Development Fund (ERDF).

Vehicle Routing II

Specific Models, Algorithms, and Software
Logistics - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6

Contributed Session 412
Chair: Chris Potts, University of Southampton, GB

1 - A Branch-Cut-and-Price Algorithm for the TSP with Hotel Selection
Speaker: Eduardo Uchoa, UFF, BR, talk 1467
Co-Authors: *Luiz Santanna*,
The Traveling Salesperson Problem with Hotel Selection (TSPHS) is an extension of the classic TSP that has only recently been introduced to the literature. In TSPHS there is a time limit that restricts the number of clients that can be visited in a single day. Therefore, several trips may be necessary to visit all clients. However, there is not need to return to the origin, there is a set of available hotels for the salesperson to stay in between trips. The TSPHS presents an interesting optimization challenge, since its solutions may have a complex topology. It also has direct practical applications. Current approaches focus mainly in meta-heuristic techniques. This work presents a set partitioning Integer Programing formulation and proposes a branch-cut-and-price algorithm, where the pricing subproblem is solved through a labeling algorithm. Several instances of the literature of up to 225 clients are solved to optimality and a new set of 80 benchmark instances is presented.
2 - Models and Algorithms for Dynamic Workforce Scheduling and Routing
Speaker: Chris Potts, University of Southampton, GB, talk

1612
Co-Authors: *Fulin Xie*, *Tolga Bektas*,
This paper considers a dynamic workforce scheduling and routing problem, where service requests arrive randomly over time at different geographical locations, and operational decisions on how the request is to be serviced are made immediately the request is received. To address this problem, we propose a scenario-based model that incorporates stochastic knowledge about future requests. The proposed model uses a two-stage set-partitioning framework, where thefirst stage finds a set of feasible routes covering known requests, while the second stage estimates the effect of this routing plan with respect to future requests. The performance of the proposed model is evaluated against a deterministic model and a naive greedy heuristic. This comparison is performed within a simulation framework that generates realistic instances using probability distributions derived from historical data. Computational results demonstrate that the proposed model provides a significant improvement over approaches not exploiting any stochastic information.

3 - Delivery robots, a transport innovation for the last mile
Speaker: Stefan Schaudt, Institute of Transport Log., DE, talk 1451
Co-Authors: *Uwe Clausen*,
The increasing growth rate of Courier Express Parcel (CEP) markets is a major challenge for the logistic industry worldwide. New innovative approaches and solutions are needed. For densely populated areas, so-called delivery robots are a promising solution. They drive autonomously on sidewalks or crosswalks, and have the size of a moving box with a small capacity inside. In the past few years, many startups were founded building these robots and tested them all over the world. We focus on the optimization of the delivery using autonomous robots. Assume are given a set of customers, robots and depots. Each customer has ordered a parcel and chosen an arrival due window for its order. The goal of the optimization is to create a schedule involving the robots and parcels such that the arrival time of each parcel is closest as possible to the chosen due window. One may distinguish the cases in which the assignment between robots and depots is fixed or flexible, which means that a robot can be reassigned after delivering a parcel. In the case of a fixed assignment this problem can be transformed into a scheduling problem with unrelated parallel machines and machine dependent distinct due windows. Furthermore, each of these two problems can be represented by an integer programming formulation and solved to optimality. Furthermore, heuristics can be used to solve large test instances.

Nonlinear Optimization

CONTINUOUS OPTIMIZATION
NLP - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11
CONTRIBUTED SESSION 429
Chair: Marc Steinbach, Leibniz Universität Hannover, DE

1 - On the Approximate Solutions of Augmented Subproblems within Sequential Methods
Speaker: Ademir Ribeiro, Federal University of Parana, BR, talk 924
Co-Authors: *Mael Sachine*, *Sandra Santos*,
Within the context of sequential methods for solving general nonlinear programming problems this study deals with the theoretical reasoning behind handling the original subproblems by an augmentation strategy. We do not assume feasibility of the original problem, nor the fulfillment of any constraint qualification. The analysis is made along two directions. First and foremost, the exact nature of the stationary points usually considered is alleviated under an approximate stationary perspective. Second, the analysis has been developed using general vector norms. Therefore, the present results have been obtained under mild hypotheses, and with a involved examination. We stress that we are not concerned with the sequential method itself, nor with computational results. We focus on the features about the original problem that can be inferred from the properties of the solution of the augmented problem, being the solutions analyzed in an approximate sense. Examples illustrating the obtained results are included.

2 - An Elastic Primal Active Set Method for Structured SQP
Speaker: Marc Steinbach, Leibniz Universität Hannover, DE, talk 1271
Co-Authors: *Daniel Rose*,
We consider SQP methods for large structured NLP that may arise, e.g., from branch-and-bound schemes for MINLP or from robust nonlinear model predictive control. The talk presents a generic primal active set method that employs an arbitrary, possibly matrix-free KKT solver in l_1 and l_2 slack relaxations of the QP subproblems to allow for efficient warm starts from infeasible points. Our approach involves Schur complement and projection techniques that preserve the NLP sparse structure in the KKT system. We also discuss relevant aspects of the software design and present numerical results for QP from the CUTEst test set and for large structured NLP.

3 - A Dynamic Penalty Parameter Updating Strategy for SQP Methods
Speaker: Hao Wang, ShanghaiTech University, CN, talk 369
Co-Authors: *Frank Curtis*, *James Burke*, *Jiashan Wang*,
This paper focuses on the design of sequential quadratic optimization (commonly known as SQP) methods for solving large-scale nonlinear optimization problems. The most computationally demanding aspect of such an approach is the computation of the search direction during each iteration, for which we consider the use of matrix-free methods. In particular, to reduce overall computational costs, we consider the use of matrix-free methods in such a way that only inexact subproblem solutions are required to guarantee convergence of the SQP method. It is known that SQP methods can be plagued by poor behavior of the global convergence mechanism. To confront this issue, we propose the use of an exact penalty function with a dynamic penalty parameter updating strategy to be employed within the subproblem solver in such a way that the resulting search direction predicts progress toward both feasibility and optimality. We present our penalty parameter updating strategy and prove that, under reasonable assumptions, the strategy does not modify the penalty parameter unnecessarily. We also discuss matrix-free subproblem solvers in which our updating strategy can be readily incorporated. We close the paper with a discussion of the results of numerical experiments that illustrate the benefits of our proposed techniques.

Distributionally Robust Optimization

Optimization under Uncertainty
Robust - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: DENIGES Building: C, Ground Floor, Zone: 5

Invited Session 446
Organizer: Daniel Kuhn, EPFL, CH

1 - Chebyshev Inequalities for Products of Random Variables
Speaker: Napat Rujeerapaiboon, EPFL, CH, talk 608
Co-Authors: *Daniel Kuhn*, *Wolfram Wiesemann*,
We derive sharp probability bounds on both left and right tails of a product of non-negative random variables using only information about their first two moments. We first prove that these bounds can be computed efficiently using semidefinite programming. Then, we show that all left probability bounds, in fact, reduce to the trivial bound 1 if the number of random variables in the product exceeds an explicit threshold. Thus, in the worst case, the weak-sense geometric random walk defined through the running product of the random variables is absorbed at 0 with certainty as soon as time becomes sufficiently large. Finally, our techniques for computing Chebyshev bounds for products can also be used to derive Chebyshev bounds for sums, maxima, and minima of non-negative random variables.

2 - Variational Theory for Optimization under Stochastic Ambiguity
Speaker: Johannes Royset, Naval Postgraduate School, US, talk 951
Stochastic ambiguity provides a rich class of uncertainty models that includes those in stochastic, robust, risk-based, and semi-infinite optimization and that accounts for uncertainty about parameter values as well as incompleteness of the description of uncertainty. We provide a novel, unifying perspective on optimization under stochastic ambiguity that rests on two pillars. First, ambiguity is formulated in terms of probability distributions that might depend on the decision variable. We derive a series of estimates by introducing a metric for the space of distribution functions based on the hypo-distance between upper semicontinuous functions. In the process, we show that this metric is consistent with convergence in distribution of the associated probability measures. Second, we rely on the theory of lopsided convergence to establish existence, convergence, and approximation of solutions of optimization problems with stochastic ambiguity. We estimate a distance between bifunctions and show that this leads to bounds on the solution quality for problems with stochastic ambiguity. Among other consequences, these results facilitate the study of the “price of robustness” and related quantities.

3 - Distributionally Robust Inverse Covariance Estimation
Speaker: Daniel Kuhn, EPFL, CH, talk 820
Co-Authors: *Viet Anh Nguyen*, *Peyman Mohajerin Esfaha*,
We introduce a distributionally robust maximum likelihood estimation model with a Wasserstein ambiguity set to infer the inverse covariance matrix of a p-dimensional Gaussian random vector from n independent samples. The proposed model minimizes the worst case (maximum) of Stein’s loss across all normal reference distributions within a prescribed Wasserstein distance from the normal distribution characterized by the sample mean and the sample covariance matrix. We prove that this estimation problem is equivalent to a semidefinite program that is tractable in theory but beyond the reach of general purpose solvers for practically relevant problem dimensions p. In the absence of any prior structural information, the estimation problem has an analytical solution that is naturally interpreted as a nonlinear shrinkage estimator. Besides being invertible and well-conditioned even for p>n, the new shrinkage estimator is rotation-equivariant and preserves the order of the eigenvalues of the sample covariance matrix. These desirable properties are not imposed ad hoc but emerge naturally from the underlying distributionally robust optimization model. Finally, we develop a sequential quadratic approximation algorithm for efficiently solving the general estimation problem subject to conditional independence constraints typically encountered in Gaussian graphical models.

Discrete methods for data centers and graphs

Specific Models, Algorithms, and Software
Learning - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 16 Building: I, 2nd floor, Zone: 7

Invited Session 477
Organizer: Aaron Archer, Google, US

1 - Overcommitment in Cloud Services - Bin Packing with Chance Constraints
Speaker: Philipp Keller, Facebook, US, talk 1383
Co-Authors: *Maxime Cohen*, *Morteza Zadimoghaddam*, *Vahab Mirrokni*,
We consider a traditional problem of resource allocation: scheduling jobs on machines. One such recent application is cloud computing, where jobs arrive in an online fashion with capacity requirements and need to be immediately scheduled on physical machines in data centers. It is often observed that the requested capacities are not fully utilized, hence offering an opportunity to employ an overcommitment policy, i.e., selling resources beyond capacity. Setting the right overcommitment level can yield a significant cost reduction for the cloud provider, while only inducing a very low risk of violating capacity constraints. We introduce and study a model that quantifies the value of overcommitment by modeling the problem as a bin packing with chance constraints. We then propose an alternative formulation that transforms each chance constraint to a submodular function. We show that our model captures the risk pooling effect and can guide scheduling and overcommitment decisions. We also develop a family of online algorithms that are intuitive, easy to implement, and provide a constant factor guarantee from optimal. Finally, we calibrate our model using realistic workload data and test our approach in a practical setting. Our analysis and experiments illustrate the benefit of overcommitment in cloud services, and suggest a cost reduction of 1.5**2 - Cache-aware load balancing of data center applications via balanced partitioning**
Speaker: Aaron Archer, Google, US, talk 528
Co-Authors: *Kevin Aydin*, *Hossein Bateni*, *Vahab Mirrokni*, *Aaron Schild*, *Ray Yang*, *Richard Zhuang*,
Our deployment of cache-aware load balancing in a large-

scale commercial web search engine reduced cache misses by about 2x, greatly increasing the throughput of our serving clusters by relieving a bottleneck. This innovation has benefited all production workloads since 2015, serving O(billions) of queries daily. A load balancer forwards each query to one of several identical serving replicas. The replica pulls each term's postings list into RAM from flash, either locally or over the network. Flash bandwidth is a critical bottleneck, motivating an application-directed RAM cache on each replica. Sending the same term reliably to the same replica would increase the chance it hits cache, and avoid polluting the other replicas' caches. However, most queries contain multiple terms and we have to send the whole query to one replica, so it is not possible to achieve a perfect partitioning of terms to replicas. We solve this via a voting scheme, whereby the load balancer conducts a weighted vote by the terms in each query, and sends the query to the winning replica. We develop a multi-stage scalable algorithm to learn these weights. We first construct a large-scale term-query graph from logs and apply a distributed balanced graph partitioning algorithm to cluster each term to a preferred replica. This yields a good but simplistic initial voting table, which we then iteratively refine via cache simulation to capture feedback effects.

3 - Compressing Graphs and Indexes with Recursive Graph Bisection

Speaker: Sergey Pupyrev, Facebook, US, talk 644

Co-Authors: *Laxman Dhulipala*, *Igor Kabiljo*, *Brian Karrer*, *Giuseppe Ottaviano*, *Alon Shalita*,

Graph reordering is a powerful technique to increase the locality of the representations of graphs, which can be helpful in several applications. We study how the technique can be used to improve compression of graphs and inverted indexes. We extend the recent theoretical model of Chierichetti et al. (KDD 2009) for graph compression, and show how it can be employed for compression-friendly reordering of social networks and web graphs and for assigning document identifiers in inverted indexes. We design and implement a novel theoretically sound reordering algorithm that is based on recursive graph bisection. Our experiments show a significant improvement of the compression rate of graph and indexes over existing heuristics. The new method is relatively simple and allows efficient parallel and distributed implementations, which is demonstrated on graphs with billions of vertices and hundreds of billions of edges.

Classification, regression and clustering

Specific Models, Algorithms, and Software Learning - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: FABRE Building: J, Ground Floor, Zone: 8

Contributed Session 480

Chair: Dimitris Bertsimas, MIT, US

1 - Interpretable Machine Learning

Speaker: Dimitris Bertsimas, MIT, US, talk 1184

Co-Authors: *Jack Dunn*,

We introduce optimal classification (OCT) and regression (ORT) trees for prediction and prescription with and without hyperplanes. We show that (a) Trees are very interpretable, (b) They can be calculated in large scale in practical times and (c) In a large collection of real world data sets they give comparable or better performance than random forests or boosted trees. Their prescriptive counterparts have a significant edge on interpretability and comparable or better performance than causal forests. Finally, we show that optimal trees with hyperplanes have at least as much modeling power as (feedforward, convolutional and recurrent) neural networks and comparable performance in a variety of real world data sets. These results suggest that optimal trees are both interpretable, practical to compute in large scale and provide state of the art performance compared to black box methods.

2 - Logistic Regression and Principal Curves Applied to Discriminant Analysis

Speaker: Inácio Guimarães, UTFPR Univ. Tec. Federal do PR, BR, talk 241

Co-Authors: *Zaudir Dal'Cortivo*, *Jair Marques*,

Studies on logistic regression usually consider the model with linear discriminant functions, but there are situations where quadratic discriminant functions work better. However, the quadratic logistic regression model involves the estimation of a great number of parameters, which leads to computational difficulties, in terms of memory and computing time. Another problem is that the model may not work when the data set has no overlapping. To deal with this issue we propose an extension of the hidden logistic model, whose advantage is the existence of estimators, even when there is no overlap. Principal curves, that pass through the middle of a p-dimensional data set, providing a summary of the data in Rp, have been used for discriminant analysis. We propose an algorithm which extracts principal curves from the Fisher discriminant matrix, using the k-segments algorithm. This algorithm generates a polygonal line used to classify an observation in the class whose polygonal line has the shortest Euclidean distance by orthogonal projection.

3 - Sufficient Conditions for L1-Norm Best-Fit Lines

Speaker: James Brooks, Virginia Commonwealth Universi, US, talk 341

Co-Authors: *Jose Dula*,

A procedure for fitting a line to multi-dimensional data using the L1 norm has been recently developed and streamlined to be highly efficient by Brooks and Dula. The procedure is not guaranteed to produce optimal solutions, although it performs well for data contaminated with outliers. We discuss sufficient conditions on the data for the procedure to produce an optimal solution.

Routing

Discrete Optimization & Integer Programming IPpractice - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 44 Building: C, 3rd floor, Zone: 1

Contributed Session 484

Chair: Cole Smith, Clemson University, US

1 - Solving the Time-Dependent TSP using Machine Learning Guidance

Speaker: Imke Joormann, TU Braunschweig, DE, talk 1159

Co-Authors: *Christoph Hansknecht*,

In this talk, we consider the time-dependent traveling salesman problem (TDTSP), a generalization of the asymmetric traveling salesman problem (ATSP), to incorporate time-dependent cost functions. Since the traveling times on an arc can change with every minute, the IP formulation of the TDTSP is quite large and cannot be solved easily. We introduce multiple families of cutting planes for the TDTSP as well as different LP-based primal heuristics, a propagation method and a branching rule. We conduct computational experiments to evaluate the effectiveness of our approaches on several randomly generated instances. The TDTSP has its origin in a real-world application, where, e.g., delivery routes in one city but for different days are planned. This results in lots of instances sharing (partly) the same structure. We explore how machine learning techniques can be used to exploit this structure and be incorporated in the Branch-and-Cut-and-Price solver.

2 - Column generation for routing a fleet of plug-in hybrid vehicles

Speaker: Ann-Brith Strömberg, Chalmers Univ. of Technology, SE, talk 1453

Co-Authors: *Jonathan Ruffieux*, *Peter Lindroth*,

We study the hybrid-VRP, i.e., the routing of a homogeneous fleet of plug-in hybrid vehicles, having a limited load capacity and being subject to time windows for delivery. The vehicles have two propellant options, electricity and diesel, and we assume that one can chose freely what propellant to use as long as the battery is not empty, in which case diesel is the only option. Recharging of a vehicle battery is optional and can be done only at special recharging sites, the recharging time being dependent on the battery's charge level upon arrival at the site. The objective is to minimize the cost of the diesel used while fulfilling the customers' demand. The hybrid-VRP is modelled as a mixed integer linear program (MILP) and solved using column generation (CG), separating the MILP into a set covering master problem and subproblems being elementary shortest path problems with resource constraints (ESPPRC). We have further developed dominance criteria in order to improve the dynamic programming algorithm used to solve the ESPPRCs. Our tests show that the most cost-efficient routes in hybrid-VRPs may differ substantially from those of traditional VRPs, and that the hybrid-VRPs are time-consuming to solve exactly using conventional branch-and-cut methods. The solution times are, however, considerably reduced by the CG approach in combination with the application of our dominance criteria.

3 - The consistent path problem and binary decision diagrams

Speaker: Cole Smith, Clemson University, US, talk 275

Co-Authors: *David Bergman*, *Leonardo Lozano*,

The application of decision diagrams in combinatorial optimization has proliferated in the last decade. In recent years, authors have begun to investigate how to utilize not one, but a set of diagrams, to model constraints and objective function terms. Optimizing over a collection of decision diagrams, the problem we refer to as the consistent path problem (CPP) can be accomplished by associating a network-flow model with each decision diagram, jointly linked through channeling constraints. A direct application of integer programming to the ensuing model has already shown to result in algorithms that provide orders-of-magnitude performance gains over classical methods. Lacking, however, is a careful study of dedicated solution methods designed to solve the CPP. This talk provides a detailed study of the CPP, including a discussion on complexity results and a thorough polyhedral analysis. We propose a cut-generation algorithm which, under a structured ordering property, finds a cut if one exists through an application of the classical maximum flow problem, albeit in an exponentially sized network. We use this procedure to fuel a cutting-plane algorithm that is applied to unconstrained binary cubic optimization and a variant of the market split problem, resulting in the state-of-the-art algorithm for both.

Global Optimization 2

Continuous Optimization

Global - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 20 Building: G, 1st floor, Zone: 6

Contributed Session 502

Chair: Mirjam Duer, Augsburg University, DE

1 - Deterministic upper bounds in global minimization with equality constraints

Speaker: Christian Füllner, KIT, DE, talk 971

Co-Authors: *Peter Kirst*, *Oliver Stein*,

We address the problem of deterministically determining upper bounds in continuous non-convex global minimization of box-constrained problems with nonlinear equality constraints. These upper bounds are important for the termination of spatial branch-and-bound algorithms. Our method is based on the theorem of Miranda which helps to ensure the existence of feasible points in certain boxes. Then, the computation of upper bounds for the objective function over those boxes yields an upper bound for the globally minimal value. A proof of convergence is given under mild assumptions. An extension of our approach to problems including inequality constraints is possible.

2 - Nonconvex Optimization Approach to Equilibrium and Bilevel Problems

Speaker: Andrei Orlov, IDSTU SB RAS, RU, talk 492

This work addresses a special class of Operations Research problems with a bilinear structure. For such problems, a new approach to finding solutions is developed. It is based on two principal properties of bilinear functions: any bilinear function is affine with respect to each group of its variables when the other group is fixed; any bilinear function can be represented as a difference of two convex functions (so, a bilinear function is a d.c. function). In addidion, the approach takes into account that some Operations Research problems can be considered as nonconvex optimization problems, which are addressed by the Global Search Theory developed by A.S. Strekalovsky. In contrast to mainstream approaches in the nonconvex optimization, this theory uses methods of the modern convex optimization when designing global search algorithms. In this work we developed algorithms for solving polymatrix games of three players and quadratic bilevel problems. Computational testing has shown the efficiency of the approach.

3 - On Solving the General Fractional Problem via D.C. Optimization

Speaker: Tatiana Gruzdeva, ISDCT SB RAS, RU, talk 489

Co-Authors: *Alexander Strekalovskiy*,

This work addresses the problems of fractional programming which numerators and denominators of ratios are given by differences of two convex functions. Such problems are, in general, nonconvex (with numerous local extrema). We develop an efficient global search method for fractional program based on two different approaches. The first one generalizes the Dinkelbach's idea and uses a solution of an equation with the optimal value of an auxiliary d.c. optimization problem with a vector parameter. The second approach deals with another auxiliary problem with nonconvex inequality constraints. Both auxiliary problems are d.c. optimization problems, which allows us to apply the Global Optimization Theory and develop the new method for solving fractional programs, which combines the two approaches. The algorithm has been substantiated and tested on an extended set of sum-of-ratios problems with up to 200 variables and 200 terms in the sum.

IP Practice III

Discrete Optimization & Integer Programming
IPpractice - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 36 Building: B, Intermediate, Zone: 4
Contributed Session 507
Chair: Samuel Brito, UFOP, BR

1 - Valid inequalities for solving a stochastic lot-sizing problem with returns
Speaker: Franco Quezada, LIP6, FR, talk 1155
Co-Authors: *Celine Gicquel*, *Safia Kedad-Sidhoum*,
We seek to plan production activities on a re-manufacturing system over a multi-period horizon. The system comprises three processes; disassembly, refurbishing and reassembly. Uncertainties are assumed on the quality and quantity of returned products, customers demand and production costs. This leads to a multi-echelon stochastic lot-sizing problem with product returs and lost sales minimizing the total expected production costs. We propose a multi-stage stochastic integer programming approach relying on a scenario tree to represent the uncertain information structure, resulting in the formulation of a large-size MILP. New valid tree inequalities are obtained by mixing previously known path inequalities. They are used in a Branch-and-Cut framework to solve the problem. Computational results will illustrate the effectivness of the proposed method. The number of instances solved to optimality is increased by a factor of 1.8 as compared to the use of the commercial solver CPLEX.
2 - Improving COIN-OR CBC MIP Solver Using Conflict Graphs
Speaker: Samuel Brito, UFOP, BR, talk 1389
Co-Authors: *Haroldo Santos*,
Conflict Graphs (CGs) are an important structure in Mixed Integer Programs with binary variables: implications between variables can be used to improve preprocessing and to generate stronger cutting planes. In its current version, COIN-OR Branch-and-Cut solver (CBC) only does a limited usage of CGs. In this work we improve the performance of CBC in problems with this structure with the following additions: (i) a module to quickly detect implications in general constraints and build dense conflict graphs; (ii) clique merging based preprocessing and (iii) improved clique, odd-hole and knapsack cover cut separators using CGs. Our experiments show that the improved dual bounds obtained with our customized CBC solver allowed us to optimally solve more instances and to significantly reduce the integrality gap on executions with restricted time limits.
3 - Two Lower Bound Approaches for the Keyboard Layout Problem
Speaker: Maximilian John, MPII Saarbrücken, DE, talk 748
Co-Authors: *Andreas Karrenbauer*,
The keyboard layout problem consists of assigning letters to keys on a particularly shaped keyboard, optimizing certain aspects like ergonomics or typing speed, for example. As a special case of the quadratic assignment problem, solving the keyboard layout problem is one of the hardest combinatorial optimization problems. The key success factor of specialized branch-and-bound frameworks for minimizing quadratic assignment problems is an efficient implementation of a strong lower bound. In this presentation, we propose two lower bound approaches for this problem. The first one introduces the notion of cut pseudo bases, which allows for a transformation to a small and efficiently solvable semidefinite program. This transformation is self-tightening in a branch-and-bound process. The second approach is tailored to assignment problems with sparse quadratic cost. Our proposed algorithm dynamically generates the quadratic part of the layout problem and solves a sparsified linearization of the original problem in every iteration. This procedure results in a hierarchy of lower bounds on the one hand, and, in addition, provides heuristic primal solutions in every iteration on the other hand. While the former approach has been published at ISCO 2016 and can be found in the conference proceedings (pages 414-425), the latter framework is still unpublished work.

Extended Formulations

Discrete Optimization & Integer Programming
IPtheory - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 42 Building: C, 3rd floor, Zone: 1
Contributed Session 514
Chair: Bartosz Filipecki, TU Chemnitz, DE

1 - An Extended Formulation for the 1-Wheels of the Stable Set Polytope
Speaker: Bernd Perscheid, Trier University, DE, talk 1018
Co-Authors: *Sven de Vries*, *Ulf Friedrich*,
It is desirable to describe the convex hull of incidence vectors of the stable set polytope by a polynomial system of inequalities. However, since the maximum stable set problem is NP-hard, this is most likely out of reach. The edge constrained stable set polytope is of polynomial size, but usually allows fractional extreme points. Although the odd cycle inequalities are an exponential class of valid inequalities, Yannakakis (1991) showed how the separation problem for odd cycles can be solved by an extended formulation. A tighter description of the stable set polytope is achieved by the 1-wheel polytope, which includes the 1-wheel inequalities. They are, as well as the odd cycle inequalities, of exponential size. We present an efficient and compact extended formulation for the 1-wheel polytope, which has a polynomial number of variables and inequalities. Therefore, we are able to optimize over this polytope in polynomial time.
2 - Extended formulations for higher-order spanning tree polytopes
Speaker: Mirjam Friesen, OvGU Magdeburg, DE, talk 503
Co-Authors: *Volker Kaibel*,

We are interested in the convex hull of all vectors (x,y), where x is the characteristic vector of a spanning tree of a given graph and the entries of y are certain monomials in x. Polynomial spanning tree optimization is equivalent to linear optimization over such polytopes. We present small extended formulations for some types of those polytopes: The case of one single bilinear monomial, the case of a set of monomials corresponding to nested trees and the case of nested monomials up to degree 3. Our formulation can be used with any formulation for the spanning tree polytope and only increases its size by $O(mk)$, where m is the number of edges of the graph and k is the size of the largest monomial.

3 - Stronger Path-based Extended Formulation for the Steiner Tree Problem

Speaker: Bartosz Filipecki, TU Chemnitz, DE, talk 1158

Co-Authors: *Mathieu Van Vyve*,

The Steiner tree problem (STP) is a classical NP-hard combinatorial optimization problems with applications in computational biology and network wiring. Given an undirected graph with edge costs, the objective is to find a minimum-cost spanning tree of a subset of vertices called terminals. Current linear programming algorithms for STP rely mostly on one of two approaches - the bidirected cut relaxation (BCR) or hypergraphic formulations (HYP), the first of which can offer better computational performance, but the second one was proven to achieve better bounds on the integrality gap. We propose a new hierarchy of improving path-based extended formulations for STP. This hierarchy provides better integrality gaps on graph instances used to prove the worst case lower bounds on the integrality gap for both BCR and HYP. We present numerical results on several difficult instances, which show that our hierarchy can achieve significant integrality gap reduction in comparison to standard approaches and often closes the gap completely.

Optimization in Energy

Specific Models, Algorithms, and Software

Energy - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 22 Building: G, 2nd floor, Zone: 6

Contributed Session 515

Chair: Andrea Simonetto, IBM Research Ireland, IE

1 - Upstream-downstream dynamic programming for optimization of tree-shaped flows

Speaker: Christiano Lyra, University of Campinas, BR, talk 1200

Given a network operated as a tree with supply and demands at the nodes along with the costs of flows over each arc and the costs for allocating or controlling facilities at the nodes that alter the flows, the upstream-downstream dynamic programming strategy gives the best compromise between the cost of flows over the network and the cost of facilities or controls; cost and flow equations can be expressed as non-linear and non-convex functions. A generalization of the functional equation of dynamic programming assures global optimal solutions to these tree-shaped flow optimization problems, which appear in different fields and are finding new applications in power distribution networks, due to intermittent energy sources and other innovations associated to the smart grid paradigm. A constructive demonstration of global optimality is provided, for both deterministic and stochastic instances of the problem. The low computational complexity of the algorithm and possible generalizations to dynamic tree-shaped flow optimization problems are also discussed.

2 - Mathematical Programming for Forecasting Supplies and Demands in Gas Networks

Speaker: Milena Petkovic, Zuse Institute Berlin, DE, talk 1058

Co-Authors: *Inken Gamrath*,

Over the years, lower prices and better infrastructure lead to significant increase of natural gas usage in transportation, industrial and residential sectors. Transmissions system operators (TSO) are responsible for gas transmission and have the main priority to secure gas supplies and demands. The main goal of the work we present is to compute accurate hourly forecasts of gas flows for more than 1,000 entry and exit nodes of the complex transmission network in order to support different operational decisions and provide network stability. We introduce an optimization based approach for short-term gas flows forecasting combining online forecasting based on Linear Programming and offline training based on Mixed Integer Programming for choosing the optimal set of features for different nodes in order to adapt the model but also to avoid overfitting. Our results are based on real world data of Open Grid Europe, Germany's largest TSO, and compared to some classical benchmarks for time series forecasting.

3 - Time-varying optimization: algorithms and engineering applications

Speaker: Andrea Simonetto, IBM Research Ireland, IE, talk 580

Continuously varying optimization programs have appeared as a natural extension of time-invariant ones when the cost function, the constraints, or both, depend on a time parameter and change continuously in time. This setting captures relevant control, signal processing, and machine learning problems. Recently, running and prediction-correction methods have been put forward to set up iterative algorithms that sample the continuously-varying optimization program at discrete time steps track the optimizer(s) trajectory while it evolves in time up to an asymptotical error bound. In this talk, we will review current state-of-the-art algorithms in time-varying optimization, with a special emphasis in computational complexity, distributed implementation, and convergence (rate) analysis. We then present some relevant engineering applications for these algorithms in transportation systems and power grids, and we discuss how they perform.

Optimization for Energy System Planning

Specific Models, Algorithms, and Software

Energy - Fr 3:15pm-4:45pm, Format: 3x30 min

Room: Salle 23 Building: G, 3rd floor, Zone: 6

Contributed Session 524

Chair: Andrew Liu, Purdue University, US

1 - Expansion Planning of a Small Size Electric Energy System

Speaker: Luigi Boffino, University of Bergamo, IT, talk 892

Co-Authors: *Luis Baringo*, *Giorgia Oggioni*,
We propose a stochastic adaptive robust optimization approach for the expansion of a small size electricity system problem. This involves the construction of candidate renewable generating units, storage units and charging stations for electric vehicles (EVs). The problem is formulated under the perspective of the Distribution System Operator, which aims at determining the expansion plan that minimizes both investments and operation costs, including the power bought from the main grid. Long-term uncertainties in the future peak demands, in the cost of purchasing power from the main grid, and in the number of EVs are modeled using confidence bounds, while short-term uncertainties in the demand variability, in the production of stochastic units and in the electricity prices are modeled through a number of operating conditions. The effectiveness of the proposed approach is confirmed by the results of an illustrative example.

2 - Regaining tractability in SDDP algorithms for large energy planning problems
Speaker: Marion Lemery, Edinburgh University, GB, talk 1059
Co-Authors: *Ken McKinnon*, *Philippe Mahey*,
Stochastic Dual Dynamic Programming is a well known technique to solve multistage convex energy production planning problems under uncertainty. Most implementations discretize the underlying random process, but this leads to an approximation of each expected cost-to-go function and the bounds are no longer guaranteed to be valid. Also this approach becomes intractable when the discretized space is large, which occurs for example when the underlying stochastic process is autocorrelated. We use an alternative to state space discretization for such problems. Cuts are built in the joint space of the reservoir levels and the parameters of the stochastic process. We present an 8 region hydrothermal planning problem and show that the optimality gap shrinks to below 3 percent very quickly. We reduce the gap further by constructing a small set of realizations which approximates the random process in such a way as to generate as tight a valid bound as possible for the chosen number of realizations.

3 - Capacity Expansion through Decentralized Optimization
Speaker: Andrew Liu, Purdue University, US, talk 752
Co-Authors: *Run Chen*,
Power grids' planning and operation exhibit extreme multiscale, ranging from hourly operation to decades of planning. The linkage of such decisions can be treated in a decoupled through a consensus-style algorithm to produce multiple independent subproblems. We propose to use the predictor-corrector proximal method (PCPM) to design a parallel algorithm to solve such multiscale problems. Convergence can be shown for convex problems and linear convergence rate can be obtained under strong convexity. We use the algorithm to demonstrate the convenience of using chronological load modeling to incorporate storage resources, and the importance to consider ramping constraints in finer time-scale in long-term capacity planning with large-scale renewable resources.

Machine Scheduling 1

Specific Models, Algorithms, and Software Scheduling - Fr 3:15pm-4:45pm, Format: 3x30 min
Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 527
Chair: Renan Trindade, UFRJ, BR

1 - Maximum Probabilistic All-or-Nothing Paths and Critical Chains
Speaker: Noam Goldberg, Bar-Ilan University, IL, talk 1260
Co-Authors: *Michael Poss*,
We consider the problem of a maximum probabilistic all-or-nothing network path; each arc is associated with a profit and a probability and the objective is to select a path with maximum product of probabilities times the sum of arc profits. In a general graph the problem generalizes the strongly NP-hard longest path problem. The problem is motivated by an application to the critical path analysis in acyclic project networks. When procuring activities along the critical path, each activity must be completed in a timely and satisfactory manner in order for the entire project to be deemed successful. We develop a dynamic programming (DP) method for this problem in the acyclic graph setting. Two different fully-polynomial approximation schemes are developed based on DP formulations, one applies repeated rounding and scaling and another uses only rounding of the input data. In experiments we compare the DP approach with integer nonlinear programming (INLP) branch and cut. We also evaluate the solution of our model in general graphs using integer programming methods.

2 - Max-Cost Scheduling with Controllable Processing Times and a Common Deadline
Speaker: Vitaly Strusevich, University of Greenwich, GB, talk 852
Co-Authors: *Akiyoshi Shioura*, *Natalia Shakhlevich*,
We consider a range of scheduling problems with controllable processing times, in which the jobs must be completed by their deadlines by compressing appropriately their processing times. The objective is to minimize the maximum compression cost and preemption is allowed. Traditionally, these models are studied within the body of research on imprecise computation. In our recent survey (A. Shioura, N.V. Shakhlevich and V.A. Strusevich, Preemptive models of scheduling with controllable processing times and of scheduling imprecise computation: A review of solution approaches. European Journal of Operational Research, 2018, 266, 795-818), we have described improved algorithms for the problems with arbitrary deadlines. In this paper, we present a number of polynomial-time algorithms for the problems with a common deadline. The algorithms are derived from common general principles adapted with a purpose of reducing the resulting running times.

3 - An arc-flow formulation for minimizing makespan on a batch processing machine
Speaker: Renan Trindade, UFRJ, BR, talk 1653
Co-Authors: *Olinto C. B. de Araújo*, *Marcia Fampa*,
We present a new formulation for the problem of minimizing the makespan on a single batch processing machine with non-identical job sizes. We apply an arc-flow approach to model the problem and show though computational experiments the capacity of the formulation of solving to optimality with very good running times, instances not solved before, when compared to previous result for this problem from the literature.

Moment relaxations for polynomial optimization with symmetries

CONTINUOUS OPTIMIZATION
NLP - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: GINTRAC Building: Q, Ground Floor, Zone: 8
INVITED SESSION 10
Organizer: Markus Schweighofer, Universität Konstanz, DE

1 - Coloring the Voronoi tessellation of lattices
Speaker: Frank Vallentin, University of Cologne, DE, talk 40
Co-Authors: *David Madore*,
In this talk I will define the chromatic number of a lattice: It is the least number of colors one needs to color the interiors of the cells of the Voronoi tessellation of a lattice so that no two cells sharing a facet are of the same color. I will introduce two lower bounds for the chromatic number: the sphere packing lower bound and the spectral lower bound. Using them I will show how to compute, sometimes using polynomial optimization, the chromatic number of several important lattices.

2 - Semidefinite optimization and arithmetic progressions
Speaker: Cordian Riener, Arctic University of Norway, NO, talk 109
Co-Authors: *Aron Rahman*, *Frank Vallentin*,
A finite arithmetic progression is a finite sequence of numbers such that the difference between the consecutive terms is constant. We are interested in the following question closely related to the so called Erdős–Turán constant: What is the minimal number of arithmetic progressions of fixed length every fixed-density subset of a given field of prime order must contain? In order to study this question we derive a sequence of semidefinite optimization problems which yield increasingly sharper lower bounds for the number of such arithmetic progressions. After applying symmetry reduction techniques, we are able to compute these lower bounds for three and four term progressions.

3 - The upper density of sets avoiding norm one in the real space of dimension n
Speaker: Philippe Moustrou, University of Tromsø, NO, talk 83
Co-Authors: *Christine Bachoc*, *Sinai Robins*,
What is the largest density of a subset of the real space of dimension n such that the difference of any pair of points of this subset does not achieve norm one? This question is related to the long standing problem of the determination of the chromatic number of the plane. We will review some results and conjectures relative to the case of norms whose unit sphere tiles space by translations. We will show how to obtain an upper bound through the Fourier transform of a finite measure supported on the unit sphere. In particular, we will see that point measures lead to interesting polynomial optimization problems.

Computer-assisted analyses of optimization algorithms II

CONTINUOUS OPTIMIZATION
SDP - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: Salle AURIAC Building: G, 1st floor, Zone: 6
INVITED SESSION 16
Organizer: Adrien Taylor, INRIA, FR

1 - SDP performance analysis of inexact Newton-type methods for self-concordant func
Speaker: Etienne De Klerk, Tilburg University, NL, talk 15
Co-Authors: *Adrien Taylor*, *Francois Glineur*,
We provide new tools for worst-case performance analysis of the gradient (or steepest descent) method of Cauchy for smooth strongly convex functions, and Newton's method for self-concordant functions. The analysis uses semidefinite programming performance estimation, as pioneered by Drori en Teboulle, and extends recent performance estimation results for the method of Cauchy by the authors. To illustrate the applicability of the tools, we sketch how to give a rigorous worst-case complexity analysis of a recent interior point method by Abernethy and Hazan. The algorithm of Abernethy and Hazan has sparked much recent interest, since it demonstrates the formal equivalence between an interior point method and a simulated annealing algorithm for convex optimization, but several details of the worst-case analysis are omitted in their paper.

2 - A Universal Interior Point Method Using Hit-and-Run Sampling
Speaker: Riley Badenbroek, Tilburg University, NL, talk 90
Co-Authors: *Etienne De Klerk*,
We study an interior point method that only assumes a membership oracle of the feasible region. The barrier of choice, called the entropic barrier, has a natural interpretation in terms of a family of exponential distributions over the feasible set. The gradient and Hessian of this barrier can thus be approximated by Monte Carlo methods such as hit-and-run sampling. This method is applicable to optimization problems over convex sets where the barrier function is unknown of not efficiently computable, like the Subtour Elimination Polytope.

3 - Worst-case analyses of stochastic gradient-based methods using SDPs
Speaker: Adrien Taylor, INRIA, FR, talk 20
Co-Authors: *Francis Bach*,
We present a novel approach for analysis and design of stochastic gradient-based methods using semidefinite programming. The methodology relies on the one hand on performance estimation problems, and on the other hand on novel approaches for designing Lyapunov functions based on convex interpolation. In the most simple settings, the approach inherits tightness guarantees from performance estimation problems, and in the other cases, it provides valid worst-case certificates for the behavior of SGD-based methods. In this talk, we present both the approach and corresponding consequences for the stochastic gradient-based method.

Sparse Semidefinite Programming

CONTINUOUS OPTIMIZATION
SDP - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: Salle LC5 Building: L, Intermediate 1, Zone: 10
INVITED SESSION 17
Organizer: Somayeh Sojoudi, UC Berkeley, US

1 - Sparse Semidefinite Relaxations of Communicability-Based Graph Partition Problem
Speaker: Martin Andersen, Technical Univ. of Denmark, DK, talk 123
We consider a class of graph partition problems that are based on communicability-weighted cuts. The communicability between two nodes in a network can be though of as a generalization of the concept of the shortest path that takes all possible walks from one node to the other into account (Estrada and Hatano, 2007). Semidefinite relaxations of the resulting partition problems are generally dense, and hence computationally expensive to solve when the number of nodes is large. We show that under some assumptions, the semidefinite relaxation has a sparse reformulation, and we demonstrate with some numerical experiments that the sparse reformulation significantly reduces the cost of solving many relaxation problems.
2 - Lasserre hierarchy for large scale polynomial optimization
Speaker: Cedric Josz, UC Berkeley, US, talk 112
Co-Authors: *Daniel Molzahn*,
We propose general notions to deal with large scale polynomial optimization problems and demonstrate their efficiency on a key industrial problem of the twenty first century, namely the optimal power flow problem. These notions enable us to find global minimizers on instances with up to 4,500 variables and 14,500 constraints. First, we generalize the Lasserre hierarchy from real to complex to numbers in order to enhance its tractability when dealing with complex polynomial optimization. Complex numbers are typically used to represent oscillatory phenomena, which are omnipresent in physical systems. Using the notion of hyponormality in operator theory, we provide a finite convergence criterion which generalizes the Curto-Fialkow conditions of the real Lasserre hierarchy. Second, we introduce the multi-ordered Lasserre hierarchy in order to exploit sparsity in polynomial optimization problems (in real or complex variables) while preserving global convergence. It is based on two ideas: 1) to use a different relaxation order for each constraint, and 2) to iteratively seek a closest measure to the truncated moment data until a measure matches the truncated data. Third and last, we exhibit a block diagonal structure of the Lasserre hierarchy in the presence of commonly encountered symmetries. To the best of our knowledge, the Lasserre hierarchy was previously limited to small scale problems, while we solve a large scale industrial problem with thousands of variables and constraints to global optimality.
3 - Fast Algorithms for Max-Det Matrix Completion and Graphical Lasso
Speaker: Somayeh Sojoudi, UC Berkeley, US, talk 111
Co-Authors: *Salar Fattahi*, *Richard Zhang*,
In this talk, we consider the Graphical Lasso (GL) problem that is a popular method for learning the sparse representations of high-dimensional datasets. First, we show that GL can be reduced to a maximum determinant matrix completion problem and drive a recursive closed-form solution for the GL, provided that the thresholded sample covariance matrix has a chordal structure. For large-scale chordal problems with up to 450 million variables, the proposed method can solve the GL problem in less than 2 minutes, while the state-of-the-art methods converge in more than 2 hours. For a general sparse structure that is not necessarily chordal, we develop a numeral algorithm based on Newton's method and Conjugate Gradient with a linear time and memory complexity. We offer several case studies and solve non-chordal problems with as many as 200,000 variables to 7-9 digits of accuracy in less than an hour on a standard laptop computer running MATLAB.

Derivative-free global optimization algorithms

Continuous Optimization
DerFree - Fr 5:00pm-6:00pm, Format: 2x30 min
Room: Salle 21 Building: G, Intermediate, Zone: 6

Contributed Session 41
Chair: Zaikun Zhang, Hong Kong Polytechnic Univ., HK

1 - Optimization with global surrogate and trust-region assisted local search
Speaker: Limeng Liu, Natl. Univ. Singapore, SG, talk 271
Co-Authors: *Christine Shoemaker*,
We propose a new optimization framework for global optimization of computational expensive, black-box functions that seeks to improve accuracy by intelligently selecting among local minima in the surrogate for points at which to do derivative free trust regions search with expensive evaluations selected by the local optimizer ORBIT. We iteratively utilize a Global-Local loop structure with three phases: Global phase, Link phase and Local phase. The Global phase uses radial basis function models as the global surrogate to guide the search. The Link phase finds the local minima of global surrogate with Multi-Level Single Linkage algorithm and selects among local minima in the surrogate for local search based on two criteria: surrogate value and extent of exploration. The Local phase also uses a radial basis function as its surrogate to do derivative free trust regions search with local optimizer ORBIT. Two versions of the algorithm (GOLO-BFGS, GOLO-Gen) are proposed in our paper. They are different in the link phase. In numerical experiments, our algorithms are compared with 5 other algorithms on 43 test problems with dimension from 2 to 40. The results show that our algorithms have the best overall performance, especially on high dimensional problems. For low dimensional problems, our algorithms can also find better solutions than other algorithms, but the difference is not as large as in high dimensional problems. In conclusion, the proposed algorithms, GOLO is a good choice for global optimization of expensive, black box functions.
2 - Benchmarking Bayesian, Derivative-Free, and Stochastic Blackbox Algorithms
Speaker: Anne Auger, Inria and Ecole Polytechnique, FR, talk 555
Co-Authors: *Dimo Brockhoff*, *Pierre Marion*, *Lin Lu*, *Nikolaus Hansen*,
Bayesian optimization (BO) methods are model-based algorithms for blackbox optimization, tailored towards problems with expensive evaluations. They are often used for complex hyperparameter tuning tasks in the context of machine learning. Performance evaluation of BO algorithms is often restricted in the difficulty of investigated test functions, problem dimensions, and the number of algorithms involved. The Comparing Continuous Optimizers platform (COCO), on the

contrary, provides a large set of well understood and scalable problems and an automated well-founded functionality to produce and visualize algorithm performance data. In this presentation, we show benchmarking results of three popular BO methods, implemented in libraries for hyperparameter tuning, in the wider context of (expensive) blackbox optimization. With the help of COCO, we compare the methods TPE, Spearmint, and SMAC with other algorithms from the derivative-free and stochastic optimization fields on a wide range of test problems of varying difficulty and dimension. We find that some of the BO algorithms under consideration perform well for specific budgets and problem properties, but more importantly that well-known derivative-free and blackbox optimizers often outperform them—matching statements from a recent independent comparison of a subset of the considered algorithms on a more restricted set of machine learning problems.

Subspace methods in NLP II

Continuous Optimization
NLP - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: Salle KC7 Building: K, Intermediate 2, Zone: 10

Invited Session 44
Organizer: Panos Parpas, Imperial College London, GB

1 - Distributed Subspace Decomposition
Speaker: Panos Parpas, Imperial College London, GB, talk 384
Conventional distributed optimization algorithms are not able to exploit the large number of cores in modern computer architectures. Recent first-order algorithms can use a large number of cores but they are only suitable for some applications (e.g. machine learning). First-order methods are too slow for applications where each function evaluation is expensive, or if higher accuracy is necessary (e.g. in PDE constrained problems). We propose an alternative distributed optimisation algorithm based on subspace corrections. The proposed algorithm uses a reduced order model to predict the value of complicating variables (global prediction phase). It then performs corrections, in parallel using a much smaller model (local correction phase). We discuss the convergence of the algorithm and present numerical results.

2 - Subspace Frameworks for Eigenvalue Optimization
Speaker: Emre Mengi, Koc University, TR, talk 430
The talk concerns the optimization of a prescribed eigenvalue of a symmetric matrix depending on several parameters. The topic is motivated by various applications, for instance in graph theory, control theory and structural design problems. We start with a review of a general algorithm for nonconvex eigenvalue optimization, which is based on global piece-wise quadratic approximations for the nonconvex eigenvalue function. The second part features a greedy subspace framework for large-scale eigenvalue optimization problems involving large matrices. At every iteration, a reduced eigenvalue optimization problem is obtained by projecting the large matrices onto small carefully chosen subspaces. The final part explores an adaptation of the subspace framework for convex semidefinite programs with large matrix variables. Here we benefit from the eigenvalue optimization characterization of the dual of a semidefinite program.

3 - A block-coordinate Gauss-Newton method for nonlinear least squares
Speaker: Jaroslav Fowkes, University of Oxford, GB, talk 455
Co-Authors: *Coralia Cartis*,
Nonlinear (nonconvex) least squares problems are used for a range of important scientific applications, such as data assimilation for weather forecasting and climate modelling, where parameter estimation is needed in order to specify simulation models that fit observations. In many of these applications, a model run is computationally expensive but provides the full vector of simulated observations. However, calculating the entire Jacobian may be too expensive as it may involve additional model runs along each variable coordinate. We propose a block-coordinate Gauss-Newton method that calculates Jacobians only on a subset of the variables/parameters at a time. We investigate globalising this approach with a regularization term or with a trust-region and show global complexity results for both variants, as well as extensive computational results on CUTEst test problems. Furthermore, as we exhibit very slow rates of convergence on certain problems, we design adaptive block size variants of our methods that can overcome these inefficiencies.

Nonsmooth DC optimization with applications

Continuous Optimization
NonSmooth - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 8 Building: N, 4th floor, Zone: 12

Contributed Session 46
Chair: Napsu Karmitsa, University of Turku, FI

1 - PIECEWISE LINEAR REGRESSION VIA NONSMOOTH DC OPTIMIZATION
Speaker: Sona Taheri, Federation University, AU, talk 199
Co-Authors: *Adil Bagirov*, *Soodabeh Asadi*,
The problem of finding a continuous piecewise linear function approximating a regression function is considered. This problem is formulated as a nonconvex nonsmooth optimization problem where the objective function is represented as a difference of convex (DC) functions. Subdifferentials of DC components are computed and an algorithm is designed based on these subdifferentials to find piecewise linear functions. The algorithm is tested using some synthetic and real world data sets and compared with other regression algorithms.

2 - Double Bundle Method for Nonsmooth DC Optimization
Speaker: Kaisa Joki, University of Turku, FI, talk 118
Co-Authors: *Adil Bagirov*, *Napsu Karmitsa*, *Marko Mäkelä*, *Sona Taheri*,
A class of functions presented as a difference of two convex (DC) functions constitutes an important subclass of nonconvex functions, since these functions preserve some important properties of convex functions. In addition, many practical problems can be expressed in a DC form such as location planning, engineering design and cluster analysis. However, most nonsmooth DC algorithms guarantee only criticality for the solution point and this condition is weaker than Clarke stationarity typically used in general nonconvex nonsmooth

optimization. We will introduce a new double bundle method for unconstrained nonsmooth DC minimization utilizing explicitly the DC decomposition of the objective. The main novelty of the method is a new escaping procedure designed to ensure Clarke stationarity for candidate solutions by using only information about the DC components. In addition, if a candidate solution is not Clarke stationary, then the escaping procedure yields a descent direction. In practice, this means that we are able to avoid some drawbacks encountered when criticality is used as an optimality condition. Some encouraging numerical results will also be presented.

3 - Support vector machines for clusterwise linear regression

Speaker: Napsu Karmitsa, University of Turku, FI, talk 537
Co-Authors: *Kaisa Joki*, *Adil Bagirov*, *Marko Mäkelä*, *Sona Taheri*,

In clusterwise linear regression (CLR), the aim is to partition a data into a given number of clusters and simultaneously find regression coefficients for each of these cluster. In this paper, we propose a novel approach to solve the CLR problem. The main idea is to utilize the support vector machine (SVM) approach to model the CLR problem. In other words we use the SVM for regression to approximate each cluster. This new formulation of the CLR problem is represented as an unconstrained nonsmooth optimization problem, where we minimize a difference of two convex (DC) functions. A method based on the combination of the incremental algorithm and the double bundle method for DC optimization is designed for solving it. Numerical experiments are made and analysed to validate the reliability of the new formulation for CLR and the efficiency of the proposed method. The results show that the SVM approach is beneficial in solving CLR problems, especially, when there are outliers in data.

Mixed-Integer PDE-Constrained Optimization

Discrete Optimization & Integer Programming
MINLP - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: DURKHEIM Building: A, 3rd floor, Zone: 1

Invited Session 63
Organizer: Sven Leyffer, Argonne National Laboratory, US

1 - Inversion of Convection-Diffusion PDE with Discrete Source

Speaker: Meenarli Sharma, IIT Bombay, IN, talk 1094
Co-Authors: *Sven Leyffer*, *Lars Ruthotto*,

We consider a version of the source inversion problem for the stationary convection-diffusion equations. Given discrete measurements of the concentration on the computational domain, our goal is to identify an unknown number of active sources among a given set of candidates. We formulate the inverse problem as a mixed integer nonlinear program (MINLP) that consists of minimizing the distance between the measured and simulated data which is given by the solution of the discretized partial differential equation (PDE) forward model. The resulting model belongs to the challenging class of mixed-integer PDE-constrained optimization (MIPDECO) problems. Our numerical experiments using different off-the-shelf mixed-integer nonlinear solvers indicate that solving the MINLP is computationally prohibitive for a sufficiently large number of candidate sources, fine mesh sizes, and for 3-dimensional cases. We present heuristics that use continuous relaxation of the MIPDECO problem and a clustering technique to determine number and location of sources. Our heuristic solution can serve as an initialization for shape optimization approaches to source inversion, whose performance depends critically on reliably estimating the number and location of the active sources.

2 - Shape optimization towards binary variables with PDE constraints

Speaker: Martin Siebenborn, Universität Hamburg, DE, talk 607

In many applications, which are modeled by partial differential equations, there is a small number of materials or parameters distinguished by interfaces to be identified. While classical approaches in the field of optimal control yield continuous solutions, a spatially distributed, binary variable is closer to the desired application. It is thus favorable, to treat the shape of the interface between an active and inactive control as the variable. We investigate a combination of classical PDE constrained optimization methods and a rounding strategy based on shape optimization for the identification of interfaces. The goal is to identify the location of pollution sources in fluid flows represented by a control, that is either active or inactive. We use a relaxation of the binary problem on a coarse grid as initial guess for the shape optimization with higher resolution. The result is a computationally cheap method, that does not have to perform large shape deformations. We demonstrate that our algorithm is moreover able to change the topology of the initial guess.

3 - Set-valued steepest descent for binary topology and control optimization

Speaker: Mirko Hahn, OvGU Magdeburg, DE, talk 1036
Co-Authors: *Sebastian Sager*, *Sven Leyffer*,

PDE- and ODE-constrained optimization problems with integer-valued control functions are often computationally intractable due to the fact that the number of integer variables increases as control meshes are refined. We discuss a method which avoids these issues for a class of problems with a single binary-valued control function by reformulating the original problem as an optimization problem over the sigma-algebra of Lebesgue-measurable sets. By reformulating the problem in terms of set-valued variables, we can transfer much of the theory of continuous nonlinear programming to mixed-integer problems, which we demonstrate by developing an analogue of the steepest descent method. In addition, we address issues of precision and convergence, as well as possible extensions and theoretical limitations of our approach.

Primal-dual and ADMM algorithms for nonlinear programming

Continuous Optimization
NLP - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 05 Building: Q, 1st floor, Zone: 11

Invited Session 91
Organizer: Marco Sciandrone, Università di Firenze, IT

1 - Smooth Primal-Dual Coordinate Descent for Nons-

mooth Convex Optimization
Speaker: Ahmet Alacaoglu, EPFL, CH, talk 347
Co-Authors: *Quoc Tran-Dinh*, *Olivier Fercoq*, *Volkan Cevher*,
We propose a new randomized coordinate descent method for a convex optimization template with broad applications. Our analysis relies on a novel combination of four ideas applied to the primal-dual gap function: smoothing, acceleration, homotopy, and non-uniform sampling. As a result, our method features the first convergence rate guarantees that are the best-known under a variety of common structure assumptions on the template. We provide numerical evidence to support the theoretical results with a comparison to state-of-the-art algorithms.

2 - A primal-dual algorithm for general convex-concave saddle point problems
Speaker: N. Serhat Aybat, Penn State University, US, talk 767
Co-Authors: *Erfan Y. Hamedani*,
In this talk, we propose a primal-dual algorithm with a momentum term, which can be viewed as a generalization of the method proposed by Chambolle and Pock in 2016, to solve saddle point problems defined by a convex-concave function $L(x,y) = f(x) + \Phi(x,y) - h(y)$ with a general coupling term $\Phi(x,y)$ that is not assumed to be bilinear. Given a saddle point (x^*, y^*), assuming the partial gradients of Φ satisfy certain Lipshitz continuity property, we derive error bounds in terms of $L(x_k, x^*) - L(y^*, y_k)$ for the ergodic sequence $\{x_k, y_k\}$; in particular, we show $O(1/k)$ rate that when the problem is merely convex in x. Furthermore, assuming $\Phi(x,y)$ is linear in y for each fixed x and f is strongly convex, we can obtain the ergodic convergence rate of $O(1/k^2)$ – we are not aware of any other work in the related literature showing $O(1/k^2)$ rate when Φ is not bilinear. We tested our method for solving kernel matrix learning problem, and compare it against the Mirror-prox algorithm and interior point methods.

3 - ADMM with Plug-and-Play Regularizers: Convergence Guarantees and Applications
Speaker: Mario Figueiredo, Instituto de Telecomunicacoes, PT, talk 774
This talk will address a recent trend in the use of ADMM (alternating direction method of multipliers) in imaging inverse problems: the so-called plug-and-play (PnP) approach, wherein a formal regularizer is replaced with a black-box denoiser, aiming at leveraging state-of-the-art denoisers in more general inverse problems. Since these denoisers usually lack an optimization formulation, classical results on the convergence of ADMM cannot be directly invoked. Recently, we have proposed a class of denoisers which, while achieving excellent performance, also allow guaranteeing convergence of the resulting PnP-ADMM algorithm. These denoisers are particularly well suited to certain data fusion problems in imaging, which we will describe and use to illustrate the proposed approach.

4 - Alternating minimization methods for constrained nonconvex optimization
Speaker: Giulio Galvan, Università di Firenze, IT, talk 631
Co-Authors: *Matteo Lapucci*, *Tommaso Levato*, *Marco Sciandrone*,
The Alternating Direction Method of Multipliers (ADMM) is often successfully employed to solve optimization problems in which the feasible set has a particular structure, namely, is defined by sets of constraints that are easy to treat when considered separately. The performance of ADMM, however, strongly depends on the choice of the penalty parameter of the algorithm which is, in general, very hard to tune. Furthermore, while the convergence of the algorithm is well understood in the convex case, convergence for non-convex functions is still a vivid topic of research. We study alternating minimization methods as modifications of ADMM, where block decomposition methods are embedded within an augmented Lagrangian framework. The proposed approach allows us to 1) deal naturally with the non-convex case 2) iteratively tune the penalty parameter. A global convergence analysis is performed and the results of some computational experiments are presented.

Global Optimization for nonconvex MINLPs

Discrete Optimization & Integer Programming
MINLP - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 39 Building: E, 3rd floor, Zone: 1

Invited Session 92
Organizer: Hassan Hijazi, Los Alamos National Laboratory, US

1 - Global Optimization for AC Optimal Power Flow Applications
Speaker: Anya Castillo, Sandia National Laboratories, US, talk 761
Co-Authors: *Michael Bynum*, *Carl Laird*, *Jean-Paul Watson*,
Efficient and reliable operation of the electric grid is critical for both the economy and public safety. The grid is typically operated by solving optimization problems with linear approximations of the physics governing the transmission of electricity across the grid. More efficient and more reliable operation is possible with higher fidelity models. However, this would involve the solution of mixed-integer nonlinear programs (MINLPs), which can be computationally challenging. The first step towards efficient solution of such MINLP problems (e.g., the Unit Commitment (UC) problem or Optimal Transmission Switching (OTS) problem) with high fidelity nonlinear, alternating current (AC) network models is the efficient global optimization of the Alternating Current Optimal Power Flow Problem (ACOPF). In this talk we will focus on global optimization techniques to solve the ACOPF problem that leverage commercial solvers Gurobi/Cplex, which are the standard for power system operations and market settlements in real-world applications. We will also present preliminary results for global optimization of applicable MINLP with AC network models. We close with a discussion on future directions that the community needs to explore to be able to solve the ACOPF problem and its applications to global optimality, efficiently and effectively.

2 - Tight Piecewise Formulations and Algorithms for Global Optimization of MINLPs
Speaker: Harsha Nagarajan, Los Alamos National Laboratory, US, talk 782
Co-Authors: *Kaarthik Sundar*, *Russell Bent*, *Site Wang*, *Jeff Linderoth*,
MINLPs arise in practical applications such as synthesis of process and water networks, energy infrastructure networks,

to name a few. Efficient algorithms to solve such optimization problems to global optimality is a key to addressing these applications. State-of-the-art techniques go by the philosophy of sub-dividing down the original problem into a large number of "easy-to-solve" sub-problems which will in turn be used to find the globally optimal solution. To this end, there has been development of MILP-based approaches, that leverage commercial solvers like Gurobi/Cplex, to solve a MINLP by applying piecewise polyhedral relaxations iteratively by partitioning the variable domains. However, the two major bottlenecks for this approach are (a) The tightness of the lower-bounding MILPs (with min. objective) and (b) The efficiency of the iterative algorithm. To address the former, we present tight MILP formulations of piecewise, polyhedral relaxations of multilinear functions. We present two formulations to characterize the disjunctive unions of resulting polyhedrons and prove the existence of locally-ideal and locally-sharp properties of these disjunctive formulations. To address the latter, we discuss an algorithm based on adaptive, multivariate partitioning with non-uniform variable partitions combined with optimality-based bound tightening to speed up the convergence to global optimum. Finally, we provide a brief demo/snapshot of an open-source solver (using Julia/JuMP) based on the proposed algorithms and show some results comparing it with state-of-the-art solvers.

3 - Semidefinite Programming Cuts in Gravity

Speaker: Hassan Hijazi, Los Alamos National Laboratory, US, talk 753

Co-Authors: *Ksenia Bestuzheva*, *Carleton Coffrin*,

In this talk, we will present recent work on generating polynomial and linear cuts to capture positive semidefinite constraints in an attempt to scale up semidefinite programming relaxations of nonconvex problems. We will discuss implementation challenges in Gravity and applications such as the AC Optimal Power Flow and its discrete extensions allowing for line switching and investment planning.

Recent Advances and Applications of MINLP

Discrete Optimization & Integer Programming

MINLP - Fr 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 35 Building: B, Intermediate, Zone: 4

Invited Session 139

Organizer: Jose Ucha, Universidad de Sevilla, ES

1 - Duality and multidimensional kernels in ℓ_p-Support Vector Machines

Speaker: Victor Blanco, Universidad de Granada, ES, talk 874

Co-Authors: *Justo Puerto*, *Antonio Rodríguez-Chía*,

In this talk, we will show an extension of the methodology developed for Support Vector Machines (SVM) using ℓ_2-norm to the more general case of ℓ_p-norms with $p \geq 1$ (ℓ_p-SVM). The resulting primal and dual problems are formulated as mathematical programming problems; namely, in the primal case, as a second order cone optimization problem and in the dual case, as a polynomial optimization problem involving homogeneous polynomials. Scalability of the primal problem is obtained via general transformations based on the expansion of functionals in Schauder spaces. The concept of Kernel function, widely applied in ℓ_2-SVM, is extended to the more general case by defining a new operator called multidimensional Kernel. This object gives rise to reformulations of dual problems, in a transformed space of the original data, which are solved by a moment-sdp based approach. The results of some computational experiments on real-world datasets are presented showing rather good behavior in terms of standard indicators such as the accuracy index and its ability to classify new data.

2 - An algebraic exact method for multi-objective RAP in series-parallel systems.

Speaker: Jose Ucha, Universidad de Sevilla, ES, talk 1069

Co-Authors: *M Isabel Hartillo*, *Haydee Jimenez*,

In this talk we will show how to apply an algebraic algorithm for multi-objective redundancy allocation problems in series-parallel systems. Our method computes exactly all the Pareto-optimal points, and it is based on the idea of algebraic test-sets associated to a single-objective problems and the classical ϵ-constraint method. We use a decomposition of the problems into several multi-objective linear subproblems to later combine their solutions.

3 - On Testing Attainment of the Optimal Value in Nonlinear Optimization

Speaker: Jeffrey Zhang, Princeton University, US, talk 933

Co-Authors: *Amir Ali Ahmadi*,

We prove that testing attainment of the optimal value of nonlinear optimization problems where the objective and constraints are given by low-degree polynomials is NP-hard in the strong sense. If the degrees of these polynomials are fixed, our results along with previously-known “Frank-Wolfe type” theorems show that exactly one of two cases can occur: either the optimal value is attained on every instance, or it is NP-hard to distinguish attainment from non-attainment. We also show that testing for some well-known sufficient conditions for attainment of the optimal value, such as coercivity of the objective function and closedness and boundedness of the feasible set, is NP-hard. As a byproduct, our proofs imply that testing the Archimedean property of a quadratic module is NP-hard, a property that is of independent interest to the convergence of the Lasserre hierarchy. Finally, we give semidefinite programming (SDP)-based sufficient conditions for attainment of the optimal value, in particular a new characterization of coercive polynomials that lends itself to an SDP hierarchy.

Nonlinear Optimization and Variational Inequalities IV

Continuous Optimization

Variat - Fr 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 06 Building: Q, 1st floor, Zone: 11

Invited Session 144

Organizer: Cong Sun, Beijing Univ. Post. Telecomm., CN

1 - A TVSCAD approach for image deblurring with impulsive noise

Speaker: Junfeng Yang, Nanjing University, CN, talk 87

Co-Authors: *Guoyong Gu*, *Suhong Jiang*,

We consider image deblurring problem in the presence of impulsive noise. It is known that total variation (TV) regularization with L1-norm penalized data fitting (TVL1) works reasonably well only when the level of impulsive noise is relatively low. For high level impulsive noise, TVL1 works poorly. The reason is that all data, both corrupted and noise free, are equally penalized in data fitting, leading to insurmountable difficulty in balancing regularization and data fitting. In this paper, we propose to combine TV regularization with nonconvex smoothly clipped absolute deviation (SCAD) penalty for data fitting (TVSCAD). Our motivation is simply that data fitting should be enforced only when an observed data is not severely corrupted, while for those data more likely to be severely corrupted, less or even null penalization should be enforced. A difference of convex functions algorithm is adopted to solve the nonconvex TVSCAD model, resulting in solving a sequence of TVL1-equivalent problems, each of which can then be solved efficiently by the alternating direction method of multipliers. Theoretically, we establish global convergence to a critical point of the nonconvex objective function. The R-linear and at-least-sublinear convergence rate results are derived for the cases of anisotropic and isotropic TV, respectively. Numerically, experimental results are given to show that the TVSCAD approach improves those of the TVL1 significantly, especially for cases with high level impulsive noise, and is comparable with a recently proposed iteratively corrected TVL1 method.

2 - A semismooth Newton based augmented Lagrangian method for solving SVM problems
Speaker: Chengjing Wang, Southwest Jiaotong University, CN, talk 72
Co-Authors: *Dunbiao Niu*, *Tang Peipei*, *Enbin Song*,
The support vector machine (SVM) is one of the most popular classification models that aims to separate two classes with maximum distance between them. Previous studies have demonstrated the superiority of the SVM in dealing with the high dimensional, low sample size (HDLSS) data analysis problems. However, with the sample size increasing,the numerical difficulties in computations of the SVM become severe. Despite the fact that there exist a large number of solvers in the literature for the SVM, few solvers are designed by exploiting the special structure of the model. In this paper, we propose a highly efficient semismooth Newton based augmented Lagrangian method for solving a large-scale convex quadratic programming problem generated by the dual of the SVM with constraints consisting of one linear equality constraint and a simple box constraint. By leveraging on available error bound results to realize the asymptotic superlinear convergence property of the augmented Lagrangian method, and by exploiting the second-order sparsity of the problem through the semismooth Newton method, the algorithm we propose can efficiently solve the aforementioned difficult problems. Numerical comparisons between our approach and a number of state-of-the-art solvers on real data sets are presented to demonstrate the high efficiency and robustness of our algorithm.

3 - Matrix optimization in data science: recent progress on algorithm foundation
Speaker: Chao Ding, AMSS CAS, CN, talk 62
Co-Authors: *Cui Ying*, *Xinyuan Zhao*,
Matrix optimization problems (MOPs) have been recognized in recent years to be a powerful tool by researchers far beyond the optimization community to model many important applications arising from data science. In this talk, I will present some recent progress on algorithm foundation of solving MOPs.

Algorithmic Fairness and Optimization

Discrete Optimization & Integer Programming
APPROX - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: LEYTEIRE Building: E, 3rd floor, Zone: 1

Invited Session 161
Organizer: Nisheeth Vishnoi, EPFL, CH

1 - Measuring Algorithmic (Un)Fairness via Inequality Indices
Speaker: Krishna Gummadi, Max Planck Institute, DE, talk 1163
Fairness of algorithmic (data-driven learning-based) decision making has received considerable attention recently. Prior work on the topic largely focuses on defining conditions for fairness, but does not define proper measures of algorithmic unfairness. In this talk, I will discuss how inequality indices from economics literature can be leveraged to measure how unequally the outcomes of an algorithm benefit different individuals or groups in a population. Inequality indices offer an axiomatically-justified and generalizable framework to compare the (un)fairness of a variety of algorithmic predictors against one another. They reveal previously overlooked trade-offs between fairness notions at the individual and the group level. I will present re-formulations of traditional learning models that include constraints on their unfairness (measured via inequality indices) and discuss the resulting optimization challenges.

2 - Controlling Bias in Bandit-based Personalization
Speaker: Elisa Celis, EPFL, CH, talk 500
Co-Authors: *Sayash Kapoor*, *Farnood Salehi*, *Nisheeth Vishnoi*,
Personalized systems on the Internet are fueled by online learning algorithms control the information that is presented to and gathered from users. Algorithmically, bandit optimization has enjoyed great success in learning user preferences and personalizing content or feeds accordingly. However, recent studies suggest that such personalization algorithms can propagate societal or systemic biases and dramatically polarize opinions. Consequently, there is a pressing need to design new algorithms that are socially responsible in how they learn, and socially optimal in the manner in which they use information. Towards this, we propose an algorithmic framework that allows for the possibility to control bias or discrimination in such bandit-based personalization. This work leads to new algorithms that have the ability to alleviate bias and increase diversity while often simultaneously maintaining their theoretical or empirical performance with respect to the original metrics.

3 - Calibration for the (Computationally-Identifiable) Masses
Speaker: Omer Reingold, Stanford University, US, talk 106
Co-Authors: *Ursula Hebert-Johnson*, *Michael Kim*, *Michael Kim*,
As algorithms increasingly inform and influence decisions made about individuals, it becomes increasingly important to

address concerns that these algorithms might be discriminatory. The output of an algorithm can be discriminatory for many reasons, most notably: (1) the data used to train the algorithm might be biased (in various ways) to favor certain populations over others; (2) the analysis of this training data might inadvertently or maliciously introduce biases that are not borne out in the data. This work focuses on the latter concern. We develop and study multicalbration as a new measure of algorithmic fairness that aims to mitigate concerns about discrimination that is introduced in the process of learning a predictor from data. Multicalibration guarantees accurate (calibrated) predictions for every subpopulation that can be identified within a specified class of computations. We think of the class as being quite rich, in particular it can contain many and overlapping subgroups of a protected group. We show that in many settings this strong notion of protection from discrimination is both attainable and aligned with the goal of obtaining accurate predictions. Along the way, we present new algorithms for learning a multicalibrated predictor, study the computational complexity of this task, and draw new connections to computational learning models such as agnostic learning.

4 - Fair and Diverse DPP-based Data Summarization

Speaker: Nisheeth Vishnoi, EPFL, CH, talk 1140

Co-Authors: *Elisa Celis*, *Vijay Keswani*, *Damian Straszak*, *Amit Jayant Deshpande*, *Tarun Kathuria*,

Sampling methods that choose a subset of the data proportional to its diversity in the feature space are popular for data summarization. However, recent studies have noted the occurrence of bias – under or over representation of a certain gender or race – in such data summarization methods. We initiate a study of the problem of outputting a diverse and fair summary of a given dataset. We work with a well-studied determinantal measure of diversity and corresponding distributions (DPPs) and present a framework that allows us to incorporate a general class of fairness constraints into such distributions. Coming up with efficient algorithms to sample from these constrained determinantal distributions, however, suffers from a complexity barrier and we present a fast and approximate sampler that is provably good when the input vectors satisfy a natural property.

Algorithmic Discrepancy

Discrete Optimization & Integer Programming

APPROX - Fr 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 43 Building: C, 3rd floor, Zone: 1

Invited Session 164

Organizer: Nikhil Bansal, CWI and TU Eindhoven, NL

1 - Balancing Vectors in Any Norm

Speaker: Aleksandar Nikolov, University of Toronto, CA, talk 484

Co-Authors: *Daniel Dadush*, *Kunal Talwar*, *Nicole Tomczak*,

In the vector balancing problem, we are given N vectors $v_1, \ldots, v_N$ in an n-dimensional normed space, and our goal is to assign signs to them, so that the norm of their signed sum is as small as possible. The balancing constant of the vectors is the smallest number β, such that any subset of the vectors can be balanced so that their signed sum has norm at most β. The vector balancing constant generalizes combinatorial discrepancy, and is related to rounding problems in combinatorial optimization, and to the approximate Caratheodory theorem. We study the question of efficiently approximating the vector balancing constant of any set of vectors, with respect to an arbitrary norm. We show that the vector balancing constant can be approximated in polynomial time to within factors logarithmic in the dimension, and is characterized by (an appropriately optimized version of) a known volumetric lower bound. Our techniques draw on results from geometric functional analysis and the theory of Gaussian processes. Our results also imply an improved approximation algorithm for hereditary discrepancy.

2 - The Gram-Schmidt Walk: A cure to the Banaszczyk Blues

Speaker: Daniel Dadush, CWI, NL, talk 359

Co-Authors: *Nikhil Bansal*, *Shashwat Garg*, *Shachar Lovett*,

An important result in discrepancy due to Banaszczyk states that for any set of n vectors in Rm of l2 norm at most 1 and any convex body K in Rm of Gaussian measure at least half, there exists a +/-1 combination of these vectors which lies in 5K. This result implies the best known bounds for several problems in discrepancy. Banaszczyk's proof of this result is non-constructive and a major open problem has been to give an efficient algorithm to find such a +/-1 combination of the vectors. In this paper, we resolve this question and give an efficient randomized algorithm to find a +/-1 combination of the vectors which lies in cK for c>0 an absolute constant. This leads to new efficient algorithms for several problems in discrepancy theory

3 - A Fourier-Analytic Approach For Random Set systems

Speaker: Rebecca Hoberg, University of Washington, US, talk 764

Co-Authors: *Thomas Rothvoss*,

Suppose one has n elements and m sets containing each element independently with probability p. We prove that in the regime of $n \geq \Theta(m^2 \log(m))$, the discrepancy is at most 1 with high probability. Previously, a result of Ezra and Lovett gave a bound of $O(1)$ under much stricter assumptions. We argue that a good coloring exists by analyzing the Fourier coefficients of the discrepancy of a random coloring. We hope that these techniques can be extended to a more general class of set systems.

Robust Combinatorial Optimization II

Optimization under Uncertainty

Robust - Fr 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 37 Building: B, Intermediate, Zone: 4

Invited Session 168

Organizer: Agostinho Agra, University of Aveiro, PT

1 - Robust Strategic Planning of Phytosanitary Treatments in Agriculture

Speaker: Ayse Arslan, Inria Bordeaux Sud-Ouest, FR, talk 1372

Co-Authors: *Boris Detienne*, *Francois Vanderbeck*,

This work deals with robust planning and scheduling of activities in agriculture and in particular the application of phytosanitary treatments. Agricultural crops are subject to many diseases that may arise during different time windows of the planning horizon. In response, a phytosanitary treatment can be applied to protect against a subset of these diseases for a given duration of time. Additionally, treatments are categorized as systemic or non-systemic depending on whether they are susceptible to weather conditions. Non-systemic treatments are cost-effective and environmentally friendly, however they can loose their effectiveness depending on the rainfall. As a consequence, the effective duration of treatments is uncertain depending on the type of treatment applied as well as the current whether conditions. In this work, we present a penalty function based approach to handle this uncertainty without being overly conservative. We discuss different forms to the penalty function and elaborate on solution methodologies for the resulting models. We test the effectiveness of our approach with realistically-sized instances, and present a numerical analysis of different optimization models and solution methods. We additionally present a two-stage robust optimization approach and solution methodology on a simplified version of the problem and similarly present computational results.

2 - Exact Solution Algorithms for the Robust Total Tardiness Problem

Speaker: Marco Silva, Universite d Avignon, FR, talk 274

Co-Authors: *Michael Poss*, *Nelson Maculan*,

We experiment exact solutions for the robust single machine total tardiness problem. We model the processing times as uncertain and let them take any value in a given uncertainty polytope. Therefore, the objective seeks to minimize the worst-case tardiness over all possible values. We compare, through computational experiments, two types of solution algorithms. The first combine classical MILP formulations with row-and-column generation algorithms. The second generalizes the classical branch-and-bound algorithms to the robust context, extending state-of-the-art concepts used for the deterministic version of the problem. We identify under what conditions an algorithm has better performance than others.

3 - A Lagrangean dual model for the robust inventory problem

Speaker: Agostinho Agra, University of Aveiro, PT, talk 277

Co-Authors: *Cristina Requejo*, *Filipe Rodrigues*,

We consider the lot-sizing problem where demands are assumed to be uncertain and to belong to the well-known budget polytope introduced by Bertsimas and Sim (2004). The demand can be satisfied by production, by inventory held in stock, or backlogged. A recourse model is considered where the production decisions are first stage decisions and the inventory variables are adjustable to the demands. Two classical robust approaches for this problem, the true min-max approach introduced by Bienstock and Ozbay (2008) and the dualization approach from Bertsimas and Thiele (2006), are revisited. A new model based on the Lagrangean dual problem resulting from a relaxation of the uncertainty set is presented and some relations between the two classical approaches are established from it. Moreover, we show that the new model can be regarded as a less conservative approach than the dualization approach. Based on the new model, we provide simple heuristic strategies to obtain good solutions for large size instances within a short running time.

4 - Robust Expansion Planning of Interdependent Electricity, Gas, and Heat

Speaker: Yasaman Mozafari, University of Calgary, CA, talk 1411

Co-Authors: *William Rosehart*,

Long-term expansion planning in energy systems is the problem of determining the optimum size, type, and location of new infrastructure required to meet the future demand. Increasing gas-fired generation in power systems indicates interdependency between gas and electricity, which should be considered in the model for an effective expansion planning. Various sources of uncertainty are inherent in the energy system. At the end of the planning horizon, the objective is to meet demand reliably and with minimum cost under different possible realizations of the uncertainties. Robust optimization (RO) has recently gained increasing interest to address uncertainties, which is due to the fact that identifying the probability distribution for the uncertain variables is not required. Furthermore, RO is computationally tractable for large-scale systems. In this research, RO techniques is employed to deal with the uncertainty of demand and wind generation in the integrated expansion planning of electricity, heat, and gas infrastructure. The objective is to find the minimum cost solution that meets reliability criteria for possible realizations of uncertainties in the future. A two-level optimization model is proposed: In the master problem, robust long-term expansion planning is performed, the operation subproblem receives the master problem's investment plan and calculates the reliability measure expected-unserved-energy (EUE) to determine whether reliability criterion is met. The two-level optimization is solved iteratively until desired reliability criterion is achieved.

Energy-aware planning and scheduling 2

Specific Models, Algorithms, and Software

Energy - Fr 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 23 Building: G, 3rd floor, Zone: 6

Invited Session 178

Organizer: Christian Artigues, LAAS-CNRS, FR

1 - Modelling uncertainties in short-term operational planning optimization

Speaker: Paul Javal, Mines Paristech - EDR R & D, FR, talk 1093

Co-Authors: *Welnigton de Oliveira*, *Hugo Morais*, *Sophie Demassey*, *Wim van Ackooij*,

Political decisions incentivising the development and use of renewable base generation and the development of competitive electricity markets are creating new challenges both for the transmission and distribution networks operators. Additionally, the consumption profiles are also changing and will continue changing due to the increase penetration of electric vehicles. Increased access to the grid comes with increased uncertainties in the process of decision making, and invalidates a costly robust approach. Existing electric equipment (as switches), new technologies (based in power electronics) and current or prospective contracts with actors connected on the grid (distributed generation or electric vehicles charging points) bring new flexibilities for the distributor to ensure the quality of electricity. Seven realistic flexibilities are identified and modelled in this project for a stochastic approach. Determining how to use these flexibilities to face an uncertain short-term future based on consumption and production predictions is a challenging non-convex mixed-integer program that can bring substantial improvement in the distributor' decisions.

2 - Solving an electric vehicle routing problem with capacitated charging stations
Speaker: Aurélien Froger, Université de Tours, FR, talk 1536
Co-Authors: *Ola Jabali*, *Gilbert Laporte*, *Jorge Mendoza*,
In this research we focus on an electric vehicle routing problem in which 1) vehicles can be partially recharged between customer visits, 2) the quantity of energy recharged is a non-linear function of the time spent charging, and 3) the number of vehicles simultaneously charging at each charging station does not exceed the number of available chargers. The objective is to minimize the total time needed to serve all the customers. The problem is a combined routing and scheduling problem. To tackle it we propose a route-first assemble-second matheuristic. We first generate a pool of routes with a local search-based metaheuristic. To exactly evaluate each move, we use labeling techniques to insert charging decisions in the routes. Then, we combine the routes from the pool to build a solution to the problem using a Benders' like decomposition method. Specifically, we decompose the problem into a route selection master problem and a capacity management sub-problem. We investigate different versions of the capacity management problem ranging from a simple check of the capacity constraints to the delay of the starting times of the routes and the introduction of waiting times at charging stations. We discard by means of cuts infeasible solutions or solutions for which the objective is underestimated. We report computational results on a set of instances we adapted from the literature.

3 - Polyhedral approach for a continuous energy-constrained scheduling problem
Speaker: Christian Artigues, LAAS-CNRS, FR, talk 1150
Co-Authors: *Margaux Nattaf*, *Markó Horváth*, *Tamás Kis*, *Pierre Lopez*,
This talk deals with a scheduling problem involving a continuously-divisible and cumulative resource with limited capacity. During its processing, each task requests a part of this resource, which lies between a minimum and a maximum requirement. A task is finished when a certain amount of energy is received by it within its time window. This energy is received via the resource and an amount of resource is converted into an amount of energy with an increasing and pseudo-linear efficiency function. The goal is to minimize the resource consumption. The talk focuses on an event-based mixed integer linear program, providing several valid inequalities, which are used to improve the performance of the model. Furthermore, we give a minimal description of the polytope of all feasible assignments to the on/off binary variable for a single activity along with a dedicated separation algorithm. Computational experiments are reported in order to show the effectiveness of the results.

Nonconvex Optimization: Theory and Methods - Part 3

Continuous Optimization
NonSmooth - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: Salle LC4 Building: L, Intermediate 1, Zone: 9
Invited Session 188
Organizer: Genaro Lopez, University of Seville, ES

1 - Globally Solving a Class of Optimal Power Flow Problems in Radial Networks
Speaker: Alexander Shtof, Technion, IL, talk 811
Co-Authors: *Amir Beck*, *Yoash Levron*, *Luba Tetruashvili*, *Yuval Beck*,
We devise an algorithm for finding the global optimal solution of the so-called optimal power flow problem (OPF) for a class of power networks with a tree topology, also called radial networks, for which an efficient and reliable algorithm was not previously known. The algorithm we present is called the tree reduction/expansion method, and is based on an equivalence between the input network and a single-node network. Finally, our numerical experiments demonstrate the reliability and robustness of our algorithm.

2 - Algorithms based on unions of nonexpansive maps
Speaker: Matthew Tam, University of Goettingen, DE, talk 140
In this talk, we consider a framework for the analysis of iterative algorithms which can described in terms of a structured set-valued operator. More precisely, at each point in the ambient space, we assume that the value of operator can be expressed as a finite union of values of single-valued quasi-nonexpansive operators. Our main result, which shows that the associated fixed point iteration is locally convergent around strong fixed points, generalises a theorem due to Bauschke and Noll (2014).

3 - What do 'convexities' imply on Hadamard manifolds?
Speaker: Genaro Lopez, University of Seville, ES, talk 176
In recent years considerable efforts have been done to extend concepts and results from the Euclidean/Hilbert context to settings with no vector space structure. Various of these results based on some convexity assumptions (involving the exponential map along with affine maps, geodesics and convex hulls) have been recently established on Hadamard manifolds. In this paper we prove that these conditions are mutually equivalent and they hold if and only if the Hadamard manifold is isometric to the Euclidean space. In this way, we show that some results in the literature obtained on Hadamard manifolds are actually nothing but their well known Euclidean counterparts.

Packing Steiner Trees

Discrete Optimization & Integer Programming
COMB - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: SIGALAS Building: C, 2nd floor, Zone: 2
Invited Session 260
Organizer: Stephan Held, University of Bonn, DE

1 - Global Routing with Timing Constraints
Speaker: Dirk Müller, University of Bonn, DE, talk 234
Co-Authors: *Stephan Held*, *Jens Vygen*, *Daniel Rotter*, *Rudolf Scheifele*, *Vera Traub*,
We show how to incorporate global static timing constraints into global routing. Our approach is based on the min-max re-

source sharing model that proved successful for global routing in theory and practice. Static timing constraints are modeled by a linear number of additional resources and customers. The algorithm dynamically adjusts delay budgets and can, thus, trade off wiring congestion for delay. As a subroutine, the algorithm routes a single net. If this subroutine is near-optimal, we will find near-optimal solutions for the overall problem very efficiently. The approach works for many delay models; here we discuss a linear delay model (before buffering) and the Elmore delay model (after buffering). We demonstrate the benefit of our timing-constrained global routing algorithm by experimental results on industrial chips.

2 - Steiner Tree Packing in Rhomboidal Tiles

Speaker: Pietro Saccardi, University of Bonn, DE, talk 1537

Co-Authors: *Nicolai Hähnle*,

We suggest a new model and algorithms for global routing in chip design. Traditional global routing covers the chip with a 3D grid graph. However, terminals are implicitly mapped to vertices, any local wiring is ignored, and the structure of the nets is altered. To overcome these deficiencies, we propose a new model that always considers exact pin positions. We work with rhomboidal tiles and pack Steiner trees rather into the tiles than into a grid graph. We present a new algorithm for computing shortest paths with respect to tile prices, exploiting the rhomboidal shape of the tiles. We then solve the Steiner tree packing problem using the min-max resource sharing algorithm to approximately minimize the total wire length subject to wire density constraints. Our results are well spread routes connecting to pin shapes that are a better input for detailed routing. We demonstrate the benefits of this approach with experimental results on industrial chips.

3 - Reach- and Direction-Restricted Rectilinear Steiner Trees

Speaker: Tilmann Bihler, University of Bonn, DE, talk 617

Co-Authors: *Stephan Held*, *Sophie Spirkl*,

We study the minimum rectilinear Steiner tree problem in the presence of obstacles. Some obstacles may not be traversed at all, others may be traversed only horizontally, only vertically, or in both directions. In any case, the total length of each connected component in the intersection of the tree with the interior of the obstacles is bounded by a constant. This problem is motivated by the layout of repeater tree topologies, a central task in chip design. Large obstacles might be crossed by wires on higher layers, but repeaters may not be placed within the obstacles. A long unbuffered piece of interconnect would lead to timing violations. Due to special obstacle structures, the traversal can be restricted to one direction. We present a 2-approximation algorithm with a worst case running time of $O((k \log k)^2)$, where k is the number of terminals plus the number of obstacle corner points. Under certain realistic assumptions on the obstacle structure, the running time is $O(k(\log k)^2)$. Our algorithm is practically fast, it solves real world instances with 783352 terminals within 80 seconds, proving its practical applicability. Combined with very effective post-optimization we obtain better results than previous heuristics on large obstacle-acvoiding DIMACS benchmarks. Allowing to reach over obstacles, the algorithm provides significantly shorter solutions.

Computational Integer Programming II

Specific Models, Algorithms, and Software

Algo - Fr 5:00pm-6:30pm, Format: 3x30 min

Room: PITRES Building: O, Ground Floor, Zone: 8

Invited Session 274

Organizer: Domenico Salvagnin, University of Padova, IT

1 - Tighter LP relaxations for configuration knapsacks using extended formulations

Speaker: Gregor Hendel, Zuse Institute Berlin, DE, talk 381

Co-Authors: *Ralf Borndörfer*, *Marika Karbstein*, *Timo Berthold*, *Heide Hoppmann*,

Knapsack inequalities frequently occur in many practical MIP applications. Since their LP relaxation can be weak, modern solvers tighten the formulation incrementally using different separation techniques such as (GUB) cover inequalities. A fundamentally different approach has been introduced in the context of standard line planning (SLP) optimization by Hoppmann, Borndörfer, and Karbstein, who propose an explicit extended formulation, comparable to a Dantzig-Wolfe reformulation of the problem, which implies several important classes of inequalities. The size of the reformulation is tractable because SLP has only knapsack constraints with a bounded number of distinct weights, so-called "configuration knapsacks". We present a generalization of this approach to arbitrary MIPs involving configuration knapsacks, which we implemented in the MIP solver SCIP. We compare the obtained LP relaxations of this reformulation against standard cutting planes, and discuss the computational benefits and limitations in order to use this extended formulation in practice.

2 - Lexicographic Optimization and Recovery in Two-Stage Robust Scheduling

Speaker: Dimitrios Letsios, Imperial College London, GB, talk 504

Co-Authors: *Ruth Misener*,

In typical industrial scheduling problems, initial planning solves the problem and subsequent recovery intervenes to repair inefficiencies and infeasibilities due to uncertainties, e.g. machine failures and job processing time variations. Significant deviations from original planning incur undesirable costs and have to be considered during reoptimization. This work investigates the fundamental minimum makespan scheduling problem with job and machine perturbations. We show that planning using lexicographic optimization enables more efficient reoptimization. We derive reoptimization strategies with positive performance guarantees attained because of the lexicographic optimal substructure and not achievable with arbitrary optimal initial solutions. This talk focuses on exact, mixed-integer linear programming (MILP), lexicographic optimization methods. We introduce vectorial bounds aiming in all objectives simultaneously. Using these bounds, we develop a novel lexicographic branch-and-bound method which avoids iterative MILP of sequential methods, does not suffer precision issues of weighting methods, and reduces symmetry problems of simultaneous methods. Numerical analysis using standard commercial approaches substantiates the strength of our method.

3 - Dynamic Row Disablement: a practical Implementation of the Kernel Simplex Method

Speaker: Roland Wunderling, IBM, AT, talk 861

At ISMP 2012 we introduced the Kernel Simplex Method -

a variant of the Simplex method that replaces the Simplex basis with the Simplex Kernel as the central data structure governing the Algorithm. After reviewing this method, we will discuss how it is implemented in the new Dynamic Row Disablement feature that has been released in CPLEX 12.8. The resulting performance improvements will be reported.

Stochastic Methods for Energy Optimization

Specific Models, Algorithms, and Software
Energy - Fr 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 24 Building: G, 3rd floor, Zone: 6

Contributed Session 294
Chair: Tristan Rigaut, Efficacity, FR

1 - Stabilization of Price Signals in Energy Optimization
Speaker: Clara Lage, ENGIE - IMPA - Paris Sorbonne, FR, talk 1585
Co-Authors: *Claudia Sagastizabal*, *Mikhail Solodov*, *Guillaume Erbs*,
For stochastic optimization problems arising in the management of a power mix with thermal, hydro- and renewable plants, we study how the uncertainty discretization impacts on marginal prices. Specifically, for two-stage linear programs with recourse, we perform a study of the sensitivity of the dual variables with respect to variations of the right hand side in the constraints. We propose a stabilizing device that, among all the possible marginal prices, provides the one with smallest 2-norm. The theoretical study is complemented with a numerical assessment on a real-life power market instance showing the interest of the approach.

2 - Stochastic Unit Commitment Problem: an Exact Probabilistic Constrained Approach
Speaker: Guilherme Matiussi Ramalho, UFSC-Florianopolis, BR, talk 298
Co-Authors: *Wim van Ackooij*, *Erlon Finardi*,
The present study discusses the introduction of a new methodology to solve the day ahead hydrothermal unit commitment problem considering the uncertainty provided by the inclusion of wind power into the grid. Joint probability constraints are used to account for uncertainty. The underlying problem, where continuous distributions functions are accounted for, is solved by an extension of the classical cutting planes method adapted to the MILP framework. This extended method is based on iteratively solving two MILP subproblems, one to provide a lower bound and one to provide an upper bound. Numerical experiments examining different levels of probability and compositions of the power system allow us to show the efficiency of the method. In order to improve the convergence rate of the algorithm, several heuristics, such as providing smart initial solutions have also been examined.

3 - Long term management of energy storage using stochastic optimization
Speaker: Tristan Rigaut, Efficacity, FR, talk 1291
Co-Authors: *Jean-Philipp Chancelier*, *Michel De Lara*, *Carpentier Pierre*,
The progressive integration of renewable energy resources and prosumers requires electrical storage systems in order to ensure energy supply demand balance in real time with uncertain generation and production. These storage devices are still expensive and their long term viability as well as their real time performances have to be optimized. In an uncertain environment such dynamical systems can be managed using Stochastic Optimal Control (SOC) techniques. However the interaction between decisions and uncertain phenomena, happening on various time scales, requires to model an optimization problem with a massive amount of time steps. It is not straightforward to apply classical methods such as Stochastic Dynamic Programming (SDP) or Model Predictive Control (MPC) whose performances decrease with the number of time steps. We propose hereby a methodology to model optimization problems with multiple time scales as well as stochasticity and information revealing throughout time. That kind of problem and methods have been already studied in a deterministic setting. Our contribution is to highlight the difficulties that arise in a stochastic setting and propose algorithms to tackle them. Then we present a method based on time blocks decomposition in multistage stochastic optimization to solve a problem mixing investment decisions, battery long term aging management as well as intra-day energy arbitrage.

Machine Learning and Discrete Optimization

Discrete Optimization & Integer Programming
IPtheory - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 34 Building: B, 1st floor, Zone: 3

Invited Session 308
Organizer: Sebastian Pokutta, Georgia Tech, US

1 - Building adversarial examples in Neural Networks by Mixed Integer Optimization
Speaker: Matteo Fischetti, University of Padua, IT, talk 402
Co-Authors: *Jason Jo*,
A Deep Neural Networks (DNN) is a machine learning architecture made by layers of internal units (or neurons), each of which computes an affine combination of the output of the units in the previous layer, applies a nonlinear operator, and outputs the corresponding value (also known as activation). A commonly-used nonlinear operator is the so-called rectified linear unit (ReLU), whose output is just the maximum between its input value and zero. In this (and other similar cases like max pooling, where the max operation involves more than one input value), for fixed parameters one can model the DNN as a 0-1 Mixed Integer Linear Program (0-1 MILP) where the continuous variables correspond to the output values of each unit, and a binary variable is associated with each ReLU to model its yes/no nature. In this talk we discuss the peculiarity of this kind of 0-1 MILP models, and describe an effective bound-tightening technique intended to ease its solution. We also present a possible application arising in the construction of adversarial examples. Computational results are reported, aimed at investigating (on small DNNs) the computational performance of a state-of-the-art MILP solver when applied to a known test case, namely, hand-written digit recognition.

2 - Mathematics of Neural Networks
Speaker: Anirbit Mukherjee, Johns Hopkins University, US,

talk 1616
Co-Authors: *Amitabh Basu*, *Akshay Rangamani*, *Ashish Arora*, *Tejaswini Ganapathy*, *Trac Tran*, *Sang Chin*,
A plethora of exciting mathematics questions have gotten raised in trying to explain the resurgence of neural networks in being able to execute complex artificial intelligence tasks. In this talk I will give a brief overview of some of the questions that me and Amitabh Basu (with other collaborators) have been exploring. We will start with some of the results that we have gotten in our ICLR 2018 paper about the space of functions that these "architectures" represent (https://eccc.weizmann.ac.il/report/2017/098/). We will particularly focus on our recent works (1) (https://eccc.weizmann.ac.il/report/2017/190/) proving first of its kind lower bounds on the size of high depth neural circuits representing certain Boolean functions and (2) (https://arxiv.org/abs/1708.03735, published at ISIT 2018 and NIPS 2017 workshop on "Deep Learning Theory and Practice") which try to formalize the connection between autoencoders and sparse coding

3 - Smart "Predict, then Optimize"
Speaker: Paul Grigas, UC Berkeley, US, talk 1466
Co-Authors: *Adam Elmachtoub*,
Many real-world analytics problems involve two significant challenges: prediction and optimization. Due to the typically complex nature of each challenge, the standard paradigm is to predict, then optimize. By and large, machine learning tools are intended to minimize prediction error and do not account for how the predictions will be used in a downstream optimization problem. In contrast, we propose a new framework, called Smart "Predict, then Optimize" (SPO), which directly leverages the optimization problem structure, i.e., its objective and constraints, for designing successful predictive models. A key component of our framework is the SPO loss function, which measures the quality of a prediction by comparing the objective values of the solutions generated using the predicted and observed parameters, respectively. Training a model with respect to the SPO loss is computationally challenging, and therefore we also develop a surrogate loss function, called the SPO+ loss, which upper bounds the SPO loss, has desirable convexity properties, and is statistically consistent under mild conditions. We also propose a stochastic gradient descent algorithm which allows for situations in which the number of training samples is large, model regularization is desired, and/or the optimization problem of interest is nonlinear or integer. Finally, we perform computational experiments to empirically verify the success of our SPO framework in comparison to the standard predict-then-optimize approach.

4 - Lazy Conditional Gradients through Simpler Oracles
Speaker: Sebastian Pokutta, Georgia Tech, US, talk 386
Co-Authors: *Gábor Braun*, *Daniel Zink*,
Conditional Gradient Descent methods are popular first-order methods for (smooth) constraint convex minimization. Relying on a linear programming oracle, these methods often outperform projected gradient descent methods whenever projections into the feasible region are expensive. Unfortunately, even those methods might suffer from prohibitive running times if the linear programming oracle itself is expensive. In this talk, we will explore a general method to significantly speed-up conditional gradient descent methods by replacing the linear programming oracle with a significantly easier and cheaper oracle leading to real-world speedups by several orders of magnitude while maintaining identical theoretical converge rates modulo (small!) constant factors.

Spectral and Semidefinite Methods for Learning

Specific Models, Algorithms, and Software Learning - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: FABRE Building: J, Ground Floor, Zone: 8

Invited Session 321
Organizer: Martin Jaggi, EPFL, CH

1 - Competitive Online Algorithms with Application to Optimal Experiment Design
Speaker: Maryam Fazel, Univ. of Washington, US, talk 1160
Co-Authors: *Reza Eghbali*, *James Saunderson*,
We consider an online resource allocation problem where the goal is to maximize a function of a positive semidefinite (PSD) matrix with a scalar budget constraint. The problem data arrives online, and the algorithm needs to make an irrevocable decision at each step. Of particular interest are classic experiment design problems in the online setting, with the algorithm deciding whether to allocate budget to each experiment, as new experiments become available sequentially. We analyze two primal-dual algorithms and provide bounds on their competitive ratios. Our analysis relies on a smooth surrogate of the objective function that needs to satisfy a new diminishing returns (PSD-DR) property (that its gradient is order-reversing with respect to the PSD cone). Using the representation for monotone maps on the PSD cone given by Lowner's theorem, we obtain a convex parametrization of the family of functions satisfying PSD-DR. We then formulate a convex optimization problem to directly optimize our competitive ratio bound over this set. This design problem can be solved offline before the data start arriving. The online algorithm (that uses the designed surrogate) is tailored to the given cost function, and enjoys a competitive ratio at least as good as our optimized bound. We provide examples of computing the smooth surrogate for D-optimal and A-optimal experiment design, and demonstrate the performance of the custom-designed algorithm.

2 - Positive semi-definite embedding for dimensionality reduction
Speaker: Michael Fanuel, Université cath. de Louvain, BE, talk 812
A typical problem arising in machine learning or statistics is to find a meaningful way to embed high dimensional data into a lower dimensional Euclidean space. We propose a kernel-based method for dimensionality reduction which relies on the solution of a Semi-Definite Program (SDP). In addition, this optimization formulation and in particular the optimality conditions allow for the definition of an out-of-sample formula yielding an empirical extension of the embedding on any new data point. We will also discuss some interesting features of the embedding method such as its robustness with respect to the choice of hyper-parameter. Noticeably, the connection of the method with a diffusion process provides an interpretation of the embedding. Algorithms for solving this SDP via a low-rank factorization will also be presented. This is a joint work with A. Aspeel, J-C Delvenne and J.A.K. Suykens.

3 - Variational Perspective on Local Graph Clustering
Speaker: Kimon Fountoulakis, UC Berkeley, US, talk 337
Co-Authors: *Farbod Roosta-Khorasani*, *Julian Shun*, *Xiang Cheng*, *Michael Mahoney*,
Local spectral methods such as the Approximate Personalized PageRank (APPR) algorithm have proven to be a powerful tool for the analysis of large data graphs. They are defined operationally, and while they come with strong theory, there is no a priori notion of objective function/optimality condition that characterizes the steps taken by them. Here, we derive a novel variational formulation which makes explicit the actual optimization problem solved by the APPR algorithm. In doing so, we draw connections between APPR and a popular iterative shrinkage-thresholding algorithm (ISTA). This viewpoint between APPR and ISTA builds a bridge across two seemingly disjoint fields of graph processing and numerical optimization, and it allows one to leverage well-studied, numerically robust, and efficient optimization algorithms for processing today's large graphs.
4 - Solving lp-norm regularization with tensor kernels
Speaker: Saverio Salzo, Istituto Italiano Tecnologia, IT, talk 400
In this talk, we discuss how a suitable class of tensor kernels can be used to efficiently solve nonparametric extensions of lp regularized learning methods. We first introduce tensor kernels, which describe Banach spaces of functions and include generalizations of the exponential and polynomial kernels. Then, we propose a fast dual algorithm, and show that it allows to solve the problem efficiently. Our results contrast recent findings suggesting kernel methods cannot be extended beyond Hilbert setting. Numerical experiments confirm the effectiveness of the method.

Algorithms for Structured Statistical Optimization

Continuous Optimization
RandomM - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: Salle KC6 Building: K, Intermediate 1, Zone: 10

Contributed Session 349
Chair: Ilker Birbil, Erasmus University Rotterdam, NL

1 - A Differentially Private Stochastic Gradient Descent Algorithm with Smoothing
Speaker: Ilker Birbil, Erasmus University Rotterdam, NL, talk 1448
Co-Authors: *Nurdan Kuru*, *Sinan Yildirim*,
This paper introduces a smoothing approach to improve the differential privacy of the stochastic gradient descent algorithm. Like many other differentially private methods in the literature, this approach also perturbs the output at every iteration by adding noise to the approximate gradient. However, unlike those methods, the proposed approach uses exponential smoothing to obtain a weighted sum of the past and the most recent approximate gradients that are evaluated by subsampling the data. In order to take the effect of the noise and the sampling into consideration, we also present a new diminishing step size formula. The weighting-subsampling mechanism along with the diminishing step size allow us to run the resulting stochastic gradient descent algorithm for a large number of iterations without breaching the privacy. We support our findings with a simulation study, where we discuss the effects of the various parameters that can be adjusted by the end users.
2 - Leave-one-out approach for statistical optimization
Speaker: Lijun Ding, Cornell University, US, talk 1171
Co-Authors: *Yudong Chen*,
We develop a leave-one-out approach to obtain fine-grained, entry-wise bounds for iterative optimization procedures under statistical assumptions. We demonstrate the power of this approach by analyzing two of the most important algorithms for matrix completion: a non-convex approach based on Singular Value Projection (SVP), and a convex relaxation approach based on nuclear norm minimization (NNM). In particular, we prove for the first time that SVP converges linearly in the infinity norm and show a new sample complexity result for NNM that achieves optimal dependence on dimension and condition number.
3 - Adaptive Sampling for Online Subspace Estimation
Speaker: Greg Ongie, University of Michigan, US, talk 1099
Co-Authors: *Laura Balzano*, *Dejiao Zhang*, *David Hong*,
This work investigates adaptive sampling strategies for online subspace estimation from streaming input vectors. We consider both the general case where we allow arbitrary linear compressive measurements of the input vectors and the special case where we can only sample the streaming inputs entry-wise. We modify the previously proposed Grassmannian rank-one update subspace estimation (GROUSE) algorithm to incorporate an adaptive sampling strategy that substantially improves over random Gaussian measurements or uniform random entry-wise sampling. We discuss optimization theory of GROUSE in this context. Experiments on synthetic data demonstrate that the adaptive measurement scheme greatly improves the convergence rate of GROUSE, and in case of entry-wise measurements, allows for the recovery of highly coherent subspaces. We discuss applications to approximating the column space of a very large matrix in a memory-constrained setting.
4 - Approximation Methods for Bilevel Programming
Speaker: Saeed Ghadimi, Princeton University, US, talk 915
Co-Authors: *Mengdi Wang*,
In this talk, we consider the bilevel optimization problem where the objective function depends on the optimal solution of an inner optimization problem. We focus on the case where the inner objective function is strongly convex. We develop a deterministic bilevel approximation method and an accelerated variant, where convergence rate analysis are provided under mild assumptions. We also consider the stochastic bilevel optimization problem where the inner and outer objectives take the form of unknown expectations. We develop a bilevel stochastic approximation method establish its convergence rate and finite-sample error bound. To our best knowledge, these results are the first ones for solving bilevel programming using iterative solvers.

Transportation networks

Specific Models, Algorithms, and Software
Network - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 18 Building: I, 1st floor, Zone: 7

Contributed Session 359

Chair: Bernard Gendron, CIRRELT DIRO Univ. Montreal, CA

1 - The network maintenance problem
Speaker: Parisa Charkhgard, The University of Newcastle, AU, talk 983
Co-Authors: *Thomas Kalinowski*, *Hamish Waterer*,
The network maintenance problem is a challenging optimization problem motivated by the need to maintain infrastructure networks over time. We consider infrastructure networks in which product is transported between distinct origin-destination pairs, and at the same time the infrastructure assets need to be maintained by resources moving in the network. In order to perform maintenance, the assets have to be shut down from time to time, thus reducing the system capacity in those time periods. The objective is to maximize the total transported product by aligning the maintenance activities appropriately. This problem combines flow maximization with maintenance scheduling, and captures some important aspects of the motivating practical problem that arises in railway networks. We will formally introduce the problem and present a mixed integer linear programming formulation. We will show that the problem is NP-hard in general, but solvable in polynomial time in the special case in which the network is a single path.

2 - Airspace sectorization by set-partitioning approach
Speaker: Yasufumi Saruwatari, University of Tsukuba, JP, talk 1221
Co-Authors: *Yoichi Izunaga*, *Takamori Ukai*, *Kota Kageyama*,
We propose an algorithm for the airspace sectorization problem (ASP). The traffic safety and efficiency in the airspace are ensured by air traffic controllers. Each controller is assigned to a part of the airspace, called a sector, and is responsible for monitoring flights and avoiding conflicts between aircrafts in his/her sector. ASP is to find the reasonable number of sectors such that the controllers' workload is balanced, satisfying geometric conditions. Since a sector boundary can be determined by the intersections of the existing trajectories, we treat ASP as a graph-theoretic model where the intersections and the segments of trajectories are regarded as vertices and edges, respectively. We introduce a set-partitioning problem whose underlying set is defined by sectors, each of which is characterized by a tree in the graph. We develop the method for enumerating trees efficiently. A solution is modified so as to satisfy geometric conditions. Our algorithm is applied to the Japanese airspace model.

3 - Joint Transceiver Optimization for Wireless Information and Energy Transfer
Speaker: Bin Li, Sichuan University, CN, talk 1662
Co-Authors: *Yue Rong*,
In this talk, a two-hop non-regenerative multiple-input multiple-output (MIMO) relay system is investigated, where the relay node has no self-power supply, and relies on harvesting the radio frequency energy transferred from the source node to forward information from source to destination. For the ease of implementation in practice, we consider the time switching (TS) protocol between wireless information and energy transfer. In particular, we propose a more general energy consumption constraint at the source node during the information and energy transfer, which includes the constant power constraints used in existing works as special cases. We study the joint optimization of the source precoding matrices, the relay amplifying matrix, and the TS factor to maximize the source-destination mutual information (MI). The optimal structure of the source and relay matrices is derived, which reduces the original transceiver optimization problem to a simpler power allocation problem. We propose a primal decomposition based algorithm and an upper bound based approach to efficiently solve the power allocation problem. The first algorithm achieves the global optimum, whereas the latter one has a lower computational complexity. Numerical simulations show that both proposed algorithms yield higher system MI and better rate-energy tradeoff than existing approaches.

4 - Node-Based Lagrangian Relaxations for Multicommodity Network Design
Speaker: Bernard Gendron, CIRRELT DIRO Univ. Montreal, CA, talk 1601
Co-Authors: *Rahim Akhavan*, *Teodor Crainic*,
We present new Lagrangian relaxations for the multicommodity capacitated fixed charge network design. The relaxations induce Lagrangian subproblems that decompose by node and that do not possess the integrality property. The Lagrangian duals are solved by a bundle method that exploits the separability of the subproblems. Lagrangian heuristics are developed to compute upper bounds. Computational results are presented on a large set of randomly generated instances.

Variational Analysis 2

Continuous Optimization
Variat - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: Salle ARNOZAN Building: Q, Ground Floor, Zone: 8
Invited Session 367
Organizer: David Salas, INP-ENSIACET, FR

1 - Maximal Monotonicity Arising in Nonsmooth Lur'e Dynamical systems
Speaker: Ba Khiet Le, Universidad de O'Higgins, CL, talk 1621
Co-Authors: *Samir Adly*, *Abderrah Hantoute*,
We study a precomposition of a maximal monotone operator with linear mappings, which preserves the maximal monotonicity in the setting of reflexive Banach spaces. Instead of using the adjoint of such linear operators, as in the usual precomposition, we consider a more general situation involving operators which satisfy the so-called passivity condition. We also provide similar analysis for the preservation of the maximal cyclic monotonicity. These results are applied to derive existence results for nonsmooth Lur'e dynamical systems.

2 - Lyapunov pairs for perturbed sweeping processes
Speaker: Emilio Vilches, Universidad de OHiggins, CL, talk 411
Co-Authors: *Abderrah Hantoute*,
The sweeping process is a first-order differential inclusion involving the normal cone to a moving set depending on time. Roughly speaking, a point is swept by a moving closed set. The sweeping process was introduced and deeply studied by J.J. Moreau to model an elastoplastic mechanical system. Since then, many other applications have been given, namely in, electrical circuits, crowd motion, hysteresis in elastoplastic models, etc. In this talk, we present a full characterization of

nonsmooth Lyapunov pairs for perturbed sweeping processes under very general assumptions. As a consequence, we provide a criterion for weak invariance for perturbed sweeping process.

3 - Proximal Algorithms in Hadamard Spaces
Speaker: Parin Chaipunya, KMUTT, TH, talk 404
Co-Authors: *Poom Kumam*,
In this talk, we shall discuss about the stationary problem that is governed by a monotone vector field. By adopting the surjectivity condition on such vector field, the resolvent operator is defined and is single-valued. We finally discuss about the convergence of the iterated resolvent, known as the proximal algorithm, towards the stationary point we are seeking.

4 - Quasi-Variational Inequality problems over product sets
Speaker: David Salas, INP-ENSIACET, FR, talk 1156
Co-Authors: *Didier Aussel*, *Kien Cao*,
Quasi-Variational Inequalities (QVI) problems correspond to the classic variational inequality problems (first introduced by Stampacchia in the 60's), but with the constraints set depending on the variable. Formally, for a Banach space X, a subset C of X, and two set-valued maps $T : C \rightrightarrows X^*$ and $K : C \rightrightarrows C$, the QVI problem consists in finding a point $x \in K(x)$ and an element $x^* \in T(x)$ such that $\langle x^*, y - x\rangle \geq 0$ for every $y \in K(x)$. QVI problems over product sets are those where the involved set-valued maps can be written as products, that is, $T = \prod T_i$ and $K = \prod K_i$. These kind of problems arise very often, as for example when we search for first order necessary conditions of equilibriums in Generalized Nash Equilibrium Problems (GNEP). One of the most common hypothesis needed to guarantee existence of solutions is the quasi-monotonicity of the set-valued map T. However, in product-type problems, T may fail to be quasi-monotone, even if every component T_i is so. In this work, we show some new existence results for QVI problems over product sets, considering hypotheses only in the component maps T_i and K_i rather than on T and K. These new results are presented in the infinite-dimensional setting. We also present some applications to Generalized Nash Equilibrium Problems outside the continuity setting.

Tractability and approximation algorithms in dynamic programming

Optimization under Uncertainty
Markov - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 31 Building: B, Ground Floor, Zone: 5

Contributed Session 383
Chair: Alexander Hopp, TU Darmstadt, DE

1 - Sample-Based Approximate GMDP Solution with Theoretical Guarantees
Speaker: Yann Dujardin, INRA, FR, talk 1596
Co-Authors: *Nathalie Peyrard*, *Régis Sabbadin*,
MDP have been extended to problems with multiple state and action variables, leading to concise representations (Factored MDP). One such framework is the Graph-based MDP (GMDP) framework. Algorithms have been developed to approximately solve GMDP but none of them provide any performance guarantees. In this paper we propose the first approximation approach with theoretical performance guarantees. From a set of q samples of the GMDP transition model, we derive a combinatorial optimization problem, $GMDP_q$, whose optimal solution approximates (with stochastic guarantees) the GMDP optimal solution. $GMDP_q$ are hard to solve: we show that even $GMDP_1$ is NP-hard and not in APX. We propose an ILP formulation of the $GMDP_q$ problem and we experimentally compare our approach to existing GMDP solvers. Because of the ILP formulation, our approach allows to solve constrained GMDP and non-stationnary (finite horizon) GMDP.

2 - An FPTAS for stochastic DPs with multidimensional action and scalar state
Speaker: Giacomo Nannicini, IBM T.J. Watson, US, talk 705
Co-Authors: *Nir Halman*,
We propose a Fully Polynomial-Time Approximation Scheme (FPTAS) for stochastic dynamic programs with multidimensional action, scalar state, convex costs and linear state transition function. The action spaces are polyhedral and described by parametric linear programs. This type of problems finds applications in the area of optimal planning under uncertainty, and can be thought of as the problem of optimally managing a single non-discrete resource over a finite time horizon. We show that under a value oracle model for the cost functions this result for one-dimensional state space is "best possible", because a similar dynamic programming model with two-dimensional state space does not admit a PTAS. The FPTAS relies on the solution of polynomial-sized linear programs to recursively compute an approximation of the value function at each stage. Our paper enlarges the class of dynamic programs that admit an FPTAS by showing how to deal with multidimensional action spaces and with vectors of continuous random variables with bounded support under suitable conditions, therefore getting one step closer to overcoming the curse of dimensionality of dynamic programming.

3 - On Friedmann's subexponential lower bound for Zadeh's pivot rule
Speaker: Alexander Hopp, TU Darmstadt, DE, talk 458
Co-Authors: *Yann Disser*,
The question whether the Simplex method admits a polynomial time pivot rule remains one of the most important open questions in discrete optimization. Zadeh's pivot rule had long been a promising candidate, before Friedmann (IPCO, 2011) presented a subexponential instance, based on a close relation to policy iteration algorithms for Markov decision processes (MDPs). We investigate Friedmann's lower bound construction and show that the sequence of improving switches applied by the algorithm does not consistently follow Zadeh's pivot rule. We discuss that this is a significant problem by proving that no consistent ordering exists that updates the MDP level by level in each phase according to a fixed order. We then prove the existence of a more sophisticated ordering and associated tie-breaking rule that are in accordance with the Least-Entered pivot rule. Most importantly, our changes do not affect the macroscopic structure of Friedmann's MDP, and thus we are able to retain his original result.

Optimization and Game Theory

Specific Models, Algorithms, and Software
Sciences - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: Salle LA4 Building: L, Basement, Zone: 8

Invited Session 402
Organizer: Veerle Timmermans, RWTH Aachen, DE

1 - Computing Approximate Pure Nash Equilibria in Shapley Value Weighted Congestion
Speaker: Matthias Feldotto, Paderborn University, DE, talk 1306
Co-Authors: *Martin Gairing*, *Grammateia Kotsialou*, *Alexander Skopalik*,
We study the computation of approximate pure Nash equilibria in Shapley value (SV) weighted congestion games, introduced by Kollias and Roughgarden in 2015. This class of games considers weighted congestion games in which Shapley values are used as an alternative (to proportional shares) for distributing the total cost of each resource among its users. We focus on the interesting subclass of such games with polynomial resource cost functions and present an algorithm that computes approximate pure Nash equilibria with a polynomial number of strategy updates. Since computing a single strategy update is hard, we apply sampling techniques which allow us to achieve polynomial running time. The algorithm builds on the algorithmic ideas by Caragiannis et al., however, to the best of our knowledge, this is the first algorithmic result on computation of approximate equilibria using other than proportional shares as player costs in this setting. We present a novel relation that approximates the Shapley value of a player by her proportional share and vice versa. As side results, we upper bound the approximate price of anarchy of such games and significantly improve the best known factor for computing approximate pure Nash equilibria in weighted congestion games by Caragiannis et al..
2 - Dynamic taxes for polynomial congestion games
Speaker: Cosimo Vinci, University of L'Aquila, IT, talk 1105
Co-Authors: *Vittorio Bilò*,
We consider the efficiency of taxation in congestion games with polynomial latency functions. By exploiting the primal-dual method [Bilò, *Proceedings of the 10th Workshop on Approximation and Online Algorithms*, 2012], we obtain interesting upper bounds with respect to a variety of different solution concepts ranging from approximate pure Nash equilibria up to approximate coarse correlated equilibria, and including also approximate one-round walks starting from the empty state. Our findings show a high beneficial effect of taxation which increases more than linearly with the degree of the latency functions. In some cases, a tight relationship with some well-studied polynomials in Combinatorics and Number Theory, such as the Touchard and the Geometric polynomials, arises. In these cases, we can also show matching lower bounds, albeit under mild assumptions; interestingly, our upper bounds are derived by exploiting the combinatorial definition of these polynomials, while our lower bounds are constructed by relying on their analytical characterization.
3 - Competitive Packet Routing
Speaker: Bjoern Tauer, RWTH Aachen University, DE, talk 1045
Co-Authors: *Britta Peis*, *Veerle Timmermans*, *Laura Vargas Koch*, *Daniel Schmand*, *Tobias Harks*,
We study a game-theoretic variant of packet routing, competitive packet routing games, where several selfish acting decision makers ("players") route their packets through a network. The network is represented by a directed graph, each edge of which being endowed with a transit time, as well as a capacity bounding the number of traffic units entering an edge simultaneously. We analyze the impact of priority lists on the worst-case quality of pure Nash equilibria. A priority list is an ordered list of players that may or may not depend on the edge. Whenever the number of packets entering an edge exceeds the inflow capacity, packets are processed in list order. We prove the existence of a pure Nash equilibrium and show that it can be constructed by sequentially computing an integral earliest arrival flow for each player. Moreover we derive several bounds on the price of anarchy and stability for global and local priority policies for games, where player are in charge of one or multiple packets.
4 - Equilibrium Computation in Atomic Splittable Polymatroid Congestion Games
Speaker: Veerle Timmermans, RWTH Aachen, DE, talk 677
Co-Authors: *Tobias Harks*,
In this paper, we construct ϵ-approximate Nash equilibria in atomic splittable congestion games with convex cost functions, where the strategy space of each player is a bidirectional flow polymatroid. The idea is to compute a pure Nash equilibrium for an associated integrally-splittable congestion game. In such games, players can only split their demand in integral multiples of a common packet size. It is known that one can compute pure Nash equilibria for integrally-splittable congestion games within a running time that is pseudo-polynomial in the total demand of the players. In this paper we decide, for every $\epsilon > 0$, on a packet size k and prove that the associated k-splittable equilibrium is an ϵ-approximate equilibrium for the original atomic splittable congestion game.

Linear Optimization I
Continuous Optimization
NLP - Fr 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 9 Building: N, 4th floor, Zone: 12
Contributed Session 415
Chair: Jianming Shi, Tokyo University of Science, JP

1 - A Fast Polynomial-time Primal-Dual Projection Algorithm for Linear Programming
Speaker: Zhize Li, Tsinghua University, CN, talk 1379
Co-Authors: *Wei Zhang*, *Kees Roos*,
Traditionally, there are mainly three polynomial algorithms for linear programming, the ellipsoid method, the interior point method and the random walk method, among which the interior point method is most widely used. Since the algorithm of Chubanov, the projection and rescaling algorithm has become a potentially practical class of polynomial algorithms for the linear feasibility problems. However, this kind of algorithms usually performs better on the infeasible instances than the feasible instances. In this paper, we propose a fast Polynomial-time Primal-Dual Projection algorithm (called PPDP) to address this issue by explicitly developing the dual algorithm, and also obtain a better theoretical complexity bound (improve a $\sqrt{n}$ factor in the good situation). More importantly, our novel efficient PPDP algorithm runs significantly faster than other widely used algorithms, e.g., the optimization solver Gurobi.
2 - A polarity-based algorithm for solving linear programming problems
Speaker: Jianming Shi, Tokyo University of Science, JP, talk 1274

The linear programming problem (LP) plays a fundamentally important role in mathematical optimization. Fujishige et al. proposed the LP-Newton method for LPs with a box constrains and Kitahara et al. developed the LPS-Newton method for standard form LPs. The two algorithms above share some similarities. Both methods formulate the problem by introducing an associated linear projection. The LP-Newton solves the problem by applying projections to a related zonotope while the LPS-Newton method by applying projections to a projected convex cone. Both algorithms start from a point out of the feasible region and are required to calculate the nearest point in a polyhedral (or polytope). Inspired by the two methods, we develop a polarity-based algorithm for solving LPs. Our algorithm is not necessarily required to calculate the nearest point in a polytope. We consider the following linear programming problem with a standard form. The contributions of our method are 1) to give a new formulation for LPs 2) to propose an algorithm for solving PLs by finding the intersection point between a half line and a surface of convex hull of points.

3 - An algorithm for linear programming based on the projection onto a zonotope

Speaker: Maxim Demenkov, Institute of Control Sciences, RU, talk 1437

One possible goal of modern research into linear programming (LP) is to remove the dependence on solving large-scale systems of linear equations with each iteration. For this, we investigate a geometric approach from a little-known paper of S. Fujishige et al. Core ideas of this approach are more common for linear integer programming, nevertheless applied in the context of continuous optimization. If we have only interval (or box) constraints on all variables, one can find LP solution as an intersection between a zonotope (an affine transformation of a cube) and a line. We extend this original idea in two ways. First, to incorporate (in addition to the box constraints) general linear inequalities we propose an extended formulation (or lift) of our feasible set and represent it as a projection of some higher dimensional polytope. Second, in case we can easily find an interior point of the zonotope on the line, we derive a linearly convergent (in terms of projection steps) algorithm based on the bisection of an interval on the line. The latter projection is understood in the usual sense as finding a point of the zonotope closest, in some norm, to the given one. For this, we use recent research on the Frank-Wolfe algorithm developed in the context of machine learning applications by S. Lacoste-Julien, M. Jaggi and others. The main step of the Frank-Wolfe algorithm in our case is linear optimization over a zonotope and it's solution can be calculated using closed-form expression.

Optimization problems in graphs and related

Discrete Optimization & Integer Programming

COMB - Fr 5:00pm-6:30pm, Format: 4x20 min

Room: Salle 41 Building: C, 3rd floor, Zone: 1

Contributed Session 423

Chair: Claudio Arbib, University of l'Aquila, IT

1 - Critical node problem based on connectivity index and properties of components

Speaker: Xiucui Guan, southeast University, CN, talk 1640

Co-Authors: *Chao Liu*, *Binwu Zhang*, *Panos Pardalos*,

In this paper we deal with the critical node problem (CNP), in which we search for a given number K of nodes in a graph G, whose removal minimizes the connectivity of the residual graph in some sense. Applications of CNP considered in the literature include fragmentation of terrorist networks, network immunization, transportation network, etc. Many researchers proposed several ways to minimize some connectivity measure of the residual graph, including minimizing the (weighted or unweighted) number of connections between pairs of nodes (known as connectivity index), maximizing the number of components, minimizing the number of nodes in the maximum connect component. However, these measurements cannot overall describe the fragmentation of the residual graph. We propose a new CNP (Called Comb-CNP) by combining the above three measurements plus the degrees of the residual graph. It is a generalization of the CNP based on connectivity index, which is shown NP-completeness for general graphs.We study the case where G is a tree. In the Comb-CNP on a tree, we need to delete at most K nodes V_d such that the number of components is upper-bounded by P, the number of nodes in the maximum component is upper-bounded by M, and the objective is to minimize the sum of connectivity indexes and degrees in the residual graph. A dynamic programming algorithm is proposed to find the optimal value, as well as, an optimal solution of Comb-CNP, and the time complexity of the algorithm is $O(nK^2P^2M^2)$. A computational study is presented which shows that the algorithm is really effective.

2 - Inverse Obnoxious Spanning Tree Problems under Hamming Distance

Speaker: Binwu Zhang, Hohai University, CN, talk 1639

Co-Authors: *Xiucui Guan*, *Pengxiang Zhang*,

In this paper, we consider the obnoxious inverse minimum spanning tree problem under Hamming distance. Given a connected undirected network G in which each edge has a weight and a cost for modifying the weight, and T^0 be a spanning tree of G. We are asked to modify the weights of the edges such that T^0 is the maximum weight spanning tree and the modification cost under the sum-type and bottleneck-type Hamming distance is minimized. For the sum-type problem, a strongly polynomial time algorithm with running time $O(m^2 n\log(m/n))$ is given, and for the bottleneck-type problem, we present a strongly polynomial algorithm with running time O(mn).

3 - The random assignment problem on a full preference domain with submodular

Speaker: Ping Zhan, Edogawa University, JP, talk 976

Co-Authors: *Yoshio Sano*,

(Title: The random assignment problem on a full preference domain with submodular constraints on goods) We consider the allocation problem with submodular constraints on goods among agents. This is a further generalization of our recent work ([1]). Unlike our previous settings, here agents are allowed to be indifferent between goods, i.e., we consider a full preference domain. Our main contributions are: 1. Supported by our preliminary results, we show that the probabilistic serial (PS) mechanism of Bogomolnaia and Moulin (2001), and its extended one by Katta and Sethuraman (2006) can naturally be extended to the allocation problem with polymatroid constraints. 2. We show that our mechanisms, Algorithm

I and Algorithm II, are ordinally efficient and normalized envy-free. 3. Based on the results given by Fujishige (1980), lexicographic characterization of our extended mechanisms is also possible as shown by Bogomolnaia (2015). The randomized mechanism provided in our previous paper ([1]) can also be used to assign indivisible goods for the problems here. Reference [1] S. Fujishige, Y. Sano, and P. Zhan: The random assignment problem with submodular constraints on goods. ACM Transactions on Economics and Computation, 6 (2018) Article No. 3, 28 pages (https://doi.org/10.1145/3175496).

4 - On uncapacitated metric location and pricing

Speaker: Matteo Tonelli, Gran Sasso Science Institute, IT, talk 1067

Co-Authors: *Claudio Arbib*,

In a (Location and) Pricing problem, a set of p potential sites for facility location is given, and one has to decide (where and) at which price to place the offer. An optimal decision is one maximizing the total profit, taking into account demand, competitors, and other costs. The model is metric because is embedded into a graph $G = (V, E)$ that represents a transport infrastructure. Nodes in V correspond to locations of facilities/customers, and customers act as followers of a price setter, adding, via arc weights, a transportation cost from the facility which they decide to be served from. After pointing out connections to **envy-free pricing**, we show that the problem is hard even when G is a path. We also show that it is hard to be approximated within $O(\log^{\varepsilon}(n))$ even with metric transportation costs and zero opening costs, and within $O(p^{1-\varepsilon})$ with non-zero opening costs, for any $\varepsilon > 0$. We however show that, for the interesting case of G tree, the problem admits a polynomial-time approximation algorithm also when every customer has its own reservation price. Moreover, an exact solution can be found in polynomial time if prices are selected out of a discrete set of constant size.

Wasserstein Distributionally Robust Optimization

Optimization under Uncertainty

Robust - Fr 5:00pm-6:30pm, Format: 3x30 min

Room: Salle 33 Building: B, Ground Floor, Zone: 5

Invited Session 448

Organizer: Peyman Mohajerin Esfaha, TU Delft, NL

1 - Risk-Averse Optimization over Structured Wasserstein Ambiguity Set

Speaker: Viet Anh Nguyen, EPFL, CH, talk 1234

Co-Authors: *Daniel Kuhn*, *Soroosh Shafieezadeh*, *Peyman Mohajerin Esfaha*,

By injecting structural information about the unknown true distribution of the uncertain problem parameters into a Wasserstein ambiguity set, we obtain several new optimization problems where the decision maker is minimizing risk measures such as the Value-at-Risk, the Conditional Value-at-Risk or the entropic risk measure.

2 - Wasserstein DRO: Modeling and Optimal Choice of Uncertainty Size

Speaker: Jose Blanchet, Stanford University, US, talk 1518

Co-Authors: *Fan Zhang*, *Karthyek Murthy*,

In this talk, we discuss fundamental questions in Distributionally Robust Optimization (DRO) using Optimal Transport (OT) costs to select the distributional uncertainty set. The Wasserstein distance between distributions is a particular case of OT costs, but we argue that in practice it often makes sense to select consider a much more general class of costs. The choice of the underlying cost function provides a wide range of flexibility to model distributional uncertainty and one can often guide such a choice in a data-driven way. Moreover, we provide a comprehensive theory for choosing the size of the uncertainty set in an optimal way using a natural statistical criterion. We illustrate these ideas in examples drawn from portfolio optimization and various other applications.

3 - Data-driven Inverse Optimization with Imperfect Information

Speaker: Peyman Mohajerin Esfaha, TU Delft, NL, talk 845

Co-Authors: *Soroosh Shafieezadeh*, *Grani Hanasusanto*, *Daniel Kuhn*,

In data-driven inverse optimization an observer aims to learn the preferences of an agent who solves a parametric optimization problem depending on an exogenous signal. Thus, the observer seeks the agent's objective function that best explains a historical sequence of signals and corresponding optimal actions. We focus here on situations where the observer has imperfect information, that is, where the agent's true objective function is not contained in the search space of candidate objectives, where the agent suffers from bounded rationality or implementation errors, or where the observed signal-response pairs are corrupted by measurement noise. We formalize this inverse optimization problem as a distributionally robust program minimizing the worst-case risk that the predicted decision (i.e., the decision implied by a particular candidate objective) differs from the agent's actual response to a random signal. We show that our framework offers rigorous out-of-sample guarantees for different loss functions used to measure prediction errors and that the emerging inverse optimization problems can be exactly reformulated as (or safely approximated by) tractable convex programs when a new suboptimality loss function is used. We show through extensive numerical tests that the proposed distributionally robust approach to inverse optimization attains often better out-of-sample performance than the state-of-the-art approaches.

Logistics Networks

Specific Models, Algorithms, and Software

Logistics - Fr 5:00pm-6:00pm, Format: 2x20 min

Room: Salle 16 Building: I, 2nd floor, Zone: 7

Contributed Session 468

Chair: El Hassan Laaziz, ECOLE MOHAMMADIA D'INGENIEURS, MA

1 - Robust supply chain network equilibrium model with random demands

Speaker: Yasushi Narushima, Yokohama National University, JP, talk 289

Co-Authors: *Tatsuya Hirano*,

Competitive situations can occur in supply chains, owing to the involvement of multiple decision-makers (players) that independently decide their behaviors. To investigate competitive supply chain networks, Nagurney et al. (2002) proposed a supply chain network equilibrium (SCNE) model. Since particular attention has been paid to risk management of a supply chain, Hirano and Narushima (2017) developed a robust SCNE model of which involves uncertainties in the other players' strategies. However, in their model, demands of products in demand markets do not involve uncertainties. In this talk, incorporating an idea of Dong et al. (2004) into the robust SCNE model, we propose a robust SCNE model with random demands in demand markets. We reformulate the proposed model by a variational inequality problem (VIP), and prove existence and uniqueness of solutions of the VIP. In addition, we provide some numerical examples to investigate relations between the magnitudes of uncertainties and performance of the supply chain networks.

2 - Method Benchmarking for Two-Echelon Capacitated Vehicle Routing

Speaker: Guillaume Marques, Université de Bordeaux, FR, talk 1661

Co-Authors: *Ruslan Sadykov*, *Francois Vanderbeck*, *Remy Dupas*, *Jean-Christophe Deschamps*,

In the two-echelon capacitated vehicle routing problem the deliveries to customers are performed by processing and consolidating goods through intermediate depots. Each level involves a fleet of vehicles which we assume to be homogeneous. This NP-hard problem can hardly be tackled directly by calling a MIP solver on a compact formulation. An efficient Branch-Cut-and-Price algorithm is required to solve the problem exactly. It is essential to combine the best techniques proposed recently for vehicle routing problems: bucket-graph-based labelling algorithm for solving the pricing problem, ng-path relaxation, separation of limited memory rank-1 cuts, automatic dual-price smoothing stabilization, reduced cost fixing of bucket arcs, enumeration of elementary routes, and multi-phase strong branching. We compare such algorithm with the state-of-the-art approaches on standard instances of the literature.

Decomposition II

Discrete Optimization & Integer Programming
IPpractice - Fr 5:00pm-6:30pm, Format: 4x20 min
Room: Salle 44 Building: C, 3rd floor, Zone: 1

Contributed Session 487
Chair: Natashia Boland, Georgia Institute of Technolog, US

1 - Discrete Nonlinear Optimization by State-Space Decompositions

Speaker: Andre Cire, University of Toronto, CA, talk 1357

Co-Authors: *David Bergman*,

We present a new approach for nonlinear discrete optimization problems based on a network-based decomposition. In particular, the work proposes the use of decision diagrams to model the objective function, which are then linked together into a single mixed-integer linear program through a network flow linearization. Experimental results on problems arising in revenue management, portfolio optimization, and healthcare exhibit orders-of-magnitude improvement in solution times compared with state-of-the-art nonlinear solvers.

2 - Strengthening of mixed integer linear program bounds using variable splitting

Speaker: Jens Clausen, DTU, DK, talk 501

Co-Authors: *Stefan Ropke*, *Richard Lusby*,

Lagrangian decomposition or variable splitting can strengthen the bounds of MILPs by splitting the problem into smaller sub-problems in which the integrality constraints are enforced. This talk presents our results of applying variable splitting to the single commodity fixed charge network flow problem (SCFCNFP). In the SCFCNFP the flow of a directed graph must obey the demand and supply of the nodes while minimizing the total cost. The cost is derived from the edge flows and is comprised of a per-unit of flow cost and a fixed cost to open the edge. The experiments include examining how different decompositions affect the strength of the bounds and performance of the algorithm, these decompositions are obtained using hypergraph partitioning. The bounds can be further improved by adding cuts to the sub-problems, e.g. two nodes with edges going each way between them should never use both those edges.

3 - A column generation based model to pickup and delivery problems with trans

Speaker: Cristiam Gil, Universidad de Chile, CL, talk 22

Co-Authors: *Michel Gendreau*, *Cristián Cortés*, *Pablo Rey*,

Exact methods in the PDP-T literature were only employed for solving small instances with larges computational times: the best is no more than 75 requests and 4 transfer points running up to 1 CPU time hours (an imposed limit) with average gaps of 33.84 percent (Masson et al., 2014), showing an existing gap in real applications. Some recent promising works have improved gaps in reasonable computational times. Cortes et al. (2010) proved the computational benefits of implementing a branch-and-cut algorithm (based on Benders decomposition) to solve PDP-T problems. They reported savings of around 90 percent in CPU time when compared to standard MIP solvers. Ghilas et al. (2017) solves the PDPTW-T, through a Branch-and-Price method mainly consider for the PDPTW with scheduled lines, with up to 40 requests on the considered instances. Gschwind (2015) evidenced the effectiveness of column generation approaches for the PDP (with no transfer), solving 786 out of 864 (91 percent) small and medium size instances (<= 80 requests) and 127 out of the 192 (66 percent) of large size instances to optimality. Currently, we are developing of cutting-edge solution methods to Pickup and Delivery problem with transfers, specifically methodologies based in Column Generation. The purpose of this work is to show our ongoing progress in this problem: to propose a new methodology to address the problem including precedence, route synchronization and capacity constraints.

4 - Decomposition Branching for Mixed Integer Programming

Speaker: Natashia Boland, Georgia Institute of Technolog, US, talk 1613

Co-Authors: *Baris Yildiz*, *Martin Savelsbergh*,

Resource-directive decomposition is a classical technique in linear programming. Here, we use resource-directive decomposition concepts to derive a new form of branching in mixed integer programming (MIP), which exploits decomposable structure in a problem and employs solution of smaller MIP subproblems to determine the branching rule. The branching is naturally multiway, rather than the traditional binary branching, although for branching involving only binary variables, the multiway branches can easily be replaced by binary branches. The decomposable structure of a problem is assumed given, with the variables partitioned so that each set in the partition has variables in constraints common to relatively few other sets (few linking constraints). This leads to a subproblem for each set of variables in the partition. This structure is exploited as follows. Given a fractional solution at a node of the branch and bound tree, one or more subproblems that include fractional variables is solved (to MIP optimality). The solution(s) either prove that the current dual bound is optimal, or yield a valid multiway branching. They may also yield a feasible solution to the original MIP. We discuss the advantages of the branching scheme in producing a more balanced tree and in combating symmetry. Preliminary computational tests with cover problems show that decomposition branching has the potential to reduce the number of branch and bound nodes by 3 to 4 orders of magnitude when compared with the classical branching scheme.

Topics in stochastic optimization

Optimization under Uncertainty
Stoch - Fr 5:00pm-6:30pm, Format: 3x20 min
Room: Salle 30 Building: B, Ground Floor, Zone: 5

Contributed Session 494
Chair: Quentin Mercier, Onera, FR

1 - Flexible Multi-choice Goal Programming with Fuzzy Data
Speaker: Sakina Melloul, University Centre of Maghnia, DZ, talk 69
Co-Authors: *Hocine Mouslim*,
Decision-making is a part of our daily lives, which is becoming more complex .Herbert A. Simon states that modern managers (MM) wish to "satisfice" to reaching goals subject to the optimization of a single objective. In such situations, the new version of Multi-Choice Goal Programming (MCGP) model suggested by Chang is considered as a robust tool in operational research and management science to solve this type of problems with precise data. However, in reality, the decision makers/(MM) can not know its value of data with certainty due the incomplete information. In this paper, an efficient methodology is presented basing on MCGP model and the technique of Fuzzy Set to solve this type of real world problems, where the concept of Multi-goal Functions (Mg-Fs) is introduced for modelling the preferences with uncertainty data of all kinds of the objectives. One of the main advantages of the new formulation is that it provides (MM) with more control over their flexible preferences. Finally, an illustrative example is given to demonstrate the effectiveness of our proposed model.

2 - Optimal inflow control in supply systems with uncertain demands
Speaker: Kerstin Lux, University of Mannheim, DE, talk 1281
Co-Authors: *Simone Göttlich*, *Ralf Korn*,
We are concerned with optimal control strategies subject to uncertain demands. They have a broad range of applications. Taking uncertainty into account becomes more and more important in many areas. For example, in the context of supply systems, a need for control strategies taking these uncertainties into account naturally arises. Deviations from the demand actually realized need to be compensated, which might be very costly and should be avoided. To this end, we consider different approaches to control the produced amount at a given time to meet the stochastic demand in an optimal way. Supply systems are represented by transport equations, which are solved numerically by applying appropriate numerical schemes. Stochastic differential equations (SDEs) are used to model the uncertain demand. To solve the latter ones numerically, we use the Euler-Maruyama scheme. For SDEs describing jump diffusion processes, the jump part has to be simulated and integrated into the scheme. By an adapted use of an optimization solver, those two components of the stochastic optimal control problem are put together and an optimal control is calculated. A crucial aspect of the work is the numerical investigation and comparison of the different approaches in a numerical simulation study.

3 - A descent algorithm for stochastic multiobjective optimization problems
Speaker: Quentin Mercier, Onera, FR, talk 1038
Co-Authors: *Fabrice Poirion*, *Jean-Antoine Désidéri*,
We consider a new method named SMODA (Stochastic Multiple Objective Descent Algorithm) for solving multiobjective optimization problems where the objectives are written as expectations of random functions. To ensure a Pareto equilibrium of a design for such problem without estimating the expectations, we propose an extension of the classical stochastic gradient algorithm to the multiobjective case. This extension is based on the existence of a common descent vector built from the objective gradients. Considering classic hypothesis of the stochastic gradient algorithm, the mean square and almost sure convergence can be proven. The common descent vector definition can be modified in order to extend the range of applications to non-differentiable objectives without the loss of convergence properties by building the vector around subdifferentials. Due to the construction of the common descent vector, the location of a SMODA solution is very dependent of the starting point chosen. Thus, to enhance the spreading of the Pareto front given by multiple SMODA runs, a metamodel-based method for generating starting points is proposed. Some applications are also presented to show the algorithm efficiency, as well with a proposition of using SMODA to solve a reliability optimization problem.

Global Optimization 1

Continuous Optimization
Global - Fr 5:00pm-6:30pm, Format: 3x30 min
Room: Salle 20 Building: G, 1st floor, Zone: 6

Contributed Session 501
Chair: Jean-Baptist Hiriart-Urruty, Paul Sabatier University, FR

1 - New clustering methods for large scale global optimization
Speaker: Fabio Schoen, DINFO Univ di Firenze, IT, talk 999
Co-Authors: *Francesco Bagattini*, *Luca Tigli*,
Clustering methods have been among the most popular global optimization (GO) strategies; in the 90's they have been abandoned for several reasons, one of which being the difficulties in applying them to large scale GO problems. In this paper we will show how we can apply those method to difficult large scale problems thanks to the idea, drawn from machine learning, of mapping solution to a suitable feature space. Nu-

merical experiments show that this technique can save many local searches for very hard GO problems. In this talk I will show how the method can be applied to large Lennard-Jones or Morse atomic cluster optimization as well as to sphere packing problems in a cube. These problems are notoriously hard, in particular when their dimension increase. We successfully applied the idea of clustering, which consists in starting a local descent from randomly generated initial configurations, clustering in the feature space and then applying a full descent procedure only to a few representative elements in each cluster. The method enabled us to find the putative global optima for all hard instances (e.g., all Morse clusters with $\rho = 14$ up to 200 atoms and all sphere packing problems up to 70 spheres and most of the instances up to 110 spheres) saving, in each instance, at least 50 percent of the local searches with respect to a method in which early local descent stopping is not applied. In sphere packing we were able to obtain new improved putative global optima for 83, 95, 96, 109 and 110 spheres in the unit cube.

2 - Continuous Approaches to Cluster-Detection Problems in Networks

Speaker: Sergiy Butenko, Texas A&M University, US, talk 1646

We propose continuous formulations for several cluster-detection problems in networks, including the maximum edge weight clique, the maximum s-plex, and the maximum independent union of cliques problems. More specifically, the problems of interested are formulated as quadratic, cubic, or higher-degree polynomial optimization problems subject to linear (typically, unit hypercube) constraints. The proposed formulations are used to develop analytical bounds as well as effective algorithms for some of the problems.

3 - Computational advances in the RLT algorithms: A freely available implementation

Speaker: Julio González-Díaz, Univ. Santiago de Compostela, ES, talk 541

Co-Authors: *Brais González*, *Joaquín Ossorio-Castillo*, *Diego Martínez*, *David Penas*,

We will present a new implementation of the reformulation linearization techniques, RLT, in the context of polynomial programming problems, originally introduced in Sherali and Tuncbilek (1991). RLT is a branch and bound algorithm based on linear relaxations, and ensures convergence to a global optimum. This new implementation has been developed with two main goals in mind: - Computational efficiency. The implementation incorporates most of the features of the RLT algorithm discussed in past literature. Moreover, additional enhancements have been introduced, such as parallelization and warm start features at various levels of the branching process. The current version of the algorithm has proven to be very efficient, and comparisons with other global optimization solvers such as BARON and Couenne will be presented. - Free availability. To this end, this implementation can be used in conjunction with any free and commercial linear and nonlinear solvers for the computation of the lower and upper bounds, respectively.

Dual Ascent

Discrete Optimization & Integer Programming

IPpractice - Fr 5:00pm-6:00pm, Format: 2x20 min

Room: Salle 36 Building: B, Intermediate, Zone: 4

Contributed Session 505

Chair: Sara Maqrot, INRA Toulouse, FR

1 - A dual ascent procedure for solving the generalized set partitioning model

Speaker: Stefania Pan, Horizontal Software, FR, talk 1269

Co-Authors: *Mahuna Akplogan*, *Lucas Letocart*, *Nora Touati*, *Roberto Wolfler Calvo*,

In this work we propose a dual ascent procedure for solving the generalized set partitioning problem with convexity constraints, which often models the restricted master problem of a generic column generation approach. The generalized set partitioning problem contains at the same time the set covering, set packing and set partitioning problems. The proposed dual ascent procedure is based on a parametric reformulation and it uses the Lagrangian relaxation and the subgradient method. It is different from the dual ascent already proposed in the literature, since it is able to deal with right hand side greater than one, together with under and over coverage. To prove its validity it has been applied for solving the minimum sum coloring problem, the multi-activity tour scheduling problem and for solving some new generated instances. The computational results show the effectiveness of the proposed method.

2 - Improving Wedelin's Heuristic with Sensitivity Analysis for Set Partitioning

Speaker: Sara Maqrot, INRA Toulouse, FR, talk 1432

Co-Authors: *Simon de Givry*, *Gauthier Quesnel*, *Marc Tchamitchian*,

Heuristics are important techniques to find quickly good solutions for difficult integer programs. Most heuristics depend on a solution of the relaxed linear program. On the contrary, Lagrangian relaxation offers several advantages over linear programming, namely it is extremely fast on large problems. One of the Lagrangian based heuristics is Generalized Wedelin's heuristic. The performance of this method depends crucially on the choice of its numerous parameters. To adjust these parameters and learn which ones have important influence on whether a feasible solution is found and its quality, we conduct sensitivity analysis combined with a parameter optimization metaheuristic. We have implemented a C++ parallel version of Generalized Wedelin's heuristic. The solver is called baryonyx. To test its performance, we compare it with IBM ILOG cplex and with two local search methods: a 4-flip neighborhood local search algorithm and LocalSolver. Results show that baryonyx is competitive with the existing solvers on difficult set partitioning and large weighted n-queens problems.

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