How to Navigate the Technical Sessions

There are four primary resources to help you understand and navigate the Technical Sessions:

- This Technical Session listing, which provides the most detailed information. The listing is presented chronologically by day/time, showing each session and the papers/abstracts/authors within each session.
- The Session Chair, Author, and Session indices provide cross-reference assistance (pages 168-184).
- The floor plans on page xxii show you where technical session tracks are located.
- The Master Track Schedule is on pages xvii-xxi.
- This is an overview of the tracks (general topic areas) and when/where they are scheduled.

Quickest Way to Find Your Own Session

Use the Author Index (pages 170-179) — the session code for your presentation(s) will be shown along with the track number. You can also refer to the full session listing for the room location of your session(s).

The Session Codes

TB01

Room number. Room locations are also indicated in the listing for each session.

Time Block. Matches the time blocks shown in the Master Track Schedule.

The day of the week

Time Blocks

Monday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm
F - 5:30pm – 7:00pm

Tuesday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm

Wednesday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm
F - 5:30pm – 6:20pm

Thursday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm
F - 5:30pm – 7:00pm

Friday
A - 9:00am – 9:50am
B - 10:20am – 11:50am
C - 1:10pm – 2:40pm
D - 2:45pm – 4:15pm
E - 4:35pm – 5:25pm

Monday, 9:00am - 9:50am

■ MA01

01- Grand 1

Matroid Minors Project

Cluster: Plenary
Invited Session

Chair: Monique Laurent, CWI, Tilburg University, Science Park 123, Amsterdam, 1098 XG, Netherlands, monique@cwi.nl

1 - Matroid Minors Project

Jim Geelen, University of Waterloo, Waterloo, ON, Canada, jfgeelen@uwaterloo.ca

Over the past 15 years I have been working with Bert Gerards and Geoff Whittle on extending the Graph Minors Project, of Paul Seymour and Neil Robertson, to minor-closed classes of representable matroids. This talk is intended to be a gentle overview of our project, covering the main results and some applications in coding theory. No prior exposure to matroid theory is assumed.”

Monday, 10:20am - 11:50am

■ MB01

01- Grand 1

A. W. Tucker Prize

Cluster: Tucker Prize
Invited Session

Chair: Karen Aardal, Delft University of Technology, Mekelweg 4, Delft, Netherlands, K.I.Aardal@tudelft.nl

The A. W. Tucker Prize was established by the Society in 1985, and was first awarded at the Thirteenth Symposium in 1988. Beginning in 2009, it will be awarded at each Symposium for an outstanding doctoral thesis.

Nominations are screened by Tucker Prize Committee. At most three finalists are chosen. The finalists and winner are announced at the opening session of the Symposium, at which time the Prize is awarded. The finalists are invited to give oral presentations of their work at a special session of the Symposium.

■ MB02

02- Grand 2

Complementarity/Variational Inequality I

Cluster: Complementarity/Variational Inequality/Related Problems
Invited Session

Chair: Michael Ferris, Professor, University of Wisconsin, Computer Sciences Department, 1210 West Dayton Street, Madison, WI, 53706, United States of America, ferris@cs.wisc.edu

1 - Gradient Sliding for Saddle Point and Variational Inequality Problems

Guanghui Lan, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, United States of America, glan@ise.ufl.edu

We present a new class of first order methods which can skip the computation of gradients for certaint saddle point and variational inequality problems.

2 - Applications with Complementary Constraints in Chemical Engineering

Lorenz Biegler, Carnegie Mellon University, Pittsburgh, United States of America, biegler@cmu.edu, Alexander Dowling

We explore the application of complementarity constraints to several process design applications in chemical engineering. We formulate chemical equilibrium with possible vanishing phases as a bilevel optimization problem, with Gibbs free energy minimization as the inner problem. The KKT conditions of the inner problem are then reformulated into complementarity constraints and embedded into nonlinear problems for several process design examples. The relationship between non-global solutions of the inner problem and meta-stable phase equilibrium solutions will be discussed.

3 - MOPEC, Contracts, Risk and Stochastics

Michael Ferris, Professor, University of Wisconsin, Computer Sciences Department, 1210 West Dayton Street, Madison, WI, 53706, United States of America, ferris@cs.wisc.edu

We consider extensions of Nash Games to include linking equilibrium constraints and situations where players solve multi-period stochastic programs. We demonstrate when social optima exist, what properties on risk measures and contracts are needed, and how to solve these problems in large scale application domains.

■ MB03

03- Grand 3

Resource Allocation on Networks

Cluster: Combinatorial Optimization

Invited Session

Chair: Tobias Harks, Maastricht University, Tongersetraat 53, Maastricht, Netherlands, t.harks@maastrichtuniversity.nl

1 - Finding Social Optima in Congestion Games with Positive Externalities

Guido Schaefer, CWI, Science Park 123, Amsterdam, 1098XG, Netherlands, G.Schaefer@cwi.nl

We consider the problem of optimizing the social welfare in congestion games where every player i expresses for each resource e and player j a positive externality, i.e., a value for being on e together with player j. We show that this problem is NP-hard even for the special case when the players' utility functions for each resource are affine. We derive a 2-approximation algorithm by rounding an optimal solution of a natural LP formulation of the problem. Our rounding procedure is sophisticated because it needs to take care of the dependencies between the players resulting from the pairwise externalities. We also show that this is essentially best possible by showing that the integrality gap of the LP is close to 2.

2 - Generalized Geometrical Clustering: 1-Median

Andrej Winokurow, Department of Quantitative Economics, Maastricht University, P.O. Box 616, Maastricht, 6200 MD, Netherlands, a.winokurow@maastrichtuniversity.nl, Andre Berger, Alexander Grigoriev

We introduce a generalization of the d-dimensional k-median clustering problem with p-norm, where n data points are grouped around balls of radius R as cluster centers. The linearization or other approximations of the norm do not help to solve the problem. However, for the Manhattan norm and the infinity norm an exact algorithm is presented, which runs in O(n^d). Further, we describe a randomized PTAS for finding a generalized 1-median for small enough R.

3 - Complexity and Approximation of the Continuous Network Design Problem

Max Klimm, TU Berlin, Institut für Mathematik, Sekr. MA 5-2, Strasse des 17. Juni 136, Berlin, Germany, klimm@math.tu-berlin.de, Tobias Harks, Martin Gairing

We revisit the classical (bilevel) continuous network design problem. Given a graph for which the latency of each edge depends on the ratio of the edge flow and the capacity installed, the goal is to find an optimal investment in edge capacities so as to minimize the sum of the routing costs of the induced Wardrop equilibrium and the investment costs for installing the edge's capacities. We show that continuous network design is APX-hard. As for the approximation of the problem, we provide a detailed analysis for a heuristic studied by Marcotte (Math. Program. 1985). Then, we propose a different algorithm and prove that using the better of the two algorithms results in improved approximation guarantees.

■ MB04

04- Grand 4

Geometry, Duality, and Complexity in Convex Optimization I

Cluster: Conic Programming

Invited Session

Chair: Gabor Pataki, University of North Carolina at Chapel Hill, Chapel Hill, NC, Chapel Hill, United States of America, gabor@unc.edu

1 - LP Formulations for Mixed-integer Polynomial Optimization Problems

Daniel Bienstock, Columbia University, 500 W 120th St, New York, NY, 10027, United States of America, dano@ieor.columbia.edu

We present a hierarchy of LP formulations for polynomial optimization problems with guaranteed performance bounds. In the worst case these linear programs have exponential size; however in cases where the intersection graph has bounded tree-width the LPs have linear size for each tolerance level. At the same time the LPs are not relaxations — they compute actual solutions, of smaller size than other recent approaches. As a consequence, we obtain the first polynomial-size LP formulations for the AC-OPF problem on graphs of fixed tree-width, with fixed numerical tolerance level.

2 - Strengthening the Pataki Sandwich Theorem

Vera Roshchina, Lecturer, RMIT University, School of Maths and Geospatial Sciences, Melbourne, Vi, 3310, Australia, vera.roshchina@unimelb.edu.au, Levent Tuncel

The sandwich theorem originally proposed by Gabor Pataki provides (different) necessary and sufficient conditions for a convex cone to be nice (or facially dual complete). We strengthen the necessary condition and discuss examples.

3 - Exact Duality in Semidefinite Programming using Elementary Reformulations

Gabor Pataki, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States of America, gabor@unc.edu, Minghui Liu

We describe an exact, short certificate of infeasibility of semidefinite systems using an elementary approach: we reformulate such systems using only elementary row operations and rotations. When a system is infeasible, the infeasibility of the reformulated system is trivial to verify by inspection. For feasible systems we describe a similar reformulation, which trivially has strong duality with its Lagrange dual for all objective functions. As a corollary, we obtain an algorithm to systematically generate the data of all infeasible semidefinite programs. The second part of this talk (which can be understood independently) is presented by Minghui Liu.

■ MB05

05- Kings Garden 1

Augmented Lagrangian and Related Methods

Cluster: Nonlinear Programming

Invited Session

Chair: Jonathan Eckstein, Professor, Rutgers University, 100 Rockafeller Road, Room 5145, Piscataway, NJ, 08854, United States of America, jeckstei@rci.rutgers.edu

1 - Relative Error Criterion for Multiplier Methods in the Non-Convex Case

Paulo J. S. Silva, Associate Professor, University of Campinas, Rua Sergio Buarque de Holanda 651, Campinas, SP, 13083-859, Brazil, pjssilva@ime.unicamp.br, Alberto Ramos, Jonathan Eckstein

We develop a new criterion for the approximate minimization of augmented Lagrangian subproblems in the non-convex setting based on the relative error criterion of Eckstein and Silva for the convex case. The main advantage of this type of criterion is that the error adapts to the optimization process, becoming more stringent only when convergence is taking place. Our analysis uses Pennanen's duality framework and is based on inexact variants of the proximal point algorithm for hypomonotone operators.

2 - An Asynchronous Distributed Proximal Method for Composite Convex Optimization

Necdet Serhat Aybat, Assistant Professor, PennState University, Industrial Engineering Department, University Park, United States of America, nsa10@psu.edu, Garud Iyengar, Zi Wang

We propose an asynchronous distributed first-order augmented Lagrangian (DFAL) algorithm to minimize sum of composite convex functions, where each term is a private function belonging to one node, and only nodes connected by an edge can directly communicate. This model abstracts various applications in machine-learning. We show that any limit point of iterates is optimal; and for any p>0 and eps>0, an eps-optimal and eps-feasible solution can be computed with probability at least 1-p within O(1/eps log(1/p)) communications in total. We demonstrate the efficiency of DFAL on large scale sparse-group LASSO problems.

3 - Incremental Projective Splitting for Sums of Maximal Monotone Operators

Jonathan Eckstein, Professor, Rutgers University, 100 Rockafeller Road, Room 5145, Piscataway, NJ, 08854, United States of America, jeckstei@rci.rutgers.edu, Patrick Louis Combettes

We develop an approach to computing zeroes of sums of maximal monotone operators in Hilbert space, combining ideas from Eckstein-Svaiter projective splitting with techniques from block-iterative projection methods for convex feasibility problems. The result is a family of decomposition methods in which only a subset of the subproblem systems need to be evaluated between coordination steps, and subproblems and coordination steps may be overlapped asynchronously. The subproblems have a proximal or augmented Lagrangian form. We also discuss applications, including progressive-hedging-like approaches to stochastic programming.

■ MB06

06- Kings Garden 2

Equilibrium Models for Electricity Markets under Uncertainty

Cluster: Optimization in Energy Systems

Invited Session

Chair: Andy Philpott, University of Auckland, Private Bag 92019, Auckland, New Zealand, a.philpott@auckland.ac.nz

1 - SFE Models of Beneficiaries-Pay Transmission Pricing

Anthony Downward, University of Auckland, Level 3, 70 Symonds Street, Grafton, Auckland, 1010, New Zealand, a.downward@auckland.ac.nz, Keith Ruddell, Andy Philpott

We study the effects on supply function equilibrium of a system tax on the observed benefits of generators. Such a tax provides incentives for agents to alter their offers to avoid the tax. We show how this can lead to lower prices in equilibrium. The model is extended to a setting in which the agents are taxed on the benefits accruing to them from a transmission line expansion (to help fund the line).

2 - Electricity Derivative Trading with Private Information on Price Distributions

Eddie Anderson, Professor and Associate Dean (Research), University of Sydney, University of Sydney Business School, Sydney, NS, W 2006, Australia, edward.anderson@sydney.edu.au, Andy Philpott

We examine a framework in which firms trade in a forward market and have some private information on the probability distribution of the final scenarios. Not only do different agents have different private information but they may also have different degrees of confidence in that information. We look for models that reflect the way that forward markets are driven by the hedging behavior of industry participants. We use a supply function model and explore the way in which participants can exploit the bidding behavior of other participants to learn about their private information.

3 - Capacity Equilibrium in Electricity Markets

Andy Philpott, University of Auckland, Private Bag 92019, Auckland, New Zealand, a.philpott@auckland.ac.nz, Golbon Zakeri, Corey Kok

We study the problem of optimal capacity choice by conventional generators in wholesale electricity markets. When demand is increasing this is a capacity expansion problem. When demand is flat and other technologies are growing it can be a optimal capacity reduction problem. We examine incentives in these settings using complementarity models solved by GAMS/PATH.

■ MB07

07- Kings Garden 3

New Developments in Some Optimization Software Packages

Cluster: Implementations and Software

Invited Session

Chair: Erling Andersen, CEO, MOSEK ApS, Fruebjergvej 3, Copenhagen, 2100, Denmark, e.d.andersen@mosek.com

1 - Abstract Glue for Optimization in Julia

Miles Lubin, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-149, Cambridge, MA, 02139, United States of America, mlubin@mit.edu, Madeleine Udell, Tony Kelman, Dominique Orban, Joey Huchette, Iain Dunning

We describe the MathProgBase package in Julia, an abstraction for solver-independent mathematical optimization. Linking multiple modeling packages (JuMP, Convex.jl, AMPL) to a number of open-source and commercial solvers for linear, mixed-integer, conic, and nonlinear optimization, MathProgBase significantly lowers the barrier to developing solvers, meta-solvers, and modeling languages and enables a surprising level of composability without loss of performance by using in-memory interfaces when possible. We present a number of advanced applications.

2 - The CVX Modeling Framework for Disciplined Convex Optimization

Michael Grant, CVX Research, Inc., 1104 Claire Ave., Austin, TX, 78703, United States of America, mcg@cvxr.com

CVX is well-known MATLAB-based framework for constructing and solving convex optimization models, and more recently mixed-integer problems. In this talk we will provide a brief overview of the tool, discuss its latest capabilities, and introduce plans for future development.

3 - Software for Polynomial Optimization in the Julia Language

Joachim Dahl, Software developer, MOSEK ApS, Fruebjergvej 3, Copenhagen, Denmark, joachim.dahl@mosek.com, Martin Skovgaard Andersen, Frank Permenter

We discuss an implementation of the Lasserre hierarchy of semidefinite relaxations for polynomial optimization using the semidefinite optimization capabilities in MOSEK. The conversion from polynomial problems to semidefinite relaxations is implemented in the recent language Julia, which has proven to be remarkable well-suited for such modeling layers. Moreover, we present different applications and discuss how chordal structure can be used to exploit sparsity in the Lasserre hierarchy as well as in sums-of-squares certificates.

■ MB08

08- Kings Garden 4

Linear and Semidefinite Formulations in Combinatorial Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: James Saunderson, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-D572, Cambridge, MA, 02139, United States of America, jamess@mit.edu

1 - An Axiomatic Duality Framework for the Theta Body and Related Convex Corners

Marcel de Carli Silva, University of São Paulo, Rua do Matao, 1010, São Paulo, Brazil, mksilva@ime.usp.br, Levent Tuncel

The Lovasz theta function is a cornerstone of combinatorial and semidefinite optimization and graph theory. This is partly due to a multitude of equivalent characterizations of the theta function stemming from convex optimization duality. In this work, we extend and unify many such characterizations to a richer class of generalized theta functions, which we show to include the stability number via copositive programming, as well as several related graph invariants via conic optimization.

2 - Exploiting Symmetry in the Turan Semidefinite Program

Annie Raymond, annieraymond@gmail.com, Rekha Thomas, Mohit Singh

We invoke techniques devised by Gatermann and Parrilo (2004) to investigate the role of symmetry in certifying the non-negativity of density inequalities for a-clique-free graphs. We then reevaluate this strategy in light of Razborov's flag algebras.

■ MB09

09- Kings Garden 5

Exact Algorithms for Geometric Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Sàndor P. Fekete, TU Braunschweig, Algorithms Group, Braunschweig, Germany, s.fekete@tu-bs.de

1 - The Wireless Localization Problem: A Successful Combination of IP and Algorithmic Engineering

Cid de Souza, Professor, University of Campinas, Av. Albert Einstein 1251,, Cid. Universitaria, Barao Geraldo, Campinas, SP, 13083-852, Brazil, cid@ic.unicamp.br, Bruno Crepaldi, Pedro de Rezende

Consider the layout of a building given by a 2D-polygon P. Wireless antennas are to be installed at some prespecified potential sites, each broadcasting its own key within a certain angle. In a feasible installation, the set of keys received at any point q in the plane must be enough to decide whether q is inside or outside P. To ascertain this, a Boolean formula must be produced along with the placement of the antennas. The goal is to minimize the number of antennas installed. We formulate the problem as an integer program and show how to reduce the model to manageable sizes. We also highlight several implementation details we used to obtain an efficient algorithm, able to find the optimum for polygons with 1000+ vertices very quickly.

2 - Area- and Boundary-Optimal Polygonalization of Planar Point Sets

Michael Hemmer, TU Braunschweig, Muehlenpfordtstrasse 23, Braunschweig, 38106, Germany, mhsaar@gmail.com, Sandor P. Fekete, Melanie Papenberg, Arne Schmidt, Julian Troegel

Given a set of points in the plane, we consider problems of finding polygonalizations that use all these points as vertices and that are minimal or maximal with respect to covered area or length of the boundary. By distinguishing between polygons with and without holes, this results in eight different problems, one of which is the famous Traveling Salesman Problem. Starting from an initial flexible integer programming (IP) formulation, we develop specific IPs and report preliminary results obtained by our implementation.

3 - Computing MaxMin Edge Length Triangulations

Sandor P. Fekete, TU Braunschweig, Algorithms Group, Braunschweig, Germany, s.fekete@tu-bs.de

We show that finding a MaxMin Edge Length Triangulation for a set of n points in the plane is NP-hard, resolving an open problem dating back to 1991, and discuss exact approaches. A straightforward IP based on pairwise disjointness of the T(n^2) segments has T(n^4) constraints, making this IP prohibitively large, even for relatively small n. We demonstrate how the combination of geometric insights with refined methods of combinatorial optimization can still help to put together an exact method capable of computing optimal MELT solutions for planar point sets up to n = 200. Our key idea is to exploit specific geometric properties in combination with more compact IP formulations, such that we are able to drastically reduce the IPs.

■ MB11

11- Brigade

Flows

Cluster: Combinatorial Optimization

Invited Session

Chair: Renata PoznanskiMSc Student in Operations Research, Tel Aviv University, Israel, Savyon 10, Ramat Gan, 5257523, Israel, renatabo@mail.tau.ac.il

1 - The Budgeted Minimum Cost Flow Problem with Unit Upgrading Cost

Annika Thome, RWTH Aachen University, Kackertstr. 7, Aachen, 52072, Germany, thome@or.rwth-aachen.de, Sarah Kirchner, Christina Büsing

We present a capacitated bi-level minimum cost flow optimization problem. In this problem, we are given a directed graph with several sources and sinks. The arcs are associated with capacities and lower/upper costs. The leader problem is finding a selection of K arcs where the lower costs apply and the follower problem is finding a minimum cost flow that satisfies the demand. In this talk, we prove our problem to be strongly NP-hard even in the single-source single-sink case. However, for special graphs we present polynomial algorithms.

2 - Faster Separation of Robust Single-Commodity Cut-Set Inequalities

Daniel Schmidt, CMU, 317b Posner Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, schmidtd@cmu.edu, Chrysanthos Gounaris

Designing networks that are both reliable and cost-efficient in a large number of scenarios is a difficult task. Here, a challenge is to find a robust integer programming formulation that admits a compact or efficiently separable linear programming relaxation. Two standard robust formulations of the single-commodity network design problem with uncertain demands exist: An arc-flow based formulation with an infinite number of variables and a capacity based formulation with an exponential number of constraints. We explore techniques to approximate the arc-flow based formulation with fewer variables and evaluate the use of meta-heuristics for the NP-hard separation problem that arises from the capacity based formulation.

3 - Optimal Multiperiod Network Flows with Coupling Constraints

Renata Poznanski, MSc Student in Operations Research, Tel Aviv University, Israel, Savyon 10, Ramat Gan, 5257523, Israel, renatabo@mail.tau.ac.il, Refael Hassin

Consider two networks on duplicates of the same directed graph, with given source and sink nodes, but with different edge capacities. Our problem is to compute feasible flows such that the sum of flows is maximized subject to coupling constraints that force identical flows on duplicate copies of the same edge for a subset of edges. We prove that the solution is integral for all possible capacity functions iff the graph is series parallel. We obtain related results for the minimum cost flow problem.

■ MB12 10:30am - 11:00am

12- Black Diamond

MOSEK – Quick Tour of Mosek: Best Practices and its Fusion API

Cluster: Software Presentations

Invited Session

Chair: Andrea Cassioli, Product Manager, MOSEK ApS, Fruebjergvej 3 Symbion Science Park, Box, Copenhagen, Se, 2100, Denmark, andrea.cassioli@mosek.com

1 - MOSEK - Quick Tour of Mosek: Best Practices and its Fusion API

Andrea Cassioli, Product Manager, MOSEK ApS, Fruebjergvej 3 Symbion Science Park, Box, Copenhagen, Se, 2100, Denmark, andrea.cassioli@mosek.com

MOSEK provides high-quality software for conic optimization. The main focus of the software tutorial is two-fold: (1) to guide users through the key features and benefits of our objected-oriented API called FUSION API: speed, expressiveness and simplicity; (2) to discuss some modeling issues and best practices that may be helpful in many cases: scaling, dualization among others. Real-life example inspired by our customer will be used to show how to use MOSEK at its best.

■ MB13

13- Rivers

Optimization Problems with Moments and Polynomials I

Cluster: Conic Programming

Invited Session

Chair: Jiawang Nie, Associate Professor, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA, 92093, United States of America, njw@math.ucsd.edu

Co-Chair: Jean Lasserre, Laboratory for Analysis and Architecture of Systems, lasserre@laas.fr

1 - A Bounded Degree SOS Hierarchy for Polynomial Optimization

Jean Lasserre, Laboratory for Analysis and Architecture of Systems, lasserre@laas.fr, Kim-Chuan Toh

We provide a new hierarchy of semidefinite relaxations for polynomial optimization problems on a compact basic semi-algebraic set. This hierarchy combines some advantages of the standard LP-relaxations associated with Krivine's positivity certificate and some advantages of the standard SOS-hierarchy. In particular (a) for each relaxation the size of the matrix associated with the semidefinite constraint is the same and fixed in advance by the user and (b) finite convergence occurs at the first step of the hierarchy for an important class of convex problems. Finally (c) some important techniques for declaring a polynomial to be zero and to the use of rank-one matrices make an efficient implementation possible.

2 - Convergence Analysis for Lasserre's Hierarchy of Upper Bounds for Polynomial Optimization

Zhao Sun, Tilburg University, P.O. Box 90153, Tilburg, 5000 LE, Netherlands, sunzhao1987@gmail.com, Etienne de Klerk, Monique Laurent

We consider the problem of minimizing a polynomial over a compact set, and analyze a measure-based hierarchy of upper bounds proposed by Lasserre. This hierarchy is obtained by searching for an optimal probability density function which is a sum of squares of polynomials, so that the expectation is minimized. In this talk, we will show its rate of convergence. The main idea is to use the truncated Taylor series of the Gaussian distribution function.

3 - The CP-matrix Approximation Problem

Jinyan Fan, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai, China, jyfan@sjtu.edu.cn

In this talk, we discuss the CP-matrix approximation problem of projecting a matrix onto the intersection of a set of linear constraints and the cone of CP matrices. We formulate the problem as the linear optimization with the norm cone and the cone of moments. A semidefinite algorithm is presented for the problem. A CP-decomposition of the projection matrix can also be obtained if the problem is feasible.

■ MB14

14- Traders

Pricing and Bargaining with Middlemen

Cluster: Game Theory

Invited Session

Chair: Thanh Nguyen, Krannert School of Management, Purdue University, West Lafayette, United States of America, nguye161@purdue.edu

1 - Optimal Contracts for Intermediaries in Online Advertising

Ozan Candogan, Duke University, Fuqua School of Business, Durham, NC, 27705, United States of America, ozan.candogan@duke.edu, Santiago Balseiro

In online display advertising advertisers often contract with an intermediary to acquire impressions. This paper studies the optimal contract offered by the intermediary in a setting where advertisers' budgets and targeting criteria are private. This problem can be formulated as a multi-dimensional dynamic mechanism design problem. We tackle the problem by employing a novel performance space characterization technique, which provides a convex optimization formulation of the optimal contract design problem. We solve this problem with a duality-based approach, and obtain the optimal contracts. Our results show that an intermediary can profitably provide bidding service to a budget-constrained advertiser, and increases market efficiency.

2 - Population Monotonicity in Newsvendor Games

Zhenyu Hu, University of Illinois, Springfield, IL, United States of America, hu48@illinois.edu, Xin Chen

It is well-known that the core of the newsvendor game is non-empty and one can use duality theory in stochastic programming to construct an allocation belonging to the core, which we refer to as dual-based allocation scheme. In this work, we identify conditions under which the dual-based allocation scheme is a population monotonic allocation scheme (PMAS), which also requires each player's cost decreases as the coalition to which she belongs grows larger. Specifically, we show that the dual-based allocation scheme is a PMAS if and only if the growth of the coalition does not increase the dependence structure between each player and the coalition. Sufficient conditions for population monotonicity are provided for various special cases.

3 - Trade Capacity of A Network

Vijay Subramanian, Associate Professor, University of Michigan, EECS Dept, #4112, 1301 Beal Ave, Ann Arbor, MI, 48109, United States of America, vgsubram@umich.edu, Randall Berry, Thanh Nguyen

We study decentralized markets with the presence of middlemen, modeled by a non-cooperative bargaining game in trading networks. Our goal is to investigate how the network structure of the market and the role of middlemen influence the trade capacity of the market. We show that transaction costs and heterogeneous network structure are the two main channels that give rise to endogenous delay and reduce the trade capacity of the network.

■ MB15

15- Chartiers

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Tasuku Soma, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan, tasuku_soma@mist.i.u-tokyo.ac.jp

1 - Use of Regularization to Improve the Rate of Convergence in a Model Order Reduction (MOR) Problem

Leobardo Valera, The University of Texas at El Paso, 500 W University Ave, El Paso, TX, 79968, United States of America, lvalera@utep.edu, Martine Ceberio

A way to solve systems of differential equations is by discretizing them, which often leads to a large system of (possibly nonlinear) equations. Even when the systems are linear, direct computations only allow us to solve them in n^3 operations, which may still impose practical limits for large values of n. When looking for a faster solution of such systems of equations in a subspace of the original domain and using Model-Order Reduction, we then have to handle over-determined systems. These can be solved using the Gauss-Newton method, which in non-zero-residual cases is not as efficient as needed. We propose to use techniques inspired by Levenberg and Marquardt to improve the convergence rate of such systems.

2 - Regularization Strategies for Barrier Nonlinear Programming Solvers

Wei Wan, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, weiwan@andrew.cmu.edu, Lorenz Biegler

Barrier methods are widely used nonlinear programming solvers. Nevertheless, these solvers may behave poorly in the presence of degenerate constraints, as they often lead to ill-conditioned KKT matrices applied in the Newton step. To address this problem, we develop structured regularizations of the KKT matrix that lead to well-conditioned systems and preserve matrix inertia. This approach leads to improved performance, as compared with the current version of IPOPT on a large set of test problems.

3 - The Low-Rank Basis Problem for a Matrix Subspace

Tasuku Soma, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan, tasuku_soma@mist.i.u-tokyo.ac.jp, Yuji Nakatsukasa, Andrè Uschmajew

For a given matrix subspace, how can we find a basis that consists of low-rank matrices? This problem can be viewed as a matrix generalization of the sparse basis problem. In this work we provide a greedy algorithm for this problem and analyze its convergence. Our algorithm iteratively finds a matrix of minimum rank in the given subspace that is linearly independent to the matrices already found. We devise a simple procedure for searching such a low-rank matrix by exploiting the soft and hard singular value thresholding. A procedure for avoiding linear dependence is also provided. Our algorithm can be used for representing a matrix with memory requirement far below the classical truncated SVD.

■ MB16

16- Sterlings 1

Provably Strong Formulations

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Ricardo Fukasawa, Associate Professor, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, rfukasawa@uwaterloo.ca

1 - Theta Body Relaxations are as Strong as Symmetric SDP Relaxations for Matching

Aurko Roy, Georgia Tech University, aurko@gatech.edu

Yannakakis showed that the matching polytope does not have a small symmetric linear extended formulation. It is natural to ask whether the matching polytope can be expressed compactly in a framework such as semidefinite programming (SDP) that is more powerful than linear programming but still allows efficient optimization. We show that the existence of a small symmetric SDP formulation that approximates the matching polytope implies the existence of a small theta body relaxation that achieves the same approximation. Consequently, to lower bound the symmetric SDP rank of the matching polytope for some approximation factor it suffices to lower bound the theta rank.

2 - On Splitting Clutters

Ricardo Fukasawa, Associate Professor, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, rfukasawa@uwaterloo.ca, Ahmad Abdi, Laura Sanita

For some covering-type problems on graphs, having an integer programming formulation based on directed arcs is preferable to an undirected one, due to the fact that the former is integral, while the latter is not. This motivates us to study what are the intrinsic properties of such operations and how they can be generalized and applied to other contexts. We call such operations splitting over clutters and show how this relates to aspects like integrality, TDI-ness and the packing property.

3 - Lehman's Theorem and the Set Covering Polyhedron

Ahmad Abdi, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, a3abdi@uwaterloo.ca

In 1965, Alfred Lehman proved that any fractional set covering polyhedron has a highly regular substructure. His result was used by Bertrand Guenin in 1998 to characterize weakly bipartite graphs, thereby settling the graphic case of Paul Seymour's 1977 f-flowing conjecture. In this talk, I will talk about other applications of Lehman's powerful theorem; they include the general case of the f-flowing conjecture, as well as the directed Steiner tree polyhedron. Some parts of the talk are based on joint work with A. Feldmann, B. Guenin, J. Könemann and L. Sanità.

■ MB17

17- Sterlings 2

Exploiting Structure in Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Serge Gratton, Prof. Dr., CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, France, serge.gratton@enseeiht.fr

1 - BFO: A Trainable Derivative-Free for Mixed-Integer Nonlinear Bound-Constrained Optimization

Philippe Toint, Prof. Dr., University of Namur, 61 rue de Bruxelles, Namur, 5000, Belgium, philippe.toint@unamur.be, Margherita Porcelli

A direct-search derivative-free Matlab optimizer for bound-constrained problems is described in the talk, whose remarkable features are its ability to handle a mix of continuous and discrete variables, a versatile interface as well as a novel self-training option. Its performance is compared with that of NOMAD, a state-of-the art package. It is also applicable to multilevel equilibrium- or constrained-type problems. Its easy-to-use interface provides a number of user-oriented features, such as checkpointing and restart, variable scaling and early termination tools.

2 - Action Constrained Quasi-Newton Methods

Robert Gower, PhD Candidate, University of Edinburgh, 2/3 Eden Terrace, Edinburgh, EH10 4SB, United Kingdom, R.M.Gower@sms.ed.ac.uk, Jacek Gondzio

At the heart of Newton based methods is a sequence of symmetric linear systems. Each consecutive system in this sequence is similar to the next, so solving them separately is a waste of computational effort. Here we describe automatic preconditioning techniques for iterative methods for solving such sequences of systems by maintaining an estimate of the inverse system matrix. We update this estimate with quasi-Newton type formulas based on a general action constraint instead of the secant equation. Tests on convex problems reveal that our method is very efficient, converging in wall clock time well before a Newton-CG method without preconditioning. The flexibility of the action constraint allows for other applications.

3 - A Subspace Decomposition Framework for Nonlinear Optimization

Zaikun Zhang, Dr., CERFACS-IRIT Joint Lab, CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, 31057, France, zaikun.zhang@irit.fr, Serge Gratton, Luis Nunes Vicente

We present a parallel subspace decomposition framework for nonlinear optimization, which can be regarded as an extension of the domain decomposition method for PDEs. A feature of the framework is that it incorporates the restricted additive Schwarz methodology into the synchronization phase of the algorithm. We establish the global convergence and worst case iteration complexity of the framework, and illustrate how this framework can be applied to design parallel algorithms for optimization problems with or without derivatives.

■ MB18

18- Sterlings 3

On Cross Scenario Node Constraints for Risk Management in Stochastic Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Laureano F. Escudero, Profesor (retired), Universidad Rey Juan Carlos, Tulipan st, Mostoles (Madrid), SP, 28933, Spain, laureano.escudero@urjc.es

1 - Cluster Lagrangean Decomposition for Large-Scale Multi-Stage Mixed 0-1 Stochastic Problems

Maria Araceli Garin, Profesor, Universidad del Pais Vasco, Lehendakari Aguirre 83, Bilbao, 48015, Spain, mariaaraceli.garin@ehu.es, Laureano F. Escudero, Celeste Pizarro, Aitziber Unzueta

We present a methodology for obtaining strong bounds on risk neutral and risk averse (with first- and second-order time stochastic dominance constraints) multistage stochastic problems. The whole problem is represented by a mixture of the splitting and the compact representation. The dualization of the nonanticipativity constraints of some variables in the risk neutral version and the additional dualization of the cross scenario group constraints in the risk averse model, allows to decompose each of them into a set of independent cluster submodels. Four schemes for the Lagrangean multipliers updating are compared and computational results are presented.

2 - On Parallel BFC Based Matheuristics for Solving SMIP under Time Stochastic Dominance Constraints

Unai Aldasoro, Post-doc, Universidad del Pais Vasco, Fac. de Ciencias y Tecnologia, c/o Prof. Gloria Perez, Leioa, Vi, 48940, Spain, unai.aldasoro@ehu.es, Laureano F. Escudero, Maria Araceli Garin, Maria Merino, Gloria Perez

The Time Stochastic Dominance (TSD) risk averse strategy is considered for large stochastic multistage mixed 0-1 problems. Three parallel computing matheuristics as spin-offs of the TSD Branch-and-Fix Coordination methodology are presented . A computational experience is reported for assessing the quality of the heuristic solution by considering the TSD and Risk Neutral strategies. Parallel computing provides a perspective for solving large-scale instances by using a simultaneous coordinated branching scheme on the 0-1 variables and an iterative incumbent solution exchange to obtain tighter bounds of the original problem.

3 - A Time Stochastic Dominance Functional for Risk Management in Multistage Stochastic Optimization

Laureano F. Escudero, Profesor (retired), Universidad Rey Juan Carlos, Tulipan st, Mostoles (Madrid), SP, 28933, Spain, laureano.escudero@urjc.es, Maria Araceli Garin, Maria Merino, Gloria Perez

We extend to the multistage case two recent risk averse measures for two-stage stochastic programs based on first- and second-order stochastic dominance constraints induced by mixed-integer-linear recourse. An extension of our Branch-and-Fix Coordination algorithm, so named BFC-TSD, is presented where a special treatment is given to the cross node constraints for modeler-chosen stages. A broad computational experience is presented by comparing the risk neutral approach and the risk averse functional. The performance of the new version of the BFC algorithm versus the plain use of a state-of-the-art MIP solver is also reported.

■ MB19

19- Ft. Pitt

Challenges in PDE-Constrained Optimization

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Michael Ulbrich,, Professor, TU Muenchen, Dept. of Mathematics, Boltzmannstr. 3, Garching, 85747, Germany, mulbrich@ma.tum.de

1 - An Optimal Control Problem from Implant Shape Design

Anton Schiela, Professor, Universitaat Bayreuth, Universitaat Bayreuth, Bayreuth, 95440, Germany, anton.schiela@uni-bayreuth.de, Lars Lubkoll, Martin Weiser

We discuss a design problem for a facial bone implant that can be described as an optimal control problem. The main difficulty is the modelling of the facial soft tissue as a nonlinear elastic material. The resulting optimization problem in function space is tackled by an affine covariant composite step method. In the talk we develop the main algorithmic ideas of this method and show numerical examples from applications.

2 - Robust Optimization of a Permanent Magnet Synchronous Motor Geometry

Oliver Lass, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, lass@mathematik.tu-darmstadt.de, Stefan Ulbrich

The goal is to optimize the volume and position of permanent magnet material in the rotor of a synchronous machine while maintaining a given performance level. Due to manufacturing, there are uncertainties in material and production precision. A robust optimization problem is formulated that accounts for a selected set of uncertainties. We present approximation techniques of first and second order for the robust counterpart of general uncertain nonlinear programs governed by partial differential equations. Numerical results are presented for validation.

3 - Optimization of Nonlinear Hyperbolic Conservation Laws with Switching Controls

Stefan Ulbrich, Professor, TU Darmstadt, Dolivostr. 15, Darmstadt, Germany, ulbrich@mathematik.tu-darmstadt.de, Sebastian Pfaff

We consider optimization problems for nonlinear conservation laws in 1D. The time-dependent control acts at the boundary and switches between different C^1-functions or acts as an on/off-switch in the interior. This allows to model switched controls in networks of conservation laws describing, e.g., traffic- or fluid flow with switching (traffic lights, valves, etc.). Although the solution develops discontinuities, we show for scalar problems that typical objective functions are differentiable w.r.t. the switching times and derive an adjoint-based gradient formula. Hence, derivative based optimization methods can be applied efficiently to optimize the switching times.

■ MB20

20- Smithfield

Algorithms for Convex Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Javier Pena,, Professor of Operations Research, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jfp@andrew.cmu.edu

1 - Variants of the von Neumann Algorithm

Negar Soheili, Assistant Professor, University of Illinois at Chicago, 601 S Morgan Street, University Hall 2416, Chicago, IL, 60607, United States of America, nazad@uic.edu, Daniel Rodriguez, Javier Pena

The von Neumann algorithm is a simple greedy algorithm to determine whether the origin belongs to a polytope generated by a finite set of points. The algorithm's rate of convergence depends on the radius of the largest ball around the origin contained in the polytope. We propose some variants of the von Neumann algorithm that retain the algorithm's simplicity while achieving faster convergence rate.

2 - On the Frank-Wolfe Algorithm with Away Steps

Daniel Rodriguez, PhD Candidate, Mathematics, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, drod@cmu.edu, Javier Pena, Negar Soheili

The Frank-Wolfe Algorithm for minimizing a convex function over a polytope has attractive properties due to its simplicity and low computational cost. We show that for some convex functions a variant of the Frank-Wolfe Algorithm, which performs "away steps" at certain iterations, generates a sequence of points whose objective values converge linearly to the minimum. We provide some insightful connections between the algorithm's rate of convergence and the geometry of the problem.

3 - Iterative Shrinkage Tresholding Algorithm with Second Order Information

Hiva Ghanbari, PhD Student, Lehigh University, Harold S. Mohler Laboratory,, 200 W. Packer Ave., Bethlehem, PA, 18015, United States of America, hig213@lehigh.edu

We focus on the effect of using second order information through the Limited memory BFGS method, on the accelerated version of Iterative Shrinkage Tresholding Algorithm. Specifically, we apply this modified method on the composite optimization problems as the sum of a smooth convex function and a non-smooth convex function using proximal-gradient method. We present the analysis reflecting the use of second order information and supporting numerical result.

■ MB21

21-Birmingham

Integer Flows, Distance Queries, and Disjoint Paths in Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Álvaro Junio Pereira Franco, Federal University of Santa Catarina, Rod. Gov. Jorge Lacerda, 3201, Araranguà, SC, 88906-072, Brazil, alvaro.junio@ufsc.br

1 - Nowhere-zero Flows: The 'Minas Gerais' of Graph Theory

Cándida Nunes da Silva, DComp - CCGT - Universidade Federal de São Carlos, Rodovia Joào Leme dos Santos, km 110, Sorocaba, SP, 18052-780, Brazil, candida@ufscar.br

In 1954, William T. Tutte introduced the concept of (nowhere-zero) k-flows as a means to generalize the concept of a face k-colouring to non-planar graphs. Tutte also proposed three celebrated conjectures regarding k-flows, which remain open. There is a surprisingly high concentration of simple and elegant theorems in this subject, many of which should probably be in the "Book of God" described by Paul Erdos. Such fact inspired Daniel H. Younger to call this topic the 'Minas Gerais' of Graph Theory; an allusion to a Brazilian region that had an amazingly high concentration of gold and diamond and was intensely exploited by the Portuguese in the past. A selection of precious theorems regarding k-flows will be presented.

2 - Robust Exact Distance Queries on Massive Networks

Renato Werneck, San Francisco, CA, United States of America, rwerneck@acm.org, Thomas Pajor, Daniel Delling, Andrew Goldberg

We present a versatile and scalable algorithm for computing exact distances on real-world networks with tens of millions of arcs in real time. Unlike existing approaches, preprocessing and queries are practical on a wide variety of inputs, such as social, communication, sensor, and road networks. We achieve this by providing a unified approach based on the concept of 2-hop labels, improving upon existing methods. In particular, we introduce a fast sampling-based algorithm to order vertices by importance, as well as effective compression techniques. This work was done at Microsoft Research Silicon Valley.

3 - From a Min-Max Relation to an Algorithm to Construct the Dominator Tree of a Reducible Flowgraph

Álvaro Junio Pereira Franco, Federal University of Santa Catarina, Rod. Gov. Jorge Lacerda, 3201, Ararangua, SC, 88906-072, Brazil, alvaro.junio@ufsc.br, Carlos Eduardo Ferreira

We observed the following min-max relation in flowgraphs: given a flowgraph G, the minimum size of a dominator cover of G is equal to the maximum size of a junction partition of G. From this min-max relation we derived an output-sensitive algorithm to construct the dominator tree of a given reducible flowgraph.

■ MB22

22- Heinz

Algorithms for Non-Convex Problems and Applications

Cluster: Global Optimization

Invited Session

Chair: Miguel Anjos,, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, Succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca

1 - A Projected-Gradient Newton Type Algorithm for Solving Feasibility Problems with Complementarity

Tiara Martini, Department of Applied Mathematics, State University of Campinas, Rua Sérgio Buarque de Holanda, 651, Campinas, SP, 13083-859, Brazil, tiaramartini@gmail.com, Joaquim Judice, Roberto Andreani, José Mario Martínez

A Projected-Gradient Underdetermined Newton type (PGUN) algorithm is introduced for finding a solution of Rectangular Nonlinear Complementarity Problem (RNCP) corresponding to a feasible solution of a Mathematical Programming Problem with Complementarity Constraints (MPCC). The method employs a combination of Newton and Projected-Gradient directions and a line-search procedure that guarantees global convergence to a solution of RNCP or at least a stationary point of the merit function associated. PGUN can also be applied to the computation of a feasible solution of MPCC with a target objective function value. Computational experience is reported illustrating the efficiency of the algorithm to find feasible solutions of MPCC in practice.

2 - Global Solution of General Quadratic Programs

Amélie Lambert, CEDRIC-Cnam, 292 rue Saint Martin, Paris, 75003, France, amelie.lambert@cnam.fr, Sourour Elloumi

Let P be MIQCP that consists of minimizing a quadratic function subject to quadratic constraints. The variables can be integer or continuous. Our approach is first to consider P' that is equivalent to P. Problem P' has additional variables that are meant to be equal to the product of pairs of initial variables. When this equality is relaxed, the obtained problem from P' is quadratic and convex. Consequently, problem P' can be solved by a B&B, based on this relaxation. Moreover, our equivalent problem P' is built from the solution of a semidefinite programming relaxation of (P) and captures its strength. Computational experiences show that our general method is competitive with standard solvers, on many instances.

3 - An Improved Two-Stage Optimization-Based Framework for Unequal-Areas Facility Layout

Miguel Anjos, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca, Manuel V.C. Vieira

The facility layout problem seeks the optimal arrangement of non-overlapping departments with unequal areas within a facility. We present an improved framework combining two mathematical optimization models. The first model is a nonlinear approximation that establishes the relative position of the departments, and the second model is an exact convex optimization formulation of the problem that determines the final layout. Aspect ratio constraints are taken into account by both models. Our preliminary results show that the proposed framework is computationally efficient and consistently produces competitive, and often improved, layouts for instances from the literature as well as for new large-scale instances with up to 100 departments.

■ MB23

23- Allegheny

Robust and Adaptive Optimization

Cluster: Robust Optimization

Invited Session

Chair: Vineet Goyal, Columbia University, 500W 120th St, New York, NY, United States of America, vgoyal@ieor.columbia.edu

1 - Optimal and Near Optimal Data-Driven Ambiguity Sets

Vishal Gupta, Assistant Professor, USC Marshall School of Business, 3670 Trousdale Parkway, Bridge Hall 401 G, Los Angeles, CA, 90089-0809, United States of America, guptavis@marshall.usc.edu

We present a novel technique for constructing ambiguity sets for data-driven distributionally robust optimization. Like existing proposals, our sets are tractable, asymptotically consistent, and enjoy a finite sample performance guarantee. By combining Bayesian techniques and convex analysis, we prove that these new sets are the smallest possible ambiguity sets satisfying these properties. In this sense, they are optimal. For some special cases, we theoretically characterize the relative size of our new set to existing proposals, demonstrating a full order of magnitude improvement. Numerical experiments confirm the effectiveness of these sets over existing proposals in applications.

2 - From Predictive to Prescriptive Analytics

Nathan Kallus, Massachusetts Institute of Technology, 77 Massachusetts Ave E40-149, Cambridge, MA, 02139, United States of America, kallus@mit.edu, Dimitris Bertsimas

Combining ideas from machine learning and operations research, we develop a framework and solutions for data-driven optimization given historical data and, in a departure from other work, an observation of auxiliary quantities associated with the key uncertain variable. We show that our method is generally applicable to many problems, tractable, and asymptotically optimal even if data is not iid. To demonstrate the power of our approach in a real-world setting, we study an inventory management problem faced by the distribution arm of an international media conglomerate. We leverage both internal company data and public online data harvested from IMDb, Rotten Tomatoes, and Google to prescribe operational decisions that outperform benchmarks.

3 - On the Adaptivity Gap in Dynamic Robust Optimization

Vineet Goyal, Columbia University, 500W 120th St, New York, NY, United States of America, vgoyal@ieor.columbia.edu, Dimitris Bertsimas, Brian Lu

In this talk, I will present recent progress on the performance of static robust solutions for dynamic robust linear programs under constraint-coefficient uncertainty. We show that static solution is near-optimal for dynamic robust linear optimization problems under under fairly general conditions. In particular, we relate the performance of the static solutions to a measure of non-convexity of a transformation of the uncertainty set. We also consider the class of column-wise and constraint-wise uncertainty sets that arise naturally in many applications and provide a stronger bound on the adaptivity gap.

■ MB24

24- Benedum

Semidefinite and Copositive Approaches for Robustness

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Sam Burer, Professor, University of Iowa, S346 Pappajohn Business Building, Iowa City, IA, 52246, United States of America, samuel-burer@uiowa.edu

1 - Robust Sensitivity Analysis in the Optimal Value of Linear Programming

Guanglin Xu, PhD Student, Department of Management Sciences, The University of Iowa, S221 Pappajohn Business Building, Iowa City, IA, 52246, United States of America, guanglin-xu@uiowa.edu, Sam Burer

We study sensitivity analysis of the optimal value of linear programming under general perturbations of the objective coefficients and right-hand sides. This leads to non-convex quadratic programs (QPs), which are difficult to solve in general. We then propose copositive relaxations of these QPs that, while exact in some cases, are still computationally intractable. Finally, we derive corresponding tractable relaxations and present preliminary computational results to demonstrate their quality.

2 - Sparse but Efficient Operation: A Conic Programming Approach

Chung Piaw Teo, Prof, National University of Singapore, 1 Business Link, Singapore, Singapore, bizteocp@nus.edu.sg, Yini Gao, Zhenzhen Yan

Motivated by a workforce deployment problem in Changi International Airport (Singapore), we develop a conic programming approach to design efficient allocation/deployment solution that exploits a sparse substructure to respond to changes and deviations in the operational environment. In the case of process flexibility problem, our method can recover the k-chain structures that are known to be extremely efficient for this type of problem.

3 - Distributionally Robust Project Crashing with Moments

Karthik Natarajan, Associate Professor, Singapore University of Technology and Design, 8 Somapah Rd, Singapore, 487372, Singapore, natarajan_karthik@sutd.edu.sg, Selin Damla Ahipasãoglu, Dongjian Shi

Project crashing is a method for shortening the project duration by reducing the time of one or more activities in a project network to less than its normal activity time with additional cost. In reality activity durations are often uncertain. We propose a distributionally robust project crashing problem to minimize the worst-case expected project duration with a given budget for cost where the distributions of the activity durations are only partly specified with moments. We develop a formulation for the distributionally robust project crashing problem as a saddle point problem. Instead of solving a semidefinite program or a completely positive program, we develop a simpler algorithm to optimally crash the projects.

■ MB25

25- Board Room

Constraint-Based Scheduling I

Cluster: Constraint Programming

Invited Session

Chair: Philippe Laborie, IBM, 9, rue de Verdun, Gentilly, 94253, France, phi.laborie@free.fr

1 - Constraint-Based Search Methods for Dynamic Pickup and Delivery Problems

Stephen Smith, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, sfs@cs.cmu.edu, Zachary Rubinstein, Laura Barbulescu

We focus on constraint-based search techniques for maintaining an optimized pickup and delivery schedule as new requests are received and other disruptive events occur over time. In this context, the current schedule provides a reference point for the set of executing agents and there is pragmatic value to maintaining stability when possible. We describe a controlled, iterative search framework for revising the current schedule in response to such dynamic events. The efficacy of the approach is demonstrated on both benchmark problems and real problem data from a paratransit scheduling application.

2 - Constraint-Based Scheduling by Learning

Andreas Schutt, Researcher, NICTA and University of Melbourne, 115 Batman Street, Melbourne, Australia, Andreas.Schutt@nicta.com.au, Thibaut Feydy, Peter Stuckey

Constraint-based scheduling is one of the success stories in constraint programming (CP). Recent advanced CP solvers additionally include sophisticated conflict learning technologies. Experiments on different kind of scheduling problems, such as resource-constrained project scheduling with generalised precedence relations and flexible jobshop scheduling show that CP solvers incorporating conflict learning technologies outperform traditional CP solvers and state-of-the-art methods on some hard combinatorial problems. This talk gives an overview of such a technology developed at NICTA, Australia, and presents recent results on a few different common scheduling problems.

3 - Failure-directed Search for Constraint-based Scheduling

Petr Vilim, IBM Czech Republic, V Parku 2294/4, Prague, Czech Republic, petr_vilim@cz.ibm.com

Failure-directed search is a new constraint programming search algorithm that performs very well for number of scheduling problems (job shop, RCPSP, ..). It focuses on a systematic exploration of the search space, first eliminating assignments that are most likely to fail. Automatic search in IBM CP Optimizer (part of CPLEX Optimization Studio) is using failure-directed search as a “plan B” strategy once a less systematic Large Neighborhood Search is not improving any more.

■ MB26

26- Forbes Room

Optimal Portfolio Modeling

Cluster: Finance and Economics

Invited Session

Chair: John Birge, University of Chicago, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States of America, jbirge@chicagobooth.edu

1 - Using Simulation to Assess the Long-Term Effects of Bank Policies and Regulation

Pedro Judice, ISCTE, Rua da Madalena,113, 2 esq, Lisbon, 1100-319, Portugal, pedro_judice@yahoo.com, John Birge

Using long-term commercial bank scenario generation, we develop new balance sheet equations using the concept of target leverage and funding ratios, and define new risk and return metrics. We use the framework of these equations to quantify the benefits of low leverage, stable funding, low operating costs and activity in high interest rate environments. Our results show that the current Basel III regulation does not significantly reduce bank failure, as it gives an incentive to wholesale funding with more than a year’s maturity and the non-risk based leverage ratio limit is low. A better option for banks is to keep core deposits high and have the non-risk based leverage ratio much higher than the 3% limit imposed by the Basel Committee.

2 - Performance Analysis with Respect to an Unobserved Benchmark

Luis Chavez-Bedoya, Universidad Esan, Alonso de Molina 1652, Surco, Lima, Lima 33, Peru, lchavezbedoya@esan.edu.pe

In the framework of active portfolio management, we proposed a methodology to analyze the relative performance of a set of active managers when the benchmark is either not observed or it cannot be precisely determined by the agent performing the analysis. The methodology assesses performance with respect to an equally-weighted portfolio based on the funds under evaluation. Moreover, the fund’s betas relative to the aforementioned portfolio carry important information about relative performance in terms of information ratio. Finally, the methodology is suitable to assess performance of regulated defined-contribution pension funds.

3 - Linear Programming Approach to American Option Pricing

Zhen Liu, Options Clearing Corporation, 1547 7 Pines Road, D2, Schaumburg, IL, 60193, United States of America, zhenliu@alum.northwestern.edu

We solve the variational inequality (VI) from American option pricing problem by linear programming (LP) approach. We approximate its solution by a combination of basis functions. The objective is to minimize the absolute error of the solution and the max operator in VI is converted into linear constraints of LP. We discuss its convergence, and compare our results with Longstaff-Schwartz least-square approach and numerical partial differential equation (PDE) approach.

■ MB27

27- Duquesne Room

Sparse Optimization and Compressed Sensing

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Hongcheng Liu, Student, The Pennsylvania State University, Dept. of Industrial and Manufacturing En, Pennsylvania State University, State College, PA, 16802, United States of America, hql5143@psu.edu

1 - Compressed Sensing of Data with Known Distribution

Mateo Dìaz Dìaz, Universidad de los Andes, Cra 1 N∫ 18A- 12 Dep. de Matematicas, Bogota, Colombia, m.diaz565@uniandes.edu.co, Mauricio Junca, Felipe Rincòn, Mauricio Velasco

Compressive sensing is a technique with many important applications. For all these applications the most important parameter is the number of measurements required for perfect recovery. In this work we are able to drastically reduce the number of required measurements by incorporating information about the distribution of the data we wish to recover. Our algorithm works by minimizing an appropriately weighted l1 norm and our main contribution is the determination of good weights.

2 - Models and Architectures for Video Compressive Sensing

Aswin Sankaranarayanan, Assistant Professor, Carnegie Mellon University, ECE Dept, 5000 Forbes ave, Pittsburgh, PA, 15213, United States of America, saswin@andrew.cmu.edu

In this talk, I will outline an emerging method for sensing videos that (a) exploits redundancies in real-world videos, to (b) sense with far-fewer measurements as compared to a traditional sensor. I will present how state of the art models in video compression, which rely on motion-flow, can be used for compressive sensing. Specifically, I will discuss the design of scalable video compressive systems where the co-design of optics, in terms of novel imaging architectures, and algorithms, in terms of novel measurement matrices and video models, enable sensing at high spatial and temporal resolutions.

3 - Folded Concave Penalized Sparse Linear Regression: Complexity, Sparsity and Statistical Guarantee

Hongcheng Liu, Student, The Pennsylvania State University, Dept. of Industrial and Manufacturing En, Pennsylvania State University, State College, PA, 16802, United States of America, hql5143@psu.edu, Tao Yao, Runze Li, Yinyu Ye

This paper concerns the folded concave penalized sparse linear regression (FCPSLR) problem, which is an alternative sparse recovery method than the Lasso. A preferable property of FCPSLR is its exact recovery of the oracle solution per Zhang and Zhang (2012) when it is minimized globally. In this present paper, we first show that solving FCPSLR globally is NP-complete. Then, we provide a spectrum of conditions for any local solution to be a sparse estimator. More importantly, we show that for the regression problems with random design matrices, the recovery of the oracle solution is an immediate result of FCPSLR’s innate properties at a local solution satisfying a second order necessary condition, independent of the solution algorithms.

■ MB28

28- Liberty Room

Advances in Integer Programming I

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - A Heuristic Approach for Sequential Dependent Set-Up Timed Multi-Stage Hybrid Flow Shop Scheduling Problem

Müjgan Sagir, Professor, ESOGU, Engineering Faculty, Meselik, Eskisehir, 26480, Turkey, mujgan.sagir@gmail.com, Hacer Defne Okul

The scheduling of flow shops with multiple parallel machines per stage, referred to as the hybrid flow shop (HFS). This paper proposes a systematic approach to solve k-stage HFS scheduling problem for the objective of minimizing the makespan. The problem is to determine the allocation of jobs to the paralel machines as well as the sequence of the jobs assigned to each machine. A real life case is provided to compare current and proposed schedules.

2 - A Matheuristic for the Curriculum-Based Course Timetabling

Michael Lindahl, Technical University of Denmark, Produktionstorvet, Bygning 426, Lyngby, 2800, Denmark, miclin@dtu.dk, Matias Sörensen, Thomas Stidsen

The Curriculum-based University timetabling is a complex scheduling problem. In practice short running times are important and standard MIP solvers have difficulties finding high quality solution within these short running times. We propose a matheuristic that uses a decomposed two stage model of the problem. The algorithm creates smaller neighbourhoods by fixing and releasing connected variable and are this way able to obtain high quality solutions within short running times.

3 - A New Model to Advance Accuracy and Solution Speed in Road Design

Vahid Beiranvand, University of British Columbia, ASC 306, 3333 University Way, Kelowna, V1V 1V7, Canada, vahid.beiranvand@ubc.ca, Warren Hare, Shahadat Hossain, Yves Lucet

The vertical alignment optimization problem for road design aims to generate a vertical alignment of a new road with a minimum cost, while satisfying safety and design constraints. In this paper, we present a new model called multi-haul quasi network flow for vertical alignment optimization that improves the accuracy and reliability of a previous mixed integer linear programming model. We evaluate the performance of the new model compared to two current state-of-the-art models in the field. Numerical results will be discussed. Work on this project has been done in collaboration with our industry partner, Softree Technical Systems Inc.

■ MB29

29- Commonwealth 1

Coordinate Descent Methods for Sparse Optimization Problems I

Cluster: Nonsmooth Optimization

Invited Session

Chair: Xin Liu, Associate Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, ICMSEC510, 55, Zhong Guan Cun East Road, Beijing, China, liuxin@lsec.cc.ac.cn

1 - A Greedy Coordinate Descent Algorithm for Cardinality Constrained Convex Smooth Optimization

Ji Liu, University of Rochester, University of Rochester, Rochester, NY, 14627, United States of America, ji.liu.uwisc@gmail.com

We propose a forward-backward greedy coordinate descent algorithm for solving cardinality constrained convex smooth optimization, which is NP hard in general. We provide an upper bound of the difference between the true solution and the solution given by the proposed greedy method. This upper bound implies a sufficient condition to exactly solve the NP hard optimization. This sufficient condition is weaker (better) than the conditions required by many convex relaxation methods, for example, LASSO.

2 - First-Order Algorithms for Block Optimization: An Iteration Complexity Analysis

Shuzhong Zhang, Professor, University of Minnesota, Department of Industrial and Systems Eng, Minneapolis, MN, 55455, United States of America, zhangs@umn.edu

In this talk we shall discuss block optimization models arising from tensor projection problems and machine learning. Such models include non-separable but convex optimization and separable but non-convex optimization. We present a suite of first-order solution algorithms for solving such problems, which can be broadly described as variants of the proximal gradient and/or ADMM type methods. An iteration complexity analysis of the proposed algorithms for the afore-mentioned convex or non-convex optimization models will be presented.

3 - Magnetic Susceptibility Inversion with Full Tensor Gradient Data using the Sparse Regularization

Yanfei Wang, Institute of Geology and Geophysics, Chinese Academy of Sciences, No.19 Beitucheng Xilu, Chaoyang District, Beijing, China, yfwang@mail.iggcas.ac.cn

Retrieval of magnetization parameters using magnetic tensor gradient measurements receives attention in recent years. Little regularizing inversion results using gradient tensor modeling so far has been reported in the literature. Traditional magnetic inversion is based on the total magnetic intensity (TMI) data and solving the corresponding mathematical physical model. In this paper, we study invert the magnetic susceptibility using the full tensor gradient magnetic data. A sparse Tikhonov regularization model is established. In solving the minimization model, an alternating directions method is addressed. Numerical experiments are performed to show feasibility of our algorithm.

■ MB30

30- Commonwealth 2

Approximation and Online Algorithms I

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Lisa Zhang, Bell Labs Alcatel-Lucent, 600 Mountain Ave, 2A-442, Murray Hill, NJ, 07974, United States of America, ylz@research.bell-labs.com

1 - New Approximation Schemes for Unsplittable Flow on a Path

Tobias Mömke, Saarland University, Postfach 42 (Blaser), 66123 Saarbrücken, Saarbrücken, Germany, moemke@cs.uni-saarland.de, Jatin Batra, Amit Kumar, Andreas Wiese, Naveen Garg

We study the unsplittable flow on a path problem. We make progress towards finding a PTAS for this important problem. When the task densities - defined as the ratio of a task's profit and demand - lie in a constant range, we obtain a PTAS. We also improve the QPTAS of Bansal et al. by removing the assumption that the demands need to lie in a quasi-polynomial range. Our third result is a PTAS for the case where we are allowed to shorten the paths of the tasks by at most an epsilon-fraction. This is particularly motivated by bandwidth allocation and scheduling applications of our problem if we are allowed to slightly increase the speed of the underlying transmission link/machine.

2 - Analysis of K-Anonymity Algorithms for Streaming Location Data

Lisa Zhang, Bell Labs Alcatel-Lucent, 600 Mountain Ave, 2A-442, Murray Hill, NJ, 07974, United States of America, ylz@research.bell-labs.com, Matthew Andrews, Gordon Wilfong

We analyze algorithms to achieve k-anonymity for streaming location data, where anonymity is achieved by recording coarse common regions each of which contains at least k points. Our goal is to minimize the recorded region size so that the anonymized location is as accurate as possible. Under the adversarial model, any online algorithm can have an arbitrarily bad competitive ratio. Assuming a uniform distribution of locations, we show a simple algorithm that achieves k-anonymity and has almost matching upper and lower bounds on region size. Finally, for nonuniform distributions, we discuss heuristics that partition the space to match the given distribution before applying the algorithm for uniform distributions.

Monday, 1:10pm - 2:40pm

■ MC01

01- Grand 1

First Order Primal/Dual Methods

Cluster: Nonsmooth Optimization

Invited Session

Chair: Martin Takac, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, United States of America, martin.taki@gmail.com

Co-Chair: Martin Jaggi, Universitaetsstr 6, Zürich, 8092, Switzerland, jaggi@inf.ethz.ch

1 - Convex Interpolation and Performance Estimation of First-Order Methods

Francois Glineur, Université Catholique de Louvain, CORE, Voie du Roman Pays, 34 bte L1.03.0, Louvain-la-Neuve, B-1348, Belgium, francois.glineur@uclouvain.be, Adrien Taylor, Julien Hendrickx

The worst-case performance of a black-box first-order method can be obtained as the solution of an optimization problem over sets of (smooth) (strongly) convex functions. We develop closed-form necessary and sufficient conditions for (smooth) (strongly) convex interpolation, which provide a finite representation for those functions and allows us to reformulate the worst-case performance estimation problem as an equivalent finite dimension-independent semidefinite optimization problem. We describe several applications of this approach related to both its convex interpolation and performance estimation aspects.

2 - A Flexible ADMM Algorithm for Big Data Applications

Rachael E. H. Tappenden, Postdoctorate, John Hopkins University, Whitehead Hall, 3400 N Charles St, Baltimore, MD, 21218, United States of America, rachael.e.h.tappenden@gmail.com, Daniel P. Robinson

In this talk we present a flexible Alternating Direction Method of Multipliers (F-ADMM) algorithm for solving optimization problems involving a strongly convex objective function that is separable into n blocks, subject to linear equality constraints. The F-ADMM algorithm updates the blocks of variables in a Gauss-Seidel fashion, and the subproblems within F-ADMM include a regularization term. The algorithm is globally convergent. We also introduce a hybrid variant called H-ADMM that is partially parallelizable, which is important in a big data setting. Convergence of H-ADMM follows directly from the convergence properties of F-ADMM. We present numerical experiments to demonstrate the practical performance of this algorithm.

3 - Complexity Bounds for Primal-Dual Methods Minimizing the Model of Objective Function

Yurii Nesterov, CORE, Voie du Roman Pays 34, Louvain-la-Neuve, Belgium, yurii.nesterov@uclouvain.be

We provide Frank-Wolfe (Conditional Gradients) method with a convergence analysis allowing to approach a primal-dual solution of convex optimization problem with composite objective function. Additional properties of complementary part of the objective (strong convexity) significantly accelerate the scheme. We also justify a new variant of this method, which can be seen as a trust-region scheme applying the linear model of objective function. Our analysis works also for a quadratic model, allowing to justify the global rate of convergence for a new second-order method. To the best of our knowledge, this is the first trust-region scheme supported by the worst-case complexity bound.

■ MC02

02- Grand 2

Power Systems: Operations and Planning

Cluster: Optimization in Energy Systems

Invited Session

Chair: Jean-Paul Watson, Distinguished Member of Technical Staff, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States of America, jwatson@sandia.gov

1 - A Scalable Solution Framework for Stochastic Transmission and Generation Planning Problems

Francisco Munoz, Postdoctoral Appointee, Sandia National Laboratories, 1700 Indian Plaza Dr NE Apt 5, Albuquerque, NM, 87106, United States of America, fdmunoz@sandia.gov, Jean-Paul Watson

Current commercial software tools for transmission and generation investment planning have limited stochastic modeling capabilities. We propose a scalable decomposition algorithm to solve stochastic transmission and generation planning problems. Given stochasticity restricted to loads and wind, solar, and hydro power output, we develop a simple scenario reduction framework based on a clustering algorithm, to yield a more tractable model. The resulting stochastic optimization model is decomposed on a scenario basis and solved using a variant of the Progressive Hedging (PH) algorithm. The results indicate that large-scale problems (e.g., WECC 240-bus system) can be solved to a high degree of accuracy in at most 2 h of wall clock time.

2 - Impact of ACOPF Constraints on Security-Constrained Unit Commitment

Anya Castillo, Researcher, JHU/FERC, 5712 Yellowrose Court, Columbia, MD, 21045, United States of America, anya.castillo@gmail.com, Jean-Paul Watson, Cesar Silva-Monroy, Carl Laird

Because operational constraints on thermal units require these resources to be committed in advance of when they are needed, system operators solve a unit commitment optimization problem in the day-ahead. At times, certain out-of-merit units need to be committed for reliability reasons. Typically such units are committed in a reliability run and subsequently would receive make-whole payments so that market participants are not forced to operate at a loss. Ideally the more operational constraints and physical limitations (which would affect real-time dispatch) included in the day-ahead unit commitment optimization problem, the better convergence between day-ahead and real-time pricing. We propose a SCUC+ACOPF approach in this work.

3 - Scalable Lower and Upper Bounding Techniques for Stochastic Unit Commitment

Jean-Paul Watson, Distinguished Member of Technical Staff, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States of America, jwatson@sandia.gov

We describe configurations of a scenario-based decomposition strategy for solving the stochastic unit commitment problem, based on the progressive hedging algorithm. We consider both upper and lower bounding aspects of progressive hedging, and demonstrate parameterizations that yield extremely tight optimality gaps (<0.1%) for 100-generator cases and moderately tight optimality gaps (<1.0%) for 350-generator cases. Using modest scale (cluster) parallelism, we are able to achieve this performance in less than 15 minutes of wall clock time.

■ MC03

03- Grand 3

Approximation Algorithms for Clustering Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Viswanath Nagarajan, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, viswa@umich.edu

1 - Padded Decomposition for Minor-Free Graphs

Anupam Gupta, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, anupamg@cs.cmu.edu

We prove that given a graph G excluding Kr as a minor, and a diameter bound D, G can be partitioned into clusters of diameter at most D while removing at most O(r/D) fraction of the edges. This improves over the results of Fakcharoenphol and Talwar, who building on the work of Klein, Plotkin and Rao gave a partitioning that required to remove O(r^2/D) fraction of the edges.

2 - The Euclidean k-Supplier Problem

Baruch Schieber, IBM Research, TJ Watson Research Center, P.O. Box 218, Yorktown Heights, NY, 10598, United States of America, sbar@us.ibm.com, Viswanath Nagarajan, Hadas Shachnai

In the k-supplier problem, we are given a set of clients and set of facilities located in a metric space along with a bound k. The goal is to open a subset of k facilities so as to minimize the maximum distance of a client to an open facility. We present a 1+sqrt(3)<2.74 approximation algorithm for the k-supplier problem in Euclidean metrics. This improves the known 3-approximation algorithm which also holds for general metrics (where it is known to be tight). It has been shown that it is NP-hard to approximate Euclidean k-supplier to better than a factor of sqrt(7) (approximately 2.65). We also present an O(n log^2 n) time algorithm for Euclidean k-supplier in constant dimensions that achieves an approximation ratio of 2.965.

3 - On Uniform Capacitated k-Median Beyond the Natural LP Relaxation

Shi Li, Toyota Technological Institute at Chicago, 6045 S Kenwood Ave, Chicago, IL, 60637, United States of America, shili@ttic.edu

We study the uniform capacitated k-median problem. Obtaining a constant approximation algorithm for this problem is a notorious open problem. Most previous works are based on the natural LP-relaxation for the problem, which has unbounded integrality gap, even when we are allowed to violate the capacity constraint or the cardinality constraint by a factor of 2-epsilon. We give an exp(O(1/epsilon^2))-approximation algorithm for the problem that violates the cardinality constraint by a factor of 1+\epsilon. This is already beyond the capability of the natural LP relaxation, as it has unbounded integrality gap even if we are allowed to open (2-epsilon)k facilities. Indeed, our result is based on a novel LP for this problem.

■ MC04

04- Grand 4

Geometry, Duality, and Complexity in Convex Optimization II

Cluster: Conic Programming

Invited Session

Chair: Gabor Pataki, University of North Carolina at Chapel Hill, Chapel Hill, NC, Chapel Hill, United States of America, gabor@unc.edu

1 - On the Conditioning and Geometry of Convex Optimization Problems

Javier Pena, Professor of Operations Research, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jfp@andrew.cmu.edu, Daniel Rodriguez, Negar Soheili, Vera Roshchina

The behavior of various algorithms for convex optimization problems can be analyzed in terms of condition measures associated to the geometry of the problem. We provide novel insights into the interplay between problem conditioning, problem geometry, and the speed of convergence of algorithms for convex optimization. We illustrate these insights via recent developments on problem preconditioning and on variants of the Frank-Wolfe, von Neumann, and perceptron algorithms.

2 - Exact Duality and Exact, Short Certificates in Conic Linear Programming

Minghui Liu, UNC Chapel Hill, Department of Statistics, and Operations Research, Chapel Hill, NC, 27599, United States of America, minghuil@live.unc.edu, Gabor Pataki

In conic linear programming, unlike in linear programming, the simplest version of Farkas' lemma may not prove infeasibility. We describe our progress in finding exact duals, and exact short certificates of infeasibility in conic LPs, which are nearly as simple as Farkas' lemma in linear programming. We describe an algorithm to generate infeasible SDPs, and present computational results on our set of test problems using commercial and research codes. The first part of this talk (which can be understood independently) is presented by Gabor Pataki.

3 - Facial Reduction for Cone Optimization

Henry Wolkowicz, Professor, University of Waterloo, Faculty of Mathematics, Waterloo, ON, N2L3G1, Canada, hwolkowi@uwaterloo.ca, Yuen-Lam Voronin, Nathan Krislock, Dmitriy Drusvyatskiy

The Slater constraint qualification (SCQ) is essential for many classes of convex programs. However, SCQ fails for many problems, e.g., for many instances of semidefinite programming (SDP) that arise from relaxations of computationally hard problems. A theoretical tool to regularize these problems uses facial reduction. We consider several specific applications where the structure of the problem surprisingly allows us to exploit this degeneracy. Rather than presenting numerical difficulties, we obtain smaller stable problems that allow for efficient high accuracy solutions for many large scale instances. In particular, we look at facial reduction for sensor network localization (SNL) and molecular conformation (MC).

■ MC05

05- Kings Garden 1

Advances in Continuous Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Dominique Orban, GERAD and Ecole Polytechnique, 3000, ch. de la Cote-Sainte-Catherine, Montreal, Canada, dominique.orban@gerad.ca

1 - On the Behavior of the Method of Conjugate Gradients and Quasi-Newton Methods on Quadratic Problems

Anders Forsgren, KTH Royal Institute of Technology, Department of Mathematics, Stockholm, SE-10044, Sweden, andersf@kth.se, Tove Odland

In this talk we discuss the behavior of the method of conjugate gradients and quasi-Newton methods on a quadratic problem. In particular, we give necessary and sufficient conditions for the methods to generate identical iterates. We show that the set of quasi-Newton schemes that generate parallel search directions to those of the method of conjugate gradients is strictly larger than the one-parameter Broyden family. In addition, we show that this set contains an infinite number of symmetric rank-one update schemes. We also extend the dicussion to the behavior of unnormalized Krylov subspace methods on singular systems.

2 - ARCq: A New ARC Variant and Its Simple Convergence Proofs Unified with Trust Region Methods

Jean-Pierre Dussault, Université de Sherbrooke, 2500 Blvd Université, Sherbrooke, QC, j1k2r1, Canada, Jean-Pierre.Dussault@USherbrooke.ca

We provide a simple convergence analysis unified for TR and a new ARC algorithms, which we name ARCq and which is very close in spirit to trust region methods, closer than the original ARC is. We prove global convergence to second order points. We also obtain as a corollary the convergence of the original ARC method. Since one of our aims is to achieve a simple presentation, we sacrifice some generality which we discuss at the end of our developments. In this simplified setting, we prove the optimal complexity property for the ARCq and identify the key elements which allow it. We end by proposing an efficient implementation using a Cholesky like factorization.

3 - Linear Algebra for Matrix-Free Optimization

Dominique Orban, GERAD and Ecole Polytechnique, 3000, ch. de la Cote-Sainte-Catherine, Montreal, Canada, dominique.orban@gerad.ca

When formulated appropriately, the broad families of sequential quadratic programming, augmented Lagrangian and interior-point methods all require the solution of symmetric saddle-point linear systems. When regularization is employed, the systems become symmetric and quasi definite. The latter are indefinite but their rich structure and strong relationships with definite systems enable specialized linear algebra, and makes them prime candidates for matrix-free implementations of optimization methods. In this talk, we explore various formulations of the step equations in optimization and corresponding iterative methods that exploit their structure.

■ MC06

06- Kings Garden 2

Energy and Optimization

Cluster: Optimization in Energy Systems

Invited Session

Chair: Leonardo Taccari, Politecnico di Milano, via Ponzio 34/5, Milano, MI, 20133, Italy, leonardo.taccari@polimi.it

1 - Approximate Dynamic Programming using Dynamic Quantile-Based Risk Measures for Energy Bidding

Daniel Jiang, Princeton University, Sherrerd Hall, Charlton Street, Princeton, NJ, 08540, United States of America, drjiang@princeton.edu, Warren Powell

We consider a finite-horizon Markov decision process (MDP) for which the objective at each stage is to minimize a quantile-based risk measure of the sequence of future costs. In particular, we consider optimizing dynamic risk measures constructed using the one-step quantile (or value at risk) and the one-step conditional value at risk (CVaR). Although there is considerable theoretical development of risk-averse MDPs in the literature, the computational challenges have not been explored as thoroughly. We propose simulation-based approximate dynamic programming (ADP) algorithms, modeled after Q-learning. We also present numerical results by applying the algorithms in the context of an application to bidding in the energy market.

2 - Robust Mixed-Integer Optimization Approaches for Operational Planning of Energy Systems with Storage

Leonardo Taccari, Politecnico di Milano, via Ponzio 34/5, Milano, MI, 20133, Italy, leonardo.taccari@polimi.it

Planning the operations of energy systems is a classical problem where, given a time horizon, one aims to find a production schedule minimizing the cost while satisfying given demands and technical constraints. We focus on problems where the generated energy can be stored from one period to the following, e.g., unit commitment in microgrids with battery banks, or cogeneration systems with storage tanks for thermal energy. Finding a plan which is robust with respect to the uncertainties that may arise in the demand is crucial. In this work, we study robust mixed-integer optimization approaches that can be used in problems with fixed costs and constraints such as ramping and minimum up/downtime, and test them on real-world instances.

3 - Performance Bounds for Look-Ahead Power System Dispatch using Generalized Multi-Stage Policies

Paul Beuchat, PhD Candidate, ETH Zürich, Physikstrasse 3, Zurich, ZH, 8092, Switzerland, beuchatp@control.ee.ethz.ch, Joseph Warrington, Manfred Morari, Tyler Summers

We present a combined look-ahead dispatch and reserve optimization formulation, which extends our recent work on time-coupled reserve policies, and employs the recent notion of generalized decision rules from the robust optimization literature. This aims to improve the performance of traditional linear decision rules when applied to short-term electrical reserve operation. We derive a primal problem whose solution is a time-coupled policy for the reserve dispatch. We derive also an associated dual problem that allows the sub-optimality of a candidate solution, based on a particular decision rule parameterization, to be bounded. We demonstrate the method using a numerical case study on the standard IEEE-118 bus network.

■ MC07

07- Kings Garden 3

Software Components for Large-Scale Engineering Optimization

Cluster: Implementations and Software

Invited Session

Chair: Bart Van Bloemen Waanders, Sandia National Laboratories, P.O. Box 5800, Albuquerque, United States of America, bartv@sandia.gov

1 - The Identifiability Approach for Time-Dependent Full Waveform Inversion

Drosos Kourounis, Universita della Svizzera italiana, drosos.kourounis@usi.ch

Full-waveform inversion (FWI) has been considered the next logical step in deriving velocity models. Despite advances in computing, it still remains a computationally demanding problem due to the huge number of geological parameters. A mathematical approach is described using interior-point and sequential quadratic programming methods for identifiable parameter subsets. The suggested approach results in significantly reduced number of parameters, avoidance of local minima through second order information, and decreased computational complexity.

2 - Sundance: Unified Embedded Parallel Finite Element Computations and Analysis

Kevin Long, Texas Tech University, kevin.long@ttu.edu

Analysis of partial differential equations requires not only forward solutions, but the extraction of sensitivities with respect to input parameters. Moving beyond automating PDE solutions, we present a framework that unifies the discretization of PDEs with analysis requirements. In particular, Frechet differentiation on a class of functionals together with a high-performance, finite element framework have led to Sundance. The software provides high-level programming abstractions for finite variational forms together with operators required by analysis.

3 - Rapid Optimization Library (ROL)

Bart Van Bloemen Waanders, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM, United States of America, bartv@sandia.gov, Denis Ridzal, Drew Kouri

We present a large-scale nonlinear optimization capability in Trilinos, called Rapid Optimization Library (ROL). ROL implements hardened, production-ready, parallel-capable algorithms for unconstrained and constrained optimization. ROL features efficient use of application data structures and solvers, unified interfaces for simulators, methods for inexact computations, and algorithms to perform optimization under uncertainty. We explore reduced and full-space formulations of simulation-based optimization problems through various numerical examples and present a summary of ROL's use within Sandia's production simulators.

■ MC08

08- Kings Garden 4

Homomorphisms, Fast Algorithms and Limits

Cluster: Combinatorial Optimization

Invited Session

Chair: Jaroslav Nesetril, Professor, Computer Science Institute of Charles University, Malostranske nam.25, Prague, 11800, Czech Republic, nesetril@kam.mff.cuni.cz

1 - List Homomorphisms, Time and Space

Pavol Hell, Professor, Simon Fraser University, University Drive, Burnaby, BC, V5A1S6, Canada, pavol@cs.sfu.ca

I will describe some recent results on the time and space complexity of the list homomorphism problem for directed graphs. This is joint work with Arash Rafiey, Benoit Larose, L·szlo Egri, and Victor Dalmau.

2 - Fast Algorithms for Sparse Combinatorial Problems

Jaroslav Nesetril, Professor, Computer Science Institute of Charles University, Malostranske nam.25, Prague, 11800, Czech Republic, nesetril@kam.mff.cuni.cz, Patrice Ossona de Mendez

On the background of Nowhere dense vs Somewhere dense dichotomy (which can be expressed in a very simple way) we list several linear and almost linear algorithms for both decision and counting problems. The question of (relativised) first order definability leads to interesting approach to some old combinatorial problems.

3 - Limits and Approximations of Maps

Patrice Ossona de Mendez, Researcher, CNRS and Charles University, CAMS - EHESS, 190 avenue de France, Paris, 75013, France, pom@ehess.fr, Jaroslav Nesetril

Structural convergence is defined as the convergence, for each first-order formula in a specific fragment of first-order logic, of the satisfaction probability. This extends both Lovasz-Szegedy left-convergence of graphs and Benjamini-Schramm local-convergence of graphs with bounded degree. In this setting, we consider structural limits of finite maps. Conversely, we address the problem of approximating Borel maps by finite maps, and discuss connections with Aldous-Lyons conjecture on the approximation of graphings by finite graphs.

■ MC09

09- Kings Garden 5

Extended Formulations and the Matching Problem

Cluster: Combinatorial Optimization

Invited Session

Chair: Sebastian Pokutta, 400 Ferst Drive, Atlanta, GA, 30318, United States of America, sebastian.pokutta@isye.gatech.edu

1 - The Matching Polytope has Exponential Extension Complexity

Thomas Rothvoss, University of Washington, Seattle, WA, United States of America, rothvoss@uw.edu

A popular method in combinatorial optimization is to express polytopes P, which may potentially have exponentially many facets, as solutions of linear programs that use extra variables to reduce the number of constraints down to a polynomial. Recent years have brought amazing progress in showing lower bounds for the so called extension complexity, which for a polytope P denotes the smallest number of necessary inequalities. However, the central question in this field remained wide open: can the perfect matching polytope be written as an LP with polynomially many constraints? We answer this question negatively. In fact, the extension complexity of the perfect matching polytope in a complete n-node graph is 2^Omega(n).

2 - Quantum Communication Complexity as a Tool to Analyze PSD Rank

Ronald de Wolf, Professor, CWI and University of Amsterdam, Science Park 123, Amsterdam, 1098 XG, Netherlands, Ronald.de.Wolf@cwi.nl

We start with a brief introduction to quantum communication complexity, and then describe the connection with the positive-semidefinite rank of matrices (Fiorini et al'12): the logarithm of the psd rank of a matrix M equals the minimal quantum communication needed by protocols that compute M in expectation. Hence results about quantum communication complexity imply results about psd rank. As an example we present an efficient quantum communication protocol (Kaniewski, Lee, de Wolf'14) that induces an exponentially-close approximation for the slack matrix for the perfect matching polytope, of psd rank only roughly exp(sqrt{n}). In contrast, Braun and Pokutta'14 showed that even 1/n-approximating matrices need nonnegative rank exp(n).

3 - Matching has no Fully-Polynomial Size Linear Programming Relaxation Scheme

Gabor Braun, H. Milton Stewart School of Industrial & Systems Engineering at Georgia Tech, gabor.braun@isye.gatech.edu, Sebastian Pokutta

Rothvofl [T. Rothvofl, The matching polytope has exponential extension complexity. STOC, 263-272, 2014] established that every linear program for the matching polytope has exponential many inequalities. We generalize this to sharp bounds on polyhedral inapproximability of the matching polytope: for 0 < e < 1, every polyhedral (1 + e/n)-approximation requires exponential many inequalities, where n is the number of vertices. Thus matching is the first problem in P, whose natural linear encoding does not admit a fully polynomial-size relaxation scheme (the polyhedral version of FPTAS). Our approach reuses Rothvofl's ideas, but the main lower bounding tool is common information instead of the hyperplane separation bound.

■ MC10

10- Kings Terrace

Timetabling and Rostering in Transportation

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Mizuyo Takamatsu, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, takamatsu@ise.chuo-u.ac.jp

1 - Optimal Duty Rosters for Toll Enforcement Inspectors

Elmar Swarat, PhD Student, Zuse-Institute Berlin, Takustr. 7, Berlin, D-14195, Germany, swarat@zib.de, Thomas Schlechte, Stephan Schwartz

We consider the problem of computing optimal duty rosters for toll enforcement inspectors on German motorways. This leads to an integrated vehicle routing and duty rostering problem. The model is based on a planning graph, where rosters correspond to paths. A path models a sequence of duties and days-off, respecting several legal constraints. The duties consist of best rated control tours. According to several modeling issues this problem can be solved directly by an Integer Program based on arc variables. A computational study from real-world operation will analyse the solution behaviour.

2 - Timetabling and Passenger Routing in Public Transport

Heide Hoppmann, Zuse Institute Berlin, Takustrafle 7, Berlin, 14195, Germany, hoppmann@zib.de

In timetabling, periodic arrival and departure times of lines in a public transport system are scheduled. One objective of optimization models for timetabling is to minimize the travel time for the passengers. However, the models are generally based on fixed passenger routes and, hence, ignore potentially valuable degrees of freedom. We investigate periodic timetabling models with integrated passenger routing, compare different variants of routings, and present computational results for the city of Wuppertal.

3 - Bus Timetable Design in Areas with Low-Frequency Public Transportation Services

Mizuyo Takamatsu, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, takamatsu@ise.chuo-u.ac.jp, Azuma Taguchi

In Japan, rural areas face with sparsity in population and rapid growth of the percentage of elderly people. In these areas, a lot of bus lines have less than ten services in a day. Besides low-frequency services, it is also inconvenient to transfer to another bus service or train service. Thus, there is a strong need to design a timetable which ensures smooth transfer among buses and trains. We tackle this problem not from scratch, but by inheriting the existing bus lines and train timetables as much as possible. Based on the approach, we present a mathematical optimization model to generate a bus timetable which achieves shorter waiting time for transfer than the current timetable, and apply the model to the Tohoku district in Japan.

■ MC11

11- Brigade

Graph Theory

Cluster: Combinatorial Optimization

Invited Session

Chair: Jan Kratochvil, Charles University, Prague, Czech Republic, honza@kam.mff.cuni.cz

1 - The Structure of Even-Hole-Free Claw-Free Graphs

Kathie Cameron, Professor, Wilfrid Laurer University, Department of Mathematics, 75 University Avenue West, Waterloo, On, N2M2M6, Canada, kcameron@wlu.ca, Chinh Hoang, Steven Chaplick

A hole is an induced cycle with at least four vertices. An apple is a hole with a pendant edge. Apple-free graphs generalize claw-free graphs which generalize line-graphs, and thus independent sets in apple-free graphs generalize matchings. Minty's (1980) polytime algorithm for max weight independent set in claw-free graphs led to much research on claw-free graphs, including its generalization to apple-free graphs by Brandstadt, Lozin and Mosca (2010). Coloring line-graphs is NP-hard. We show a graph is apple-free even-hole free if and only if it can be decomposed by clique cutsets into joins of cliques and unit circular-arc graphs. This provides polytime algorithms for recognizing apple-free even-hole-free graphs and for min coloring them.

2 - Decomposition Theorems for Square-Free 2-Matchings in Bipartite Graphs

Kenjiro Takazawa, Assistant Professor, Kyoto University, Oiwake-cho, Kitashirakawa, Sakyo-ku, Kyoto, 606-8502, Japan, takazawa@kurims.kyoto-u.ac.jp

A square-free 2-matching in a bipartite graph is a simple 2-matching without cycles of length four. In this talk, we present new decomposition theorems for square-free 2-matchings in bipartite graphs. These theorems serve as an analogue of the Dulmage-Mendelsohn decomposition and the Edmonds-Gallai decomposition. We exhibit two canonical minimizers for the set function in the min-max formula, and a characterization of the maximum square-free 2-matchings with the aid of these canonical minimizers.

3 - Polyhedral and Computational Results on the k-hop Connected Dominating Set Problem

Phablo Fernando Soares Moura, PhD Student, University of São Paulo, Rua do Matão 1010, Cidade Universitaria, São Paulo, SP, 05508-090, Brazil, phablo@ime.usp.br, Rafael Santos Coelho, Yoshiko Wakabayashi

For a connected graph G and a positive integer k, a subset D of the vertices of G is called a k-hop connected dominating set if D induces a connected subgraph of G and, for every vertex v in G, there is a vertex u in D such that the distance between v and u in G is at most k. We study the minimum k-hop connected dominating set problem. An integer linear programming formulation is presented with some classes of inequalities that define facets of the corresponding polytope. We also report computational results on a branch-and-cut algorithm.

■ MC12 1:10pm - 1:50pm

12- Black Diamond

SAS – Building and Solving Optimization Models with SAS

Cluster: Software Presentations

Invited Session

Chair: Ed Hughes, SAS, ed.hughes@sas.com

1 - SAS - Building and Solving Optimization Models with SAS

Ed Hughes, SAS, ed.hughes@sas.com

SAS provides comprehensive data and analytic capabilities, including statistics, data/text mining, forecasting, and operations research methods: optimization, simulation, and scheduling. OPTMODEL from SAS provides a powerful and intuitive algebraic optimization modeling language, with unified support for LP, MILP, QP, NLP, CLP, and network-oriented models. We'll demonstrate OPTMODEL, highlighting its newer capabilities and its support for standard and customized solution approaches, working through sample problems and exploring multiple modeling and solution approaches for each.

■ MC13

13- Rivers

Conic Optimization: Algorithms and Applications

Cluster: Conic Programming

Invited Session

Chair: Miguel Anjos, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, Succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca

1 - Solution Approaches for Equidistant Double- and Multi-row Facility Layout Problems

Philipp Hungerländer, Alpen-Adria-Universitaet Klagenfurt, philipp.hungerlaender@aau.at, Anja Fischer, Miguel Anjos

We consider the multi-row equidistant layout problem in which equidistant departments are to be placed on a given number of rows so that the sum of the weighted center-to-center distances is minimized. We prove two theoretical results. First we show that although the lengths of the spaces between the departments are in general continuous quantities, every multi-row equidistant problem has an optimal solution on the grid and hence only spaces of unit length need to be used when modeling the problem. Second we give exact expressions for the minimum number of spaces that need to be added so as to preserve at least one optimal solution. We exploit these results to tailor exact approaches that outperform other recent methods for this problem.

2 - Second-order Cone Approximations for Optimal Power Flow Problems

Bissan Ghaddar, IBM Research, Damastown Industrial Estate, Mulhuddart, Dublin 15, Dublin, Ireland, bghaddar@ie.ibm.com, Xiaolong Kuang, Luis Zuluaga, Joe Naoum-Sawaya

Semidefinite programming (SDP) relaxations for general polynomial optimization problems based on sum of squares polynomials have been shown to be tight. Due to the computational challenge of solving positive semidefinite problems, it becomes difficult to use SDP for large-scale problems and for high order relaxations. In this work, we exploit recent results in polynomial optimization to construct a hierarchy of second-order cone relaxations and we evaluate the proposed approach on Optimal Power Flow problems. We show that in comparison to the SDP-based hierarchies, the second-order cone hierarchies provide global bounds on large-scale optimal power flow problems where SDP hierarchies fail.

3 - Novel Family of Cuts for SDP Relaxations for Some Classes of Binary Quadratic Optimization Problems

Elspeth Adams, École Polytechnqiue de Montreal, 2900, Boul. Édouard-Montpetit, Montreal, QB, H3T 1J4, Canada, elspeth.adams@polymtl.ca, Miguel Anjos

k-projection polytope constraints (kPPCs) are a family of constraints that tighten SDP relaxations using the inner description of small polytopes, as opposed to the typical facet description. We examine the properties of kPPCs, methods for separating violated kPPCs and their impact on the bounds in a cutting plane algorithm. Problems satisfying the required projection property, such as the max-cut and stable set problems, will be considered and results will focus on large instances.

■ MC14

14- Traders

Auctions and Mechanism Design

Cluster: Game Theory

Invited Session

Chair: Ozan Candogan, Duke University, Fuqua School of Business, Durham, NC, 27705, United States of America, ozan.candogan@duke.edu

1 - Customer Referral Incentives and Social Media

Ilan Lobel, New York University, 44 W 4th St, New York, NY, United States of America, ilobel@stern.nyu.edu, Evan Sadler, Lav Varshney

We study how to optimally attract new customers using a referral program. Whenever a consumer makes a purchase, the firm gives him or her a link to share with friends, and every purchase coming through that link generates a referral payment for the consumer. The firm chooses the referral payment function, and consumers respond by playing an equilibrium. The optimal payment function is nonlinear and not necessarily monotonic. If we approximate the optimal policy using a linear payment function, the approximation loss scales with the square root of the average consumer degree. Using a threshold payment, the loss scales proportionally to the average degree. Combining the two, we achieve a constant bound on the approximation loss.

2 - Dynamic Mechanism Design with Budget Constrained Buyers

Omar Besbes, Columbia University, New York, United States of America, ob2105@columbia.edu, Santiago Balseiro, Gabriel Weintraub

We consider the problem of a seller who has a number of perishable items arriving sequentially over a time and who sells these items to a group of budget constrained buyers. We formulate the problem as a dynamic mechanism design problem with no commitment power. We argue that this problem is generally intractable. Thus motivated, we introduce a continuous time fluid model that allows for a tractable characterization of the optimal dynamic mechanism.

3 - Structures of Optimal Policies in Dynamic Mechanism Design with One Agent

Peng Sun, Fuqua School of Business, 100 Fuqua Drive, Fuqua School Of Business, Duke Universit, Durham, NC, 27708, United States of America, peng.sun@duke.edu, Bingyao Chen, Alex Belloni

A principal procures up to one unit of a product in every period from an agent who is privately informed about its marginal production cost in each period. We allow a non-negative fixed cost in each period. We consider two dynamic models, distinguished by whether the agent allows promises of future payments. Under mild regularities conditions on the distribution of the production cost, we show that the optimal contract in both models offers at most two different procurement levels in each period depending on the newly reported production cost. This yields tractable computational procedures. Our results rely on the analysis of the “dynamic virtual valuation,” a generalization of the Myersonian virtual valuation in the static setting.

■ MC15

15- Chartiers

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Dusan Jakovetic, Biosense Center, University of Novi Sad, Ul. Zorana Djindjica 1, Novi Sad, Serbia-Montenegro, dusan.jakovetic@gmail.com

1 - Convergence Rate of Incremental Aggregated Gradient Algorithms

Mert Gurbuzbalaban, Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Boston, MA, 02139, United States of America, mertg@mit.edu, Asu Özdaglar, Pablo Parrilo

We analyze the incremental aggregated gradient method for minimizing a sum of strongly convex functions from a novel perspective, simplifying the global convergence proofs considerably and proving a new linear rate result. We also develop a class of alternative aggregated methods, provide their linear rate and analyze the trade-off between the convergence rate and the memory requirement. We finally discuss applications to distributed asynchronous optimization and large-scale data processing.

2 - Distributed Gradient Methods with Variable Number of Working Nodes

Dusan Jakovetic, Biosense Center, University of Novi Sad, Ul. Zorana Djindjica 1, Novi Sad, Serbia-Montenegro, dusan.jakovetic@gmail.com, Dragana Bajovic, Natasa Krejic, Natasa Krklec Jerinkic

We consider distributed optimization where N networked nodes minimize the sum of their local costs subject to a common constraint set. We propose a distributed projected gradient method where each node, at each iteration k, performs an update (is active) with probability p_k, and stays idle with probability 1-p_k. We show that, as long as p_k grows to one asymptotically, our algorithm converges in the mean square sense to the same solution as the standard distributed gradient method, i.e., as if all nodes were active at all iterations. Moreover, when p_k grows to one linearly, with appropriately set convergence factor, the algorithm has a linear convergence, with practically the same factor as the standard distributed gradient method.

3 - Implementation of Nonlinear Optimization Solver with Multiple Precision Arithmetic

Hiroshige Dan, Kansai University, 3-3-35, Yamate-cho, Suita-shi, Osaka, Japan, dan@kansai-u.ac.jp

Double precision arithmetic for nonlinear optimization problems (NLP) basically works well, but it sometimes fails to solve some ill-posed problems. On the other hand, multiple precision arithmetic has attracted much attention recently as a brute-force method for avoiding numerical errors. In this research, we have implemented an optimization solver for NLP by using multiple precision arithmetic and checked the advantage of multiple precision arithmetic for NLP through numerical results.

■ MC16

16- Sterlings 1

Advances in Integer Programming II

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - Investigating Mixed-integer Hulls using a MIP-solver

Matthias Walter, Otto-von-Guericke-Universitaet Magdeburg, Universitaetsplatz 2, Magdeburg, 39106, Germany, matthias.walter@ovgu.de, Volker Kaibel

A software tool is presented which, given a mixed-integer program, investigates the associated mixed-integer hull. In particular, it detects all equations and some facets valid for the hull with exact arithmetic. The facets are produced in such a way that they are helpful in optimizing the given objective function. This is in contrast to usual convex-hull algorithms which produce the entire description of the hull, but run out of resources for small dimensions already. The software can handle larger dimensions as it is based on solving MIPs. In particular, the facet computation is done using target cuts, introduced by Buchheim, Liers and Oswald in 2008.

2 - On the Complexity of Separation for the mod-k Closure

Jeff Pavelka, ISyE, Georgia Institute of Technology, 765 Ferst Drive, Atlanta, GA, 30332, United States of America, jpavelka@gatech.edu, Sebastian Pokutta

In integer programming, mod-k cuts are Chvatal-Gomory cuts where each multiplier is of the form a/k, with a being a nonnegative integer less than k. These cuts are well-studied in the case k=2, where it is known that finding a mod-2 cut which separates a given point from a polyhedron P is an NP-complete problem. We show that this result holds for any k, even in the case where P is contained in the 0-1 hypercube.

3 - Machine Learning to Balance the Load in Parallel Branch-and-Bound

Alejandro Marcos Alvarez, PhD Student, Université de Liège, Institut Montefiore (B28), 10 Grande Traverse, Liège, 4000, Belgium, amarcos@ulg.ac.be, Quentin Louveaux, Louis Wehenkel

We describe a new approach to parallelize branch-and-bound. We propose to split the optimization of the original problem into the optimization of several subproblems that can be optimized separately. The main innovation of our approach consists in the use of machine learning to create a function able to estimate the difficulty (number of nodes) of a subproblem of the original problem. These estimates are then used to decide how to partition the original optimization tree into a given number of subproblems, and how to distribute them among the available processors. Our experiments show that our approach succeeds in balancing the amount of work between the processors, and that interesting speedups can be achieved with little effort.

■ MC17

17- Sterlings 2

Numerical Methods for Nonlinear Optimization I

Cluster: Nonlinear Programming

Invited Session

Chair: Ya-xiang Yuan,, Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Zhong Guan Cun Donglu 55, Haidian, Beijing, 100190, China, yyx@lsec.cc.ac.cn

1 - Methods for Special Structured Matrix Problems

Cong Sun, Beijing University of Post and Telecommunication, No 10, Xitucheng Road, Haidian, Beijing, 100876, China, suncong@lsec.cc.ac.cn

A special matrix problem is considered from the application in wireless communications. The objective function is approximated by a fraction function. The alternating minimization method is applied. Efficient methods are proposed for the subproblems as nonconvex quadratic constrained quadratic programming and those with orothogonality constraints, where KKT points or optimal solutions are guaranteed. Simulations show the superior performances of our proposed models and algorithms.

2 - Some New Results On The Convergence Of Multi-block Admm

Shiqian Ma, Assistant Professor, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, William M.W.Mong Engineering Building, Shatin, N.T., Hong Kong - PRC, sqma@se.cuhk.edu.hk

We present the following two new results regarding to the convergence of multi-block ADMM. (1) The existing results on sufficient conditions for guaranteeing convergence of multi-block ADMM typically require the strong convexity on parts of the objective. In our work, we show convergence and convergence rate results for the multi-block ADMM applied to solve certain N-block convex minimization problems without requiring strong convexity. (2) It is known that the 2-block ADMM globally converges with any penalty parameter, i.e., it is a parameter free algorithm. In our work, we show that the unmodified 3-block ADMM is also parameter free, when it is applied to solving a certain sharing problem, which covers many interesting applications.

3 - Optimality and Stability Conditions for Symmetric Evolutionary Games

Zhijun Wu, Professor, Iowa State University, Department of Mathematics, Ames, IA, 50014, United States of America, zhijun@iastate.edu, Min Wang, Wen Zhou

Evolutionary game theory has been applied successfully to modeling evolution of various biological or social systems. In this theory, species are considered as if they are players in a game, competing for survival and reproduction. A mathematical (game) model can then be established for the study of evolution of the species. In this talk, we will focus on symmetric evolutionary games and discuss the optimality and stability conditions of their solutions. We will show that their solutions can be obtained by solving a special class of optimization problems. A set of first- and second-order optimality and stability conditions can thus be derived. Applications to genetic selection games will also be demonstrated.

■ MC18

18- Sterlings 3

Nonlinear Programming Methods for Probabilistic Programming Problems

Cluster: Stochastic Optimization

Invited Session

Chair: Miguel Lejeune, Associate Professor, George Washington University, 2201 G St, NW, Funger Hall 406, Washington, DC, 20052, United States of America, mlejeune@gwu.edu

1 - Data-Driven Chance-Constrained Optimization via Kernel Smoothing: Effective NLP Initialization

Bruno A. Calfa, Graduate Student, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, United States of America, bacalfa@cmu.edu, Francisco Trespalacios, Anshul Agarwal, Scott J. Bury, John M. Wassick

We propose a data-driven, nonparametric approach to reformulate individual and joint chance constraints with right-hand side uncertainty into algebraic constraints. The approach consists of using kernel smoothing to approximate unknown "true" continuous probability density/distribution functions. An effective NLP initialization algorithm is proposed to speed up the solution of kernel-based joint chance-constrained problems. We employ the proposed algorithm to a large-scale, industrial production planning problem. Computational results show that the initialization algorithm reduces total solution times by factors of 1.2 to 5.6.

2 - Probabilistic Optimization via Approximate p-efficient Points and Bundle Methods

Wim van Ackooij, EDF R&D, 1 Avenue du Général de Gaulle, Clamart, 92141, France, wim.van.ackooij@gmail.com, Violette Berge, Welington de Oliveira, Claudia Sagastizabal

For problems when decisions are taken prior to observing the realization of underlying random events, probabilistic constraints are an important modelling tool if reliability is a concern. A key concept to numerically dealing with probabilistic constraints is that of p-efficient points. By adopting a dual point of view, we develop a solution framework that includes and extends various existing formulations. The unifying approach is built on the basis of a recent generation of bundle methods called with on-demand accuracy, characterized by its versatility and flexibility. Numerical results for several difficult probabilistically constrained problems confirm the interest of the approach.

3 - Asymptotic Analytic Approximation for Non-Convex Chance Constrained Optimization

Abebe Geletu, Academic and Research Staff, TU-Ilmenau, Faculty of Computer Science and Automati, Simulation and Optimal Processes Group, Ilmenau, 98963, Germany, abebe.geletu@tu-ilmenau.de, Armin Hoffmann, Pu Li, Michael Kloeppel

Chance constrained optimization (CCOPT) problems are known to be quite difficult to solve. This work uses a smooth parametric approximation function to approximately solve non-convex CCOPT problems by solving a sequence of deterministic nonlinear programming problems (NLP). The proposed method has the following features. The approximating function and its gradient are easier to evaluate and converge to the probability function and gradient of the chance constraint function, respectively. The feasible set of each NLP is a subset of the feasible set of CCOPT (a-priori feasibility). Any limit-point of optimal solutions of the sequence of NLPs is an optimal solution of the CCOPT. The method works for Gaussian/non-Gaussian random variables.

■ MC19

19- Ft. Pitt

Recent Advances in PDE-Constrained Optimization

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Stefan Ulbrich, Professor, TU Darmstadt, Dolivostr. 15, Darmstadt, Germany, ulbrich@mathematik.tu-darmstadt.de

1 - Accelerated Source-Encoding Full-Waveform Seismic Tomography

Christian Boehm, ETH Zürich, Sonneggstrasse 5, NO H 39.3, Zürich, Switzerland, christian.boehm@erdw.ethz.ch, Andreas Fichtner, Michael Ulbrich

Seismic tomography infers the material properties of the Earth based on the observation of seismograms. We present Newton-type methods for full-waveform inversion governed by the elastic wave equation that utilize source-encoding strategies to substantially reduce the computational costs. In particular, we accelerate the minimization of a sample average approximation model by using mini-batch Hessian information. Furthermore, we work with inexact gradient information based on a compressed forward wavefield to reduce the memory requirements. We present numerical examples from geophysical exploration in 2d and 3d.

2 - Constrained Optimization with Low-Rank Tensors and Applications to Parametric Problems with PDEs

Sebastian Garreis, TU Muenchen, Zentrum Mathematik, M1, Boltzmannstr. 3, Garching b. Muenchen, 85748, Germany, garreis@ma.tum.de, Michael Ulbrich

Low-rank tensor methods provide efficient representations and computations with multidimensional arrays. They can break the curse of dimensionality in contrast to other methods for dealing with systems with multiple parameters (e.g. sparse grid integration). We present algorithms for constrained nonlinear optimization using low-rank tensors and their application to optimal control of PDEs with uncertain parameters and to uncertainty quantification for parametrized variational inequalities. These methods are tailored to the usage of low-rank tensor arithmetics and thus allow solving huge problems in a reasonable amount of time.

3 - Optimal Control of PDAEs as Abstract DAEs of Index 1

Hannes Meinlschmidt, TU Darmstadt, Dolivostrasse 15, Darmstadt, 64293, Germany, meinlschmidt@mathematik.tu-darmstadt.de, Stefan Ulbrich

We consider optimal control problems constrained by Partial Differential-Algebraic Equations, given by possibly nonlinearly coupled systems of each a parabolic- and a quasi-stationary elliptic equation for two unknown functions (abstract DAEs on Banach spaces). An invertibility assumption on the differential operator for the elliptic equation classifies the DAE as an Index 1 system. In order to be able to treat state constraints complementing the control problem, we focus on continuous solutions for the PDAE system. The theory allows for weak regularity data, such as bounded coefficient functions and mixed boundary conditions on (weak) Lipschitz domains. It is complemented by a real-world example, the thermistor problem.

■ MC20

20- Smithfield

ADMM and Applications

Cluster: Nonsmooth Optimization

Invited Session

Chair: Hyenkyun WooDr., Korea Institute for Advanced Study, 85 Hoegiro, Dongaemun-gu, Seoul, Korea, Republic of, hyenkyun@gmail.com

1 - An Iterative Quadratic Method for Joint Representation Classification in Face Recognition

Liping Wang, Dr., Nanjing University of Aeronautics and Astronautics, 29#, Yu Dao Street, Nanjing, China., Nanjing, China, wlpmath@nuaa.edu.cn

In this presentation, a joint representation classification (JRC) for face recognition is proposed. Underlying assuming that multi-face pictures share a similar representation pattern, JRC codes all the query images simultaneously. Aligning all the testing samples in a matrix, joint coding is formulated to a generalized minimization. To uniformly solve the mixed optimization problem, an iterative quadratic method (IQM) is designed. IQM is proved to be a strict decreasing algorithm and a practical version is proposed for large-scale cases. Experimental results on four public datasets show that the JRC saves much computational work and achieves better performance in face recognition than state-of-the-arts.

2 - Robust Asymmetric Nonnegative Matrix Factorization

Hyenkyun Woo, Dr., Korea Institute for Advanced Study, 85 Hoegiro, Dongaemun-gu, Seoul, Korea, Republic of, hyenkyun@gmail.com, Haesun Park

The problems that involve separation of outliers and low rank in a given matrix have attracted a great attention in recent years. In this talk, we introduce a new formulation called linf-norm based nonnegative matrix factorization (NMF) for the outliers and low nonnegative rank separation problems. The main advantage of linf-norm in NMF is that we can control denseness of the low nonnegative rank factor matrices. However, we also need to control distinguishability of the vectors in the low nonnegative rank factor matrices for stable basis. For this, we impose asymmetric constraints, i.e., denseness condition on the coefficient factor matrix only. The proposed model with soft regularization shows advantages in various applications.

■ MC21

21-Birmingham

Recent Advances in Derivative-Free Optimization I: Global Convergence and Worst Case Complexity

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Zaikun Zhang, Dr., CERFACS-IRIT joint lab, CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, 31057, France, zaikun.zhang@irit.fr

1 - Unconstrained Stochastic Optimization with Occasionally Dominating Non-i.i.d. Noise

Matt Menickelly, Lehigh University, 200 W. Packer Ave., Bethlehem, PA, 18015, United States of America, mjm412@lehigh.edu, Ruobing Chen, Katya Scheinberg

We present a very general framework for unconstrained stochastic optimization based on a standard trust region framework using random models. We make assumptions on the stochasticity of the objective function different from the typical assumptions of stochastic and simulation-based optimization. In particular, we assume that our models and function values satisfy quality conditions with some probability, but can be arbitrarily bad otherwise. We analyze the convergence of this general framework and present computational results for several classes of noisy functions, where noise is not iid and dominates the function values when it occurs. Our simple framework performs very well in that setting, while standard stochastic methods fail.

2 - A Derivative-Free Trust-Region Algorithm for Composite Nonsmooth Optimization

Geovani N. Grapiglia, Dr., geovani_mat@hotmail.com, Jinyun Yuan, Ya-xiang Yuan

A derivative-free trust-region algorithm is proposed for minimizing a composite nonsmooth function. Global convergence results and a function-evaluation complexity bound are proved. Numerical results with minimax problems are also reported.

3 - A Globally Convergent Method for Linearly Constrained Noisy Minimization

Deise Ferreira, University of Campinas, Rua Sergio Buarque de Holanda, 651,, Campinas, SP, 13083-970, Brazil, ra070609@ime.unicamp.br, Sandra Santos, Maria Diniz-Ehrhardt

In this work, we propose a new globally convergent derivative-free algorithm for solving linearly constrained noisy minimization problems. PSIFA (Pattern Search Implicit Filtering Algorithm) is the combination of a pattern-search approach applied to linearly constrained smooth minimization and the implicit filtering algorithm proposed by C. T. Kelley. Such a combination allows faster convergence, besides extending the range of applicability to noisy problems. Furthermore, we are free of the rational stencil required by the pattern search approach and the finite bounds required by the implicit filtering algorithm, as long as an alternative boundedness assumption is made. Numerical experimentation put the proposed algorithm into perspective.

■ MC22

22- Heinz

Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Tomas Bajbar, Karlsruhe Institute of Technology, Institute of Operations Research, Kaiserstrafle 12, Karlsruhe, 76131, Germany, bajbar@kit.edu

1 - Coercive Polynomials and their Newton Polytopes

Tomas Bajbar, Karlsruhe Institute of Technology, Institute of Operations Research, Kaiserstrafle 12, Karlsruhe, 76131, Germany, bajbar@kit.edu, Oliver Stein

We introduce the broad class of so-called gem regular multivariate polynomials and characterize their coercivity via conditions imposed on the vertex set of their Newton polytopes. For all gem irregular polynomials we introduce sufficient conditions for coercivity, too. We also establish necessary conditions for coercivity for a special class of gem irregular polynomials. We relate our results to the context of polynomial optimization theory and we illustrate our results with several examples.

2 - An Adaptive Directed Balanced Interval Method for Solving Global Optimization Problems

Sijie Liu, Graduate Student, University of Alabama, 714 1/2 12th St. B, Tuscaloosa, AL, 35401, United States of America, sliu28@crimson.ua.edu

Global optimization problems arise in many scientific fields that deals with finding the extremal value of a function in a domain of definition, subjective to various criteria. And the interval optimization techniques are designed to solve almost all types of global optimization problems including the "hard" problems by its strong capacity of providing rigorous bounds in the presence of round of errors. The adaptive directed balanced interval method is proved to improve the quality of the traditional interval computation result by dealing with the overestimation for the range of the functions. Results indicate that the proposed approach is alternative to be used to upgrade the current interval optimization algorithm.

■ MC23

23- Allegheny

Advances in Distributionally Robust Optimization

Cluster: Robust Optimization

Invited Session

Chair: Daniel Kuhn, EPFL, EPFL-CDM-MTEI-RAO, Station 5, Lausanne, Switzerland, daniel.kuhn@epfl.ch

Co-Chair: Wolfram Wiesemann, Imperial College Business School, South Kensington Campus, London, United Kingdom, ww@imperial.ac.uk

1 - Distributionally Robust Joint Chance Constraints with Conic Dispersion Measures

Vladimir Roitch, Imperial College London, 180 Queen's Gate, London, SW7 2AZ, United Kingdom, vladimir.roitch@imperial.ac.uk, Wolfram Wiesemann, Grani Hanasusanto, Daniel Kuhn

We analyse the complexity of a class of distributionally robust joint chance constrained programs where the uncertain parameters are described through their mean values and through upper bounds on general dispersion measures. We derive a tractable problem reformulation when the dispersion measure is conic and uncertain parameters only affect the right-hand side vector of the chance constraint. We also show that the problem becomes intractable if the left-hand side coefficient matrix is affected by uncertainty or the support of the uncertain parameters is restricted to a polyhedron. We illustrate the effectiveness of our exact reformulation in numerical experiments and demonstrate its superiority over state-of-the-art approximation schemes.

2 - Beyond Normality: A Cross Moment-Stochastic User Equilibrium Model

Selin Damla Ahipasãoglu, Singapore University of Technology and Design, 8 Somapah Rd, Singapore, 487372, Singapore, ahipasãoglu@sutd.edu.sg, Rudabeh Meskarian, Thomas Magnanti, Karthik Natarajan

The Stochastic User Equilibrium (SUE) model predicts traffic equilibrium flow when users choose their perceived maximum utility paths while accounting for the effects of congestion due to users sharing links. Inspired by recent work on distributionally robust optimization, specifically a Cross Moment (CMM) choice model, we develop a new SUE model that uses the mean and covariance information on path utilities without the form of the distribution. Under mild conditions, the CMM-SUE exists and is unique. It provides both modeling flexibility and computational advantages over the well-known MNP-SUE (Multinomial Probit-SUE) model that require distributional (normality) assumptions to model correlation effects from overlapping paths.

3 - Data-Driven Distributionally Robust Optimization using the Wasserstein Metric

Peyman Mohajerin Esfahani, Dr, EPFL & ETH Zurich, Funkwiesenstrasse 100, Zurich, 8050, Switzerland, peyman.mohajerin@epfl.ch, Daniel Kuhn

Abstract: We consider stochastic programs where the distribution of the uncertain parameters is only observable through a finite training dataset. Using the Wasserstein metric, we construct a ball in the space of probability distributions centered at the uniform distribution on the training samples, and we seek decisions that perform best in view of the worst-case distribution within this Wasserstein ball. Under mild assumptions, the emerging distributionally robust optimization problem admits an exact tractable reformulation, and its solutions enjoy finite-sample performance guarantees. We show that our approach also offers a new interpretation of the popular regularization techniques in machine learning.

■ MC24

24- Benedum

Applications of MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Dimitri Papageorgiou, ExxonMobil, 1545 Route 22 East,, Annandale, NJ, 08801, United States of America, dimitri.j.papageorgiou@exxonmobil.com

1 - MIP Formulations for the Floor Layout Problem

Joey Huchette, MIT Operations Research Center, 411 Norfolk St, Unit 2C, Somerville, MA, 02143, United States of America, huchette@mit.edu, Juan Pablo Vielma, Santanu Dey

The floor layout problem is to find the best configuration of N rectangular boxes on a fixed rectangular floor, and has applications in VLSI and factory design. The boxes must have a certain area, but their dimensions can vary. We present a framework for generating mixed-integer second-order cone formulations for the problem, as well as a litany of cutting planes. We emphasize a new formulation that offers computational gains by pruning redundant integer solutions.

2 - Multi-Modal Transportation Network Design Problem Considering Sustainability

Metin Turkay, Professor. Dr., Koc University, Rumelifeneri Yolu, Sariyer, Istanbul, 34450, Turkey, mturkay@ku.edu.tr, Narges Shahraki

The multi-modal transportation network design problem integrates different transportation modes in fulfilling the uncertain transportation demand of different entities (passengers, industry, commerce etc.). We present a novel bi-level optimization problem: in the lower level, transportation design problem is formulated to minimize traveler costs and in the upper level we consider minimizing emissions. The two-stage model is formulated as a single-stage MINLP problem with 2 objectives by considering optimality condition of lower level problem as a set of constraints in the upper level model. An exact solution algorithm based on outer approximation and ?-constraint method is implemented to solve the problem.

3 - Multiperiod Blending: Formulations, Discretizations, and Decompositions

Dimitri Papageorgiou, ExxonMobil, 1545 Route 22 East, Annandale, NJ, 08801, United States of America, dimitri.j.papageorgiou@exxonmobil.com

The multiperiod blending problem arises in many petrochemical planning and scheduling applications. It involves binary variables and bilinear terms yielding a nonconvex MINLP that is challenging to solve both for feasibility and to optimality. We present three techniques to overcome these hurdles: Formulations with redundant constraints to improve the MILP relaxation of the MINLP; Discretization methods for improving time to feasibility; Decomposition methods that iteratively solve an MILP master problem and an MINLP subproblem. Computational results illustrate the benefits of these techniques over state-of-the-art general purpose solvers.

■ MC25

25- Board Room

Constraint-Based Scheduling II

Cluster: Constraint Programming

Invited Session

Chair: Philippe Laborie, IBM, 9, rue de Verdun, Gentilly, 94253, France, phi.laborie@free.fr

1 - A Constraint Programming Approach for Solving Convex Quadratically-Constrained Problems

Chris Beck, University of Toronto, 5 King's College Rd., Toronto, Canada, jcb@mie.utoronto.ca, Wen-Yang Ku

Inspired by the geometric reasoning exploited in discrete ellipsoid-based search (DEBS) from the communications literature, we develop a constraint programming (CP) approach to solve problems with convex quadratic constraints. Such constraints appear in numerous applications such as modelling the ground-to-satellite distance in GPS and evaluating the efficiency of a schedule with respect to quadratic objective functions. We strengthen the key aspects of the DEBS approach and implement them as combination of a global constraint and variable/value ordering heuristics. Preliminary experiments on a variety of benchmark instances show promising results.

2 - Combinatorial Optimization for Workload Dispatching on the EURORA Supercomputer

Michele Lombardi, DISI, University of Bologna, Viale del Risorgimento 2, Bologna, 40136, Italy, michele.lombardi2@unibo.it, Andrea Borghesi, Thomas Bridi, Michela Milano, Andrea Bartolini

We tackle the problem of job dispatching on a supercomputer with heterogeneous architecture. The problem consists in mapping and scheduling a stream of computation-intensive jobs with approximately known duration. Currently, this is done done via a rule-based system that incurs the risk of causing resource fragmentation (and hence underutilization) or large waiting times. We are working on an alternative approaches based on Constraint Programming and MILP. A prototype has already been realized and deployed both in a simulated environment and on the real supercomputer. The approach is leading to significant improvements in terms of waiting times and comparable machine utilization w.r.t. the dispatcher currently installed.

3 - Scheduling Scientific Experiment for Comet Exploration

Gilles Simonin, Senior PostDoctoral Researcher, Insight Centre for Data Analytics, University College Cork,, Western Road, Cork, Ireland, gilles.simonin@insight-centre.org, Emmanuel Hebrard, Christian Atigues, Pierre Lopez

The Rosetta/Philae mission was launched in 2004 by the European Space Agency. It was scheduled to reach a comet in 2014 and attempt the first ever landing on its surface. We describe a constraint programming model for scheduling the different experiments of the mission. A feasible plan must satisfy several constraints as energy, precedence, incompatibility and the transfer of all the data produced by the instruments. We introduce a global constraint to handle data transfers. The goal of this constraint is to ensure that data-producing tasks are scheduled in such a way that no data is lost. From our results, mission control was able to compute feasible plans in a few seconds for scenarios where minutes were previously often required.

■ MC26

26- Forbes Room

Progress in Financial Optimization

Cluster: Finance and Economics

Invited Session

Chair: Somayeh Moazeni, Assistant Professor, Stevens Institute of Technology, 1 Castle Point Terrace on Hudson, Hoboken, NJ, 07030, United States of America, smoazeni@stevens.edu

Co-Chair: Boris Defourny, Assistant Professor, Lehigh University, 200 W Packer Ave, Bethlehem, PA 18015, United States of America, defourny@lehigh.edu

1 - Genetic Programming Optimization for a Sentiment Feedback Strength-based Trading

Steve Yang, Assistant Professor, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, steve.yang@stevens.edu, Sheung Yin Mo

In this study we present a novel framework to developing a sentiment-based trading strategy using genetic programming. We propose a sentiment indicator based on feedback strength between the news and tweet sentiments, and we aim to solve the optimization problem to maximize risk-adjusted returns with the sentiment indicator. We find that the sentiment-based genetic programming approach yields consistent excessive market returns with small standard deviation over the two years from 2012 to 2014. Using the Stirling ratio and other risk measures, our study suggests that news and tweet sentiment can be regarded as valuable sources of information in constructing meaningful trading system along with technical indicators.

2 - Branch-and-Cut for Cardinality and Semi-Continuous Constrained Optimization

Ming Zhao, SAS, 100 SAS Campus, Cary, United States of America, ming.zhao@sas.com, Feng Qiu

Large asset management companies usually manage assets against given indices. The desired portfolio optimization problem involves using cardinality constraints to limit the number of securities in the portfolio and semi-continuous variables to enforce the minimal transaction levels. In this talk, we present cutting planes for these combinatorial constraints and show their efficacy in computational experiments.

3 - Data-Driven Dynamic Portfolio Execution

Somayeh Moazeni, Assistant Professor, Stevens Institute of Technology, 1 Castle Point Terrace on Hudson, Hoboken, NJ, 07030, United States of America, smoazeni@stevens.edu, Boris Defourny

We study the problem of portfolio trading in the presence of permanent and temporary price impacts to maximize the expected profit. We discuss and compare optimal trading strategies under different market price models and updating approaches.

■ MC27

27- Duquesne Room

Primal-Dual and Proximal Methods in Sparse Optimization I

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Stephen Becker, Assistant Professor, University of Colorado Boulder, 526 UCB, University of Colorado, Boulder, CO, 80309, United States of America, Stephen.Becker@colorado.edu

1 - An Inertial Forward-Backward Algorithm for Monotone Inclusions

Thomas Pock, Graz University of Technology, Inffeldgasse 16, Graz, 8010, Austria, pock@icg.tugraz.at, Dirk Lorenz

In this paper, we propose an inertial forward back-ward splitting algorithm to compute a zero of the sum of two monotone operators, with one of the two operators being co-coercive. The algorithm is inspired by the accelerated gradient method of Nesterov, but can be applied to a much larger class of problems including convex-concave saddle point problems and general monotone inclusions. We prove convergence of the algorithm in a Hilbert space setting and show that several recently proposed first-order methods can be obtained as special cases of the general algorithm. Numerical results show that the proposed algorithm converges faster than existing methods, while keeping the computational cost of each iteration basically unchanged.

2 - A Family of Friendly Proximals

Gabriel Goh, UC Davis, Davis, CA, United States of America, gabgohjh@gmail.com

We show how an interior method can be used to compute the proximal operator of a convex function under different metrics, where both the metric and the function have simultaneous structure that allow the proximal map to be computed in time nearly linear in the input size. We describe how to use this approach to implement quasi-Newton methods for a rich class of nonsmooth problems that include important signal-processing applications.

3 - Barrier Smoothing Methods for Non-Smooth Composite Convex Optimization

Quoc Tran-Dinh, Laboratory for Information and Inference Systems (LIONS), EPFL, Switzerland, EPFL STI IEL LIONS, ELD 243 (B,timent ELD) Station 11, Lausanne, 1015, Switzerland, quoc.trandinh@epfl.ch, Volkan Cevher

We study a smoothing framework using self-concordant barriers for non-smooth composite convex optimization. Self-concordant barriers have been widely used in interior-point methods but have not fully exploited in composite convex optimization settings. Our main idea is to use such functions for smoothing non-smooth convex problems, and to identify the advantages of this technique. Then, develop a class of optimization algorithms, including the first-order, second order and path-following methods, for solving non-smooth composite convex minimization problems with rigorous convergence guarantees.

■ MC28

28- Liberty Room

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Matthias Koeppe, Professor, UC Davis, 1 Shields Ave, Davis, CA, 95616, United States of America, mkoeppe@math.ucdavis.edu

1 - Boolean p-Power and p-Cut Polytopes

Miriam Schloeter, Institute of Mathematics - TU Berlin, Strasse des 17. Juni 136, MA 520, Berlin, 10587, Germany, schloeter@math.tu-berlin.de, Guenter M. Ziegler

In this talk we look at generalizations of the correlation polytope and the cut-polytope. We investigate some properties of these polytopes and mainly look at their symmetry groups. In 2013 Maksimenko introduced the boolean p-power polytope BQP(n,p), a generalization of the correlation polytope. We define the p-cut polytope CUT(n,p) which generalizes the cut-polytope and shares its symmetries - it is symmetric under switchings and permutations of coordinates. Also, we show that BQP(n,p) is linearly isomorphic to CUT(n+p-1,p) via a generalization of the covariance map. Further, we derive the Euclidean symmetry groups of CUT(n,p) and BQP(n,p), present some calculations regarding their affine symmetry group and derive it for special cases.

2 - Extreme Functions for the Gomory-Johnson Infinite Group Problem

Yuan Zhou, UC Davis, 1 Shields Ave, Davis, CA, 95616, United States of America, yzh@math.ucdavis.edu, Matthias Koeppe

Extreme functions for the Gomory-Johnson infinite group problem serve as strong cut-generating functions for general integer linear programs. For the single-row infinite group problem, our recent work on computer based search discovers piecewise linear extreme functions with up to 28 slopes, breaking the previous record of 5 slopes due to Hildebrand (2013). Several open questions are resolved by some other newly discovered extreme functions. We discuss various search approaches, their computational performance and limits.

3 - Light on the Infinite Group Relaxation

Matthias Koeppe, Professor, UC Davis, 1 Shields Ave., Davis, CA, 95616, United States of America, mkoeppe@math.ucdavis.edu, Yuan Zhou, Amitabh Basu, Robert Hildebrand

The infinite group problem was introduced 42 years ago by Gomory and Johnson in their famous papers titled "Some continuous functions related to corner polyhedra I, II". We now recognize this approach as one that was decades ahead of its time and may be the key to today's pressing need for stronger, multi-row cutting planes. I will survey the recent progress on the problem, present software, and highlight open questions.

■ MC29

29- Commonwealth 1

Splitting Methods and Applications

Cluster: Nonsmooth Optimization

Invited Session

Chair: Wotao Yin, Professor, University of California, Los Angeles, Box 951555, 520 Portola Plz, MS 7620B, Los Angeles, CA, 90095, United States of America, wotaoyin@math.ucla.edu

1 - Self Equivalence of the Alternating Direction Method of Multipliers

Ming Yan, Assistant Adjunct Professor, University of California, Los Angeles, Los Angeles, CA, 90095, United States of America, yanm@math.ucla.edu, Wotao Yin

In this talk, we show many of the seemingly different ways of applying ADM are equivalent. Specifically, we show that ADM applied to a primal formulation is equivalent to ADM applied to its Lagrange dual; ADM is equivalent to a primal-dual algorithm applied to the saddle-point formulation of the same problem. These results are surprising since some previous work exhibits strong preferences in one over the other on specific problems. In addition, when one of the two objective functions is quadratic, we show that swapping the update order of the two primal variables in ADM gives the same algorithm. These results identify the few truly different ADM algorithms for a problem, which generally have different forms of subproblems.

2 - A Three Operator Splitting Scheme and its Optimization Applications

Damek Davis, University of California, Los Angeles, Box 951555, Los Angeles, United States of America, damek@math.ucla.edu, Wotao Yin

For over 50 years, operator-splitting schemes have been used to solve PDE, feasibility problems, and more recently, large-scale problems in data analysis. Despite much development, it is known that all existing splitting schemes reduce to one of three basic schemes, each introduced between 15 and 36 years ago. In this talk, we introduce a new splitting scheme that extends the Douglas-Rachford and forward-backward splitting schemes to monotone inclusions with three operators, one of which is cocoercive. We discuss why this algorithm works, derive the currently simplest three-block and proximal ADMMs, and introduce two accelerations that achieve optimal rates for strongly monotone inclusions. Finally, we discuss several applications.

3 - Total Variation Image Deblurring with Space-varying Kernel via Douglas-Rachford Splitting

Daniel O'Connor, University of California, Los Angeles, 530 Glenrock Ave, #29, Los Angeles, CA, 90024, United States of America, daniel.v.oconnor@gmail.com, Lieven Vandenberghe

Most existing methods for total variation image deblurring use the L2-TV formulation and assume the blur kernel is spatially invariant. In this talk, we show that TV deblurring algorithms based on the Douglas-Rachford splitting method are able to handle non-quadratic data fidelity terms, general (non-periodic) boundary conditions, constraints, and also spatially variant blur kernels described by the Nagy-O'Leary and Efficient Filter Flow models. Moreover, these algorithms can be implemented with a low complexity per iteration, dominated by a small number of fast Fourier transforms. Thus, though these algorithms solve a much more general problem, they achieve a complexity that is comparable to that of standard L2-TV methods.

■ MC30

30- Commonwealth 2

Approximation and Online Algorithms II

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Samir Khuller, Professor and Chair, U. Maryland, AV Williams Bldg, College Park, MD, 20742, United States of America, samir@cs.umd.edu

1 - Scheduling with State-Dependent Machine Speeds

Veerle Timmermans, Maastricht University, Tongersestraat 53, Maastricht, Ne, 6211 LM, Netherlands, v.timmermans@maastrichtuniversity.nl, Tjark Vredeveld

We study a preemptive single machine scheduling problem where the machine speed is externally given and depends on the number of unfinished jobs. The objective is to minimize the sum of weighted completion times. We introduce a greedy algorithm that solves the problem to optimality when we work with either unit weights or unit processing times. If both weights and processing times are arbitrary, we show the problem is NP-hard by making a reduction from 3-partition.

2 - A Logarithmic Approximation for Matroid Congestion Models

Tim Oosterwijk, Maastricht University, Department of Quantitative Economics, Maastricht University, P.O. Box 616, Maastricht, Netherlands, t.oosterwijk@maastrichtuniversity.nl, Tjark Vredeveld, Tobias Harks

We study the problem of computing a social optimum in matroid congestion games, where the strategy space of every player consists of the set of bases of a player-specific matroid defined on the ground set of resources. We devise and analyse an approximation algorithm. The main idea of our algorithm is to iteratively increase resource utilization in a greedy fashion and to invoke a covering oracle that checks feasibility of every computed resource utilization.

3 - Busy and Active Time Scheduling

Samir Khuller, Professor and Chair, U. Maryland, AV Williams Bldg, College Park, MD, 20742, United States of America, samir@cs.umd.edu, Jessica Chang, Koyel Mukherjee

Traditional scheduling algorithms, especially those involving job scheduling on parallel machines, make the assumption that the machines are always available and try to schedule jobs to minimize specific job related metrics. Since modern data centers consume massive amounts of energy, we consider job scheduling problems that take energy consumption into account, turning machines off, especially during periods of low demand. The ensuing problems relate very closely to classical covering problems such as capacitated set cover, and we discuss several recent results in this regard. In summary, we study several batch scheduling problems under different constraints, taking energy cost into account.

Monday, 2:45pm - 4:15pm

■ MD01

01- Grand 1

Advances in Penalization Methods for Linear and Nonlinear Programming

Cluster: Variational Analysis

Invited Session

Chair: Roger Behling, Professor, Federal University of Santa Catarina, Campus Blumenau, Blumenau, SC, 89065-300, Brazil, rogerbehling@gmail.com

1 - Penalizing Simple Constraints on Augmented Lagrangian Methods

Luis Felipe Bueno, Professor, Federal University of São Paulo, Campus São José dos Campos, São José dos Campos, SP, 12230240, Brazil, lfelipebueno@gmail.com, José Mario Martìnez, Ernesto G. Birgin

In this work an Augmented Lagrangian approach will be presented to solve optimization problems where simple constraints will be penalized. Our proposal is innovative because it breaks a usual paradigm which is to maintain the feasibility with respect to these constraints in this kind of methods. We will discuss the possibility of using this approach against active set methods and, mainly, against interior point methods. We will highlight the algebraic and geometric advantages involved in this approach. We will also present some relations with Inexact Restoration methods and Proximal methods for linear and nonlinear programming.

2 - Convergence Analysis of an Infeasible Interior-Point Method with Optimized Choice of Parameters

Luiz-Rafael Santos, Professor, Federal University of Santa Catarina, Campus Blumenau, Blumenau, SC, 89065-300, Brazil, lrsantos11@gmail.com, Fernando Villas-Boas, Aurelio Oliveira, Clovis Perin

In this work, we propose a predictor-corrector interior-point method for linear programming, where the next iterate is chosen by the minimization of a polynomial merit function on three variables: one is the step length, one defines the central path and the last one models the weight that a corrector direction must have. In this framework, we combine different directions with the aim of producing a better one. The proposed method generalizes most of predictor-corrector interior-point methods, depending on the choice of the variables described above. Convergence analysis and numerical experiments of the method are carried out, which show that this approach is competitive when compared to well established solvers, such as PCx.

3 - The Effect of Calmness on the Solution Set of Systems of Nonlinear Equations

Roger Behling, Professor, Federal University of Santa Catarina, Campus Blumenau, Blumenau, SC, 89065-300, Brazil, rogerbehling@gmail.com, Alfredo Iusem

We address the problem of solving a continuously differentiable nonlinear system of equations under the condition of calmness. This property is known to be significantly weaker than classic regularity assumptions that imply that solutions are isolated. We prove that under this condition, the rank of the Jacobian of the function that defines the system of equations must be locally constant on the solution set. In addition, we prove that locally, the solution set must be a differentiable manifold. Our results are illustrated by examples and discussed in terms of their theoretical relevance and algorithmic implications.

■ MD02

02- Grand 2

Complementarity Modelling in the Energy Sector

Cluster: Optimization in Energy Systems

Invited Session

Chair: Afzal Siddiqui, University College London, Department of Statistical Science, Gower Street, London, WC1E 6BT, United Kingdom, afzal.siddiqui@ucl.ac.uk

1 - Benders' Decomposition for Strategic Bidding Modeling in Wind-Integrated Power Systems

Ekaterina Moiseeva, PhD Student, KTH Royal Institute of Technology, Teknikringen 33, Stockholm, 10044, Sweden, moiseeva@kth.se, Mohammad Reza Hesamzadeh

The need for fast-ramping generators is especially high in wind-integrated systems. If we consider the uncertainty the problem of a profit-maximizing power company able to withhold the ramp-rate takes a form of a stochastic MPEC, which we recast as a MILP. We accelerate the convergence by applying the Benders' decomposition preceded by a bounding phase based on Jensen's inequality, and solving the linear subproblems in parallel.

2 - Endogenizing Long-Term Contracts in Gas Market Models

Yves Smeers, Professor, Université Catholique de Louvain, CORE, Voie du Roman Pays, 34, Louvain-la-Neuve, 1348, Belgium, yvessmeers@me.com, Ibrahim Abada, Andreas Ehrenmann

We present a stochastic equilibrium model that endogenously captures the contracting behavior of both the producer and the mid-streamer who strive to hedge their profit related risk and can select among contracts indexed on oil and spot gas prices. We test the impact of correlation between oil and spot gas prices and of the structure of upstream cost.

3 - How Much is Enough? Optimal Capacity Payments in a Renewable-Rich Power System

Afzal Siddiqui, University College London, Department of Statistical Science, Gower Street, London, WC1E 6BT, United Kingdom, afzal.siddiqui@ucl.ac.uk, Tuomas Rintam aeki, Ahti Salo

In Germany, the deployment of intermittent renewable energy sources has increased the need for offsetting flexible capacity. The uneven geographical distribution of wind power is causing congestion in the transmission grid, which creates a need for fast-adjusting balancing capacity. Recently, capacity payments to flexible plants have been proposed by the government to mitigate energy imbalances. We take the perspective of the regulator via a bi-level programming model to study the impacts of capacity payments and to determine their optimal level. Our results suggest that although such payments do not necessarily lower system costs, they, nevertheless, alleviate congestion and may be used as part of policy to integrate renewable energy.

■ MD03

03- Grand 3

Submodularity in Machine Learning – Theory and Practice

Cluster: Combinatorial Optimization

Invited Session

Chair: Stefanie Jegelka, Assistant Professor, MIT, Stata Center, Cambridge, MA, 02139, United States of America, stefje@mit.edu

1 - Linear Programming and Valued Constraint Satisfaction Problems

Vladimir Kolmogorov, Professor, IST Austria, Am Campus 1, Klosterneuburg, Austria, vnk@ist.ac.at

I will consider the Valued Constraint Satisfaction Problem (VCSP), whose goal is to minimize a sum of local terms where each term comes from a fixed set of functions (called a "language") over a fixed discrete domain. I will present recent results characterizing languages that can be solved using the basic LP relaxation. This includes languages consisting of submodular functions, as well as their generalizations. Based on joint papers with Andrei Krokhin, Michal Rolinek, Johan Thapper and Stanislav Zivny.

2 - Submodular Labeling Problems in Image Segmentation

Jan Vondrak, IBM Almaden Research Center, 650 Harry Rd, San Jose, CA, 95120, United States of America, jvondrak@gmail.com

We will discuss labeling/partitioning problems that arise in image segmentation. An example of such a problem is uniform metric labeling. More generally, submodular cost functions arise naturally in this context. I will describe algorithms with optimal approximation factors (assuming the UGC) for several variants of such problems.

3 - Submodular Semidifferentials: Polyhedra, Algorithms and Applications

Rishabh Iyer, PhD Student, University of Washington, Department of Electrical Engg, Seattle, WA, 98195, United States of America, rkiyer@u.washington.edu, Jeff Bilmes

In this work, we investigate submodular semidifferentials from a polyhedral and algorithmic point of view. In particular, we show the existence of the superdifferentials and tight modular upper bounds of a submodular function, and contrast this with existing results on the subdifferential of a submodular functions. We then discuss several applications of these semidifferentials (i.e sub and super differentials), including a majorization-minimization framework of algorithms for several classes of submodular optimization problems. Finally, we show connections between optimality conditions over the superdifferentials and submodular maximization, and contrast them to existing results connecting subdifferentials and submodular minimization.

■ MD04

04- Grand 4

Linear Algebra Techniques in Conic Optimization

Cluster: Conic Programming

Invited Session

Chair: Jacek Gondzio, Professor, University of Edinburgh, King's Buildings, Edinburgh, Edinburgh, EH9 3FD, United Kingdom, J.Gondzio@ed.ac.uk

1 - On the Linear Algebra Employed in the MOSEK Conic Optimizer

Erling Andersen, CEO, MOSEK ApS, Fruebjergvej 3, Copenhagen, 2100, Denmark, e.d.andersen@mosek.com

MOSEK implements a high performance interior-point based optimizer for linear, conic quadratic and semidefinite optimization problems. In this talk we will discuss the linear algebra techniques employed in the interior-point optimizer to achieve good performance. In particular we will discuss how we have addressed the many core challenge i.e. how to exploit all the cores modern CPUs have.

2 - A New Approach for Solving Large Sparse Semidefinite Programming Problems with Interior Point Methods

Stefania Bellavia, Universita degli Studi di Firenze, stefania.bellavia@unifi.it, Margherita Porcelli, Jacek Gondzio

Interior point methods for Semidefinite Programming (SDP) face a difficult linear algebra subproblem. We propose an algorithm which allows for an iterative scheme to solve the Newton equation system arising in SDP. It relies on a new preconditioner which exploits well the sparsity of matrices. Theoretical insights into the method will be provided. Computational results will be reported.

3 - Stability of Preconditioned Solvers in Inexact Interior-point Methods

Benedetta Morini, Universita di Firenze, viale G.B. Morgagni 40, Firenze, Italy, benedetta.morini@unifi.it, Valeria Simoncini

Primal-dual interior point (IP) methods for large convex quadratic programming require the solution of a linear system at each iteration, to compute the next step. We consider symmetric indefinite formulations for this system and iterative solvers for its approximate solution. We discuss some issues arising in this linear algebra phase including: conditioning of the preconditioned problem, IP-driven stopping criteria for the solver, and accuracy of the inexact step taking into account finite precision arithmetic.

■ MD05

05- Kings Garden 1

Nonconvex Optimization and Eigenvalues

Cluster: Nonlinear Programming

Invited Session

Chair: Yuji Nakatsukasa, University of Tokyo, Deptartmeht of Mathematical Informatics, Tokyo, 113-8656, Japan, nakatsukasa@mist.i.u-tokyo.ac.jp

1 - Solving the Trust Region Subproblem by a Generalized Eigenvalue Problem

Yuji Nakatsukasa, University of Tokyo, Deptartment of Mathematical Informatics, Tokyo, 113-8656, Japan, nakatsukasa@mist.i.u-tokyo.ac.jp, Satoru Iwata, Satoru Adachi, Akiko Takeda

The trust region subproblem is usually solved via an iterative process. An alternative approach is semidefinite programming, but this also involves solving linear systems iteratively. This work introduces an algorithm that requires just one eigenpair of a generalized eigenvalue problem. Our algorithm deals with the so-called hard case, directly allows for non-standard norms without changing variables, and is suited both to dense and large-sparse problems. We demonstrate its accuracy and efficiency through experiments.

2 - A Polynomial-Time Algorithm for Nonconvex Quadratic Optimization with Two Quadratic Constraints

Shinsaku Sakaue, University of Tokyo, Dept. Mathematical Informatics, University of Tokyo, Tokyo, 113-8656, Japan, shinsaku_sakaue@mist.i.u-tokyo.ac.jp, Yuji Nakatsukasa, Akiko Takeda, Satoru Iwata

We consider nonconvex quadratic optimization with two quadratic constraints (2QCQP), which includes the Celis-Denis-Tapia (CDT) problem. Until Bienstock's recent work, no polynomial-time algorithm was known for CDT. His algorithm solves CDT by admitting small errors in constraints. However, its implementation seems not straightforward. In this presentation, we propose a polynomial-time algorithm to solve 2QCQP exactly. Our algorithm computes all Lagrange multipliers via eigenvalue computation, obtains all KKT points, and finds a global solution among them.

3 - Global Convergence of the Higher-Order Power Method for Tensors via Lojasiewicz Inequality

André Uschmajew, University of Bonn, Wegelerstr. 6, 53115 Bonn, Germany, uschmajew@ins.uni-bonn.de

The higher-order power method for calculating the largest singular value of the multilinear form associated to a tensor under spherical constraints generalizes the matrix power method. It is equivalent to the alternating least-squares algorithm for best rank-one approximation. The question of global convergence (to some critical point of the multilinear form) of this algorithm has been an open problem, and was only recently established for almost every tensor by Wang and Chu. By making use of nontrivial, but well-known results on point-wise convergence of discrete gradient flows in the presence of Lojasiewicz gradient inequality, we can give an alternative, more direct proof of convergence that applies to every tensor.

■ MD06

06- Kings Garden 2

Incremental Network Design

Cluster: Telecommunications and Networks

Invited Session

Chair: Dmytro Matsypura, The University of Sydney, Rm 478 Merewether Building H04, Sydney, Australia, dmytro.matsypura@sydney.edu.au

1 - A Robust Optimisation Approach to Bushfire Fuel Management

Dmytro Matsypura, The University of Sydney, Rm 478 Merewether Building H04, Sydney, Australia, dmytro.matsypura@sydney.edu.au, Oleg Prokopyev

Bushfires represent a real and continuing problem that can have a major impact on people, wildlife and the environment. One way to reduce the severity of their effect is through fuel management, which usually consists of mechanical thinning and prescribed burning of the landscape. We propose a general methodology to address the problem of optimal resource allocation for bushfire fuel management subject to landscape connectivity and stochastic fuel regeneration. We develop a number of mixed integer programming formulations that are based on various landscape connectivity metrics and present extensive computational experiments that reveal interesting insights and demonstrate advantages and limitations of the proposed framework.

2 - On Incremental Network Design Under Uncertainty

Pavlo Krokhmal, University of Iowa, 2136 Seamans Center, Iowa City, IA, 52242, United States of America, krokhmal@engineering.uiowa.edu, Nathaniel Richmond

We consider the incremental network design problem, where the goal is to improve an existing network by building new arcs, given that only one arc can be built at a time, the arc budget is limited, and at each time step the desired network characteristic (e.g., a shortest path between two nodes) is minimized. Previous studies have shown this problem to be NP-hard. A stochastic extension of the problem is presented, and the theoretical and computational properties of its solutions are discussed.

3 - Network Flows with Blending Constraints: Application to Lithium Mining

Paul Bosch, Universidad del Desarrollo, Ave. Plaza 680, Las Condes, Santiago, Chile, pbosch@udd.cl

We present a blending model of chemical solutions over a network of interconnected pipes and pumps. The main objective of the model is to achieve quality requirements on the network's output. The traditional way of modelling this problem considers flow and quality variables, under the new proposed model the focus is on feasibility, the problem is transformed into a non-convex network flow problem. The model has been numerically implemented and tested, the results confirm the adequacy of the modelling approach to provide solutions to the problem.

■ MD07

07- Kings Garden 3

Data Sparsity in Optimization

Cluster: Sparse Optimization and Applications

Invited Session

Chair: John Duchi, Stanford University, Sequoia Hall 126, 390 Serra Mall, Stanford, CA, 94305, United States of America, jduchi@stanford.edu

1 - Measure Twice, Cut Once: Measuring Sparsity to Improve Computation

Christopher Re, Professor, Stanford University, Computer Science Department, Stanford, CA, 94305, United States of America, chrismre@cs.stanford.edu

Sparsity can be a challenge statistically and computationally, but it can also be an opportunity. This talk will describe two ways in which measuring sparsity led us to improve an algorithm's run-time. First, I'll describe asynchronous optimization algorithms in our Hogwild! and DimmWitted projects, whose central technical results revolve around different ways of measuring sparsity to provide for more rapidly converging algorithms. Second, I will describe a discrete case in which we used a kind of sparsity measure as a proxy for complexity. This led to unexpected geometric algorithms for classical problems such as finding motifs in graphs and problems in logic, which allow us to provide instance optimality runtime guarantees.

2 - Robustness, Long Tails, and Data Sparsity

John Duchi, Stanford University, Sequoia Hall 126, 390 Serra Mall, Stanford, CA, 94305, United States of America, jduchi@stanford.edu

We study stochastic optimization problems when data is sparse and long-tailed, which is in a sense dual to current perspectives on high-dimensional statistical learning and optimization. We highlight difficulties—in terms of slower convergence rates and increased sample complexity that sparse data necessitates—and potential benefits, in terms of allowing asynchrony in design of algorithms. We also consider robustness and adaptivity to sparsity, developing procedures that are robust to changes in the distribution generating problem data, showing optimization and estimation consequences thereof. We provide experimental evidence complementing our theoretical results on several medium to large-scale tasks.

3 - A General Framework for Fast Stagewise Algorithms

Ryan Tibshirani, Assistant Professor, Carnegie Mellon University, 229B Baker Hall, Pittsburgh, PA, 15213, United States of America, ryantibs@gmail.com

Forward stagewise regression has an intriguing connection to the lasso. Under some conditions, it can be shown that the sequence of forward stagewise estimates exactly coincides with the lasso path, as the stagewise step size goes to zero. Even when they do not match their l1-regularized analogues, stagewise estimates are statistically useful and computationally appealing. This motivates the question: can a simple, effective strategy like forward stagewise be applied more broadly in other regularization settings, beyond the l1 norm and sparsity? I present a general framework for stagewise estimation, which yields fast algorithms for problems such as group-structured learning, matrix completion, image denoising, and more.

■ MD08

08- Kings Garden 4

Bilevel Programming Problems in Combinatorial Optimization and Game Theory

Cluster: Combinatorial Optimization

Invited Session

Chair: Stefano Coniglio, PhD, RWTH Aachen University, Lehrstuhl 2 für Mathematik, Pontdriesch 14-16, Aachen, 52062, Germany, coniglio@math2.rwth-aachen.de

1 - Bilevel Optimization in Game Theory

Margarida Carvalho, INESC TEC and Faculty of Sciences, University of Porto, Rua Campo Alegre 1021/1055, Porto, 4169-007, Portugal, margarida.carvalho@dcc.fc.up.pt, Alberto Caprara, Gerhard Woeginger, Andrea Lodi

Real economic markets can be described as games, this is, a participant decision has influence in the other participants' revenues. In this presentation, an algorithmic method for a sequential game, the bilevel knapsack with interdiction constraints, is proposed and it's generalization to other competitive games is discussed. We conclude by showing that a broad class of simultaneous mixed integer games is at least as hard as this bilevel knapsack problem.

2 - A Backward Sampling Framework for Interdiction Problems with Fortification

Leonardo Lozano, PhD Student, Clemson University, llozano@clemson.edu, Cole Smith

We examine a class of three-stage sequential defender-attacker-defender problems that are notoriously difficult to optimize, and almost always require the third-stage (recourse) problem to be a convex optimization problem. We propose a new approach in which we allow the recourse problem to take any form. The proposed framework restricts the defender to select a recourse decision from a sample of feasible vectors and iteratively refines the sample to force finite convergence to an optimal solution. We provide computational experiments on the traveling salesman interdiction problem with fortification to demonstrate that our algorithm solves interdiction problems involving NP-hard recourse problems within reasonable computational limits.

3 - Novel Formulations for General Stackelberg and Stackelberg Security Games

Carlos Casorran-Amilburu, PhD Candidate, Université Libre de Bruxelles, Boulevard du Triomphe B-1050 Bruxelles, Brussels, 1050, Belgium, casorranamilburu@gmail.com, Martine Labbé, Fernando Ordóñez, Bernard Fortz

We categorize Stackelberg Game formulations present in the literature, according to their use of big M constants and explore how they can be ordered in terms of tightness of their continuous relaxation. We present a novel formulation whose constraints do not require large positive constants. We provide tight values for these big M constants in each of the formulations and perform exhaustive computational experiments between formulations to see where we stand. We establish a relationship between the novel formulations provided for the General Stackelberg Games and for Security Games by means of a projection result and obtain convex hull-defining formulations when we restrict the problem to a single type of follower.

■ MD09

09- Kings Garden 5

Optimization under Uncertainty I

Cluster: Combinatorial Optimization

Invited Session

Chair: Nicole Megow, Technische Universitaet Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, nmegow@math.tu-berlin.de

1 - A Randomized Algorithm for MST with Uncertainties

Julie Meissner, TU Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, jmeiss@math.tu-berlin.de, Nicole Megow, Martin Skutella

We study a network design model where uncertain data is given in the form of intervals and exact data can be explored at a certain cost. The goal is to find the optimal network minimizing the exploration cost. For the minimum spanning tree problem with uncertainties we present the first randomized algorithm that beats the deterministic lower bound of 2. We achieve a competitive ratio of roughly 1.707 in expectation.

2 - On the Adaptivity Gap of Stochastic Orienteering

Viswanath Nagarajan, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, viswa@umich.edu, Nikhil Bansal

The orienteering problem is a basic vehicle routing problem that has many applications. The input consists of a set of locations with associated rewards, distance bound B and a designated depot. In the stochastic orienteering problem, each location also has a random processing time which is realized only when that location is visited. The objective here is to find a non-anticipatory policy to visit locations that maximizes the expected reward subject to the total distance plus processing time being at most B. We focus on a natural special class of "non-adaptive" policies that are just specified by a permutation of the locations, and obtain results on how well such policies approximate the optimal adaptive policy.

3 - Stochastic Scheduling on Unrelated Machines

Marc Uetz, University of Twente, P.O. Box 217, Enschede, 7500AE, Netherlands, m.uetz@utwente.nl, Martin Skutella, Maxim Sviridenko

In this talk we study for the first time a scheduling problem that combines the classical unrelated machine scheduling model with stochastic processing times of jobs. By means of a novel time indexed linear programming relaxation, we compute in polynomial time a scheduling policy with performance guarantee (3+D)/2. Here, D is an upper bound on the squared coefficient of variation of the processing times. When jobs also have individual release dates, our bound is 2+D. We also show that the dependence of the performance guarantees on D is tight. Specifically, via D=0 the currently best known bounds for deterministic scheduling on unrelated machines are contained as special case.

■ MD10

10- Kings Terrace

Supply Chains

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Arindum Mukhopadhyay, Assistant Professor, IIM Shillong, Nongthymmai, Meghalaya, Shillong, 793014, India, arindum.iitkgp@gmail.com

1 - NLP and Derivative-Free Methods for Multi-Echelon Inventory Optimization: An Industrial Perspective

Anshul Agarwal, Associate Research Scientist, The Dow Chemical Company, 2301 Brazosport Blvd, B1603/1107, Freeport, TX, 77541, United States of America, AAgarwal2@dow.com, John M. Wassick

We present a nonlinear programming model for multi-echelon inventory optimization that captures reorder point undershoot and uses stochastic service time approach for lead time delay. Based on NLP results, we demonstrate how traditional mathematical programming approaches underestimate optimal inventory. We present a novel derivative-free simulation-optimization algorithm that uses sample average approximation, quantifies uncertainty by bootstrapping historical data, is computationally fast, captures non-standard inventory policies and constraints, and performs service level optimization. Industrial examples are presented.

2 - The Newsvendor Problem with Price-Dependent, Isoelastic Demand: Optimality and Risk Considerations

Javier Rubio-Herrero, Rutgers University, 100 Rockafeller Rd, Piscataway, NJ, 08854, United States of America, javier.rubioherrero@rutgers.edu, Melike Baykal-Gürsoy

We introduce the single-stage newsvendor problem with price-dependent, multiplicative, isoelastic demand. The goal of this study is to analyze the optimality of this problem when there are two decision variables, price and order quantity, and different risk considerations, namely risk-averse and risk-seeking individuals. We perform this work under the light of a mean-variance analysis and compare our results to others previously published using different measures of risk.

■ MD11

11- Brigade

Combinatorial Optimization under Uncertainty

Cluster: Combinatorial Optimization

Invited Session

Chair: Arie M.C.A. Koster, Professor, RWTH Aachen University, Lehrstuhl II für Mathematik, Aachen, 52056, Germany, koster@math2.rwth-aachen.de

1 - Dynamic Shortest-Path Interdiction

Cole Smith, Clemson University, jcsmith@clemson.edu, Jorge Sefair

We study a dynamic network game between an attacker and a user. The user wishes to traverse a shortest path, and the attacker seeks to interdict arcs to maximize the user's shortest-path cost. The attacker can interdict arcs any time the user reaches a node, and the user can respond by dynamically altering its chosen path. The challenge is to find an optimal path, coupled with the attacker's optimal interdiction strategy. We provide an exponential-state dynamic-programming algorithm, which can be reduced to a polynomial-time algorithm in the case of acyclic networks. We then develop bounds for the problem based on 2-stage interdiction and robust optimization models, or based on an exact solution to variations of this problem.

2 - Robust Maximum Flows over Time

Andreas Wierz, RWTH Aachen University, Kackertstrafle 7, Aachen, 52064, Germany, andreas.wierz@oms.rwth-aachen.de, Arie M.C.A. Koster, Frauke Liers, Britta Peis, Daniel Schmand, Corinna Gottschalk

We combine the fascinating world of robust optimization problems with the well-studied topic of maximum flows over time. Maximum flows over time seek to maximize the total throughput of a network within a given time horizon while flow requires a certain travel time in order to traverse each of the network's arcs. We investigate this problem in the presence of uncertain travel times under algorithmic and complexity theoretical aspects. A nominal travel time and a delay is known for each arc. Each arc assumes either its nominal or its delayed travel time and we assume that only a bounded number of edges may be disturbed simultaneously. Solutions have to satisfy ordinary flow constraints and the worst-case flow value is sought to be maximized.

3 - The Firefighter-Problem with Multiple Fires – On the Survival Rate of Trees

Nils Spiekermann, Lehrstuhl II für Mathematik RWTH Aachen University, Pontdriesch 14-16, Aachen, D-52062, Germany, spiekermann@math2.rwth-aachen.de, Eberhard Triesch

This talk deals with the firefighter problem, a game of bounding fire outbreaks on the vertices of a graph. Aim is to maximize the surviving-rate, the percentage of the vertices that can be protected on average if fires break out randomly. We extend the asymptotic constant lower bound by Cai and Wang (SIAM J. Discrete Math., 2009) for the case with one fire and one firefighter on trees, to an abritrary number of fires.

■ MD12 2:45pm - 3:25pm

12- Black Diamond

Do Analytics LLC - OPTEX Mathematical Modeling System: The Meta-Framework for Mathematical Programming

Cluster: Software Presentations

Invited Session

Chair: Jesús Velasquez, Mathematical Programming Entrepreneur - CEO and Chief Scientist, DecisionWare International Corp., Finca la Antigua, Tabio, Bogotá, Cu, Colombia, jesus.velasquez@decisionware.net

1 - Do Analytics LLC - OPTEX Mathematical Modeling System: The Meta-Framework for Mathematical Programming

Jes˙s Velasquez, Mathematical Programming Entrepreneur - CEO and Chief Scientist, DecisionWare International Corp., Finca la Antigua, Tabio, Bogota, Cu, Colombia, jesus.velasquez@decisionware.net

From 2015, the way how you make Optimization projects is going to be changed. A new company, a new technology, and a new methodology to implement real large scale mathematical programming models. Do Analytics presents OPTEX, a powerful meta-platform that: * Generates programming codes in the most powerful optimization technologies, including the SQL statements to connect any DBMS. * Mixes the power of an optimization technology with the easiness of EXCEL. * Works as a client and as an optimization server in the cloud. Easy and Fast, OPTEX represents the new generation to Do Analytics.

■ MD13

13- Rivers

Conic Programming for Low-Rank Matrix Recovery: Recent Advances in Convergence Rate Analysis and Recovery Guarantees

Cluster: Conic Programming

Invited Session

Chair: Anthony Man-Cho So, The Chinese University of Hong Kong, Dept of Sys Engg & Eng Mgmt, Shatin, NT, Hong Kong - PRC, manchoso@se.cuhk.edu.hk

1 - Convex Optimization Learning of Faithful Euclidean Distance Matrices in Dimensionality Reduction

Chao Ding, Assistant professor, Chinese Academy of Sciences, No. 55, Zhong Guan Cun Dong Lu, Haidian District, Beijing, 100190, China, dingchao@amss.ac.cn, Hou-Duo Qi

In this talk, we propose a new convex optimization model of learning Faithful Euclidean distance representations from noisy partial distances observations. For the proposed convex model, we establish a non-asymptotic error bound for the random graph model with sub-Gaussian noise, and prove that our model produces a matrix estimator of high accuracy when the order of the uniform sample size is roughly the degree of freedom of a low-rank matrix up to a logarithmic factor. A fast inexact accelerated proximal gradient method is developed, and numerical experiments show the model can produce configurations of high quality on large data points that the popular SDP approaches such as MVU and MVE would struggle to cope with.

2 - A Schatten p-Norm Perturbation Inequality and its Applications in Low-Rank Matrix Recovery

Man-Chung Yue, PhD, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, RM 2511, Man Tai House, Tsz Man Est.,, Tsz Wan Shan, KLN, Hong Kong, Hong Kong - PRC, mcyue@se.cuhk.edu.hk, Anthony Man-Cho So

In this paper, we prove a version of generalized Mirsky inequality, which answers an open question raised both in low-rank matrix recovery and linear algebra communities. As an application, we confirm the validity of a number of previously conjectured sufficient conditions for low-rank matrix recovery via the popular Schatten p-norm heuristic with $p<1$. This inequality also enables us to show that, for sufficiently small $p>0$, the number of samples needed for recovering a low-rank matrix using Schatten p-norm is less than that of using nuclear norm.

3 - On the Convergence Rate of the Proximal Gradient Method for Trace Norm Regularization

Zirui Zhou, The Chinese University of Hong Kong, ERB 511D, CUHK, Hong Kong, Hong Kong - PRC, zrzhou@se.cuhk.edu.hk, Anthony Man-Cho So

Motivated by various applications in machine learning, the problem of minimizing a convex smooth loss function with trace norm regularization has received much attention lately. Currently, a popular method for solving such problem is the proximal gradient method (PGM), which is known to have a sublinear rate of convergence. In this paper, we show that for a large class of loss functions, if strict complementarity condition is satisfied, the convergence rate of the PGM is in fact linear. Our result is established without any strong convexity assumption on the loss function. A key ingredient in our proof is a new Lipschitzian error bound for the aforementioned trace normñregularized problem, which may be of independent interest.

■ MD14

14- Traders

Games of Limited and Unlimited Rationality

Cluster: Game Theory

Invited Session

Chair: Nick Gravin, Microsoft Research, One Memorial Drive, Cambridge, Ma, 02142, United States of America, ngravin@gmail.com

1 - Economics of Repeated Sales

Balasubramanian Sivan, Microsoft Research, One Microsoft Way, Redmond, WA, 98052-6399, United States of America, balu2901@gmail.com, Nikhil R. Devanur, Yuval Peres

A special case of Myerson's (1981) classic work solves the revenue optimal mechanism design problem when a single seller sells a single item to a single buyer. In this talk, we consider a repeated version of this interaction: a seller offers to sell a single fresh copy of an item to the same buyer every day via a posted price. We compute the revenue in equilibrium when the seller is unable to commit to future prices, and also the setting when the seller is able to commit to not increase future prices upon purchase, but retains the right to lower future prices in the absence of a purchase. We highlight the striking difference in revenue between these two settings.

2 - Optimal Contracts for Revenue Extraction with Procrastinating Buyers

Emmanouil Pountourakis, PhD Candidate, Northwestern University, 2133 Sheridan Rd,, Ford Building, Ford 3-227, Evanston, IL, 60201, United States of America, manolis@u.northwestern.edu, Nicole Immorlica, Nick Gravin, Brendan Lucier

Motivated by time-inconsistent customers' behavior like in predatory money landing, and late payment fees for credit cards and utility bills we study contract design over an extended period of time for a procrastinating agent using a standard model from behavioral Economics. We assume that customer has a present bias, i.e., he overrates any immediate payment by a multiplicative factor, which is i.i.d random variable. We study structure and revenue of the optimal contract and how certain natural regulations on the contract space can affect maximal revenue.

3 - Level-0 Meta-Models for Predicting Human Behavior in Games

James Wright, PhD Candidate, University of British Columbia, 201-2366 Main Mall, Vancouver, BC, V6T 1Z4, Canada, jrwright@cs.ubc.ca, Kevin Leyton-Brown

Our own recent work has identified iterative models (e.g., quantal cognitive hierarchy) as the state of the art for predicting human play in unrepeated, simultaneous-move games. Iterative models predict that agents reason iteratively about their opponents, starting from a specification of nonstrategic behavior called level-0. In this work we replace the standard level-0 model (a uniform distribution over actions) with a ``meta-model" of how level-0 agents choose an action, given an arbitrary game, yielding substantial predictive improvements.

■ MD15

15- Chartiers

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Jose Luis Morales, Professor, ITAM, Crepusculo 53 302, Mexico City, DF, 04530, Mexico, jmorales@itam.mx

1 - Compressibility of Positive Semidefinite Factorizations

Cyril Stark, MIT, 77 Massachusetts Ave, 6-304, Cambridge, MA, 02139, United States of America, cyril@mit.edu, Aram Harrow

We investigate compressibility of the dimension of positive semidefinite matrices while approximately preserving their pairwise inner products. This can either be regarded as compression of positive semidefinite factorizations of nonnegative matrices or (if the matrices are subject to additional normalization constraints) as compression of quantum models. We derive both lower and upper bounds on compressibility. Applications are broad and range from the analysis of robustness of positive semidefinite rank to bounding the one-way quantum communication complexity of Boolean functions. (Related preprint available under arXiv:1412.7437).

2 - On the Design and Implementation of SQP Methods

Jose Luis Morales, Professor, ITAM, Crepusculo 53 302, Mexico City, DF, 04530, Mexico, jmorales@itam.mx

In this talk we will discuss different aspects related with the design and implementation of SQP methods. We will focus on methods able to solve problems in the large scale setting.

3 - Alternating Linearization for Structured Regularization Problems

Minh Pham, Research Associate, SAMSI / Duke University, 19 TW Alexander Dr., Durham, NC, 27707, United States of America, ptuanminh@gmail.com, Andrzej Ruszczynski

We adapt the alternating linearization method for proximal decomposition to structured regularization problems, in particular, to the generalized lasso problems. The method is related to two well-known operator splitting methods, the Douglas-Rachford and the Peaceman-Rachford method, but it has descent properties with respect to the objective function. The convergence mechanism is related to that of bundle methods of nonsmooth optimization.We also discuss implementation for very large problems, with the use of specialized algorithms and sparse data structures. Finally, we present numerical results for several examples, including a three-dimensional fused lasso problem, which illustrate the scalability, efficacy, and accuracy of the method.

■ MD16

16- Sterlings 1

News in High Performance MIP Software

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Thorsten Koch, Prof. Dr., ZIB / TU Berlin, Takustr. 7, Berlin, 14195, Germany, koch@zib.de

1 - Presolving in Mixed Integer Programming

Tobias Achterberg, Gurobi Optimization, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, achterberg@gurobi.com, Edward Rothberg, Zonghao Gu, Robert Bixby, Dieter Weninger

A critical component in the solution of mixed integer programs is a set of routines commonly referred to as presolve. Presolve can be viewed as a collection of preprocessing techniques that reduce the size of and, more importantly, improve the ``strength" of the given model formulation, that is, the degree to which the constraints of the formulation accurately describe the underlying polyhedron of integer-feasible solutions. In the Gurobi commercial mixed integer solver, the presolve functionality has been steadily enhanced over time. In this talk we give an overview of the techniques implemented in Gurobi and present detailed computational results to assess their impact on overall solver performance.

2 - Recent Enhancements of the FICO Xpress Optimizer

Michael Perregaard, Fair Isaac Europe Ltd, International Square, Birmingham, United Kingdom, michaelperregaard@fico.com

We will present what is new in the linear, mixed integer and non-linear programming solvers within the Xpress Optimization Suite. This includes new solution refinement techniques to return more accurate solutions for both linear and mixed integer linear programs, including a new strong dual sensitivity analysis. We will also cover performance related features, such as a new handling of extensive non-linear formulas.

3 - Recent Advances in the SCIP Optimization Suite for Solving Mixed Integer Programs

Gregor Hendel, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, hendel@zib.de

The SCIP Optimization Suite provides flexible tools for modeling and solving various optimization problems. It is build around the Constraint Integer Programming framework SCIP, one of the fastest solvers for Mixed Integer Programs available in source code. After a brief introduction of key concepts behind SCIP, we focus on recent advances for MIP in its latest release, among which are new branching concepts, techniques for reoptimization with varying cost functions, and multicriteria optimization.

■ MD17

17- Sterlings 2

Methods for Large Scale Composite Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Marianna De Santis, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, marianna.de.santis@math.tu-dortmund.de

Co-Chair: Kimon Fountoulakis, The University of Edinburgh, k.fountoulakis@sms.ed.ac.uk

1 - Performance of First- and Second-Order Methods for Huge Scale Optimization

Kimon Fountoulakis, The University of Edinburgh, k.fountoulakis@sms.ed.ac.uk, Jacek Gondzio

We study the performance of first- and second-order optimization methods for l1-regularized sparse least-squares problems as the conditioning and the dimensions of the problem increase up to one trillion. A rigorously defined generator is presented which allows control of the dimensions, the conditioning and the sparsity of the problem. The generator has very low memory requirements and scales well with the dimensions of the problem.

2 - A Fast Active-Set Block Coordinate Descent Algorithm for l1-regularized Problems

Francesco Rinaldi, Department of Mathematics University of Padua, via Trieste, 73, Padua, Italy, rinaldi@math.unipd.it, Marianna De Santis, Stefano Lucidi

The problem of finding sparse solutions to large-scale l1-regularized problems arises in several applications. In this talk, we propose an active-set block coordinate descent approach for l-1 regularized problems. We analyze the convergence properties of the proposed method, prove that its basic version converges with linear rate, and report some numerical results showing the effectiveness of the approach.

3 - Iterative Sketching for Fast Solution Approximation in Constrained Least-Squares Problems

Mert Pilanci, UC Berkeley, Berkeley, CA, Berkeley, United States of America, mert@eecs.berkeley.edu, Martin Wainwright

We study randomized sketching methods for approximately solving least-squares problem with a convex constraint. Our first main result provides a general lower bound on any randomized sketching method and as a consequence, the most widely used least-squares sketch is sub-optimal for solution approximation. We then present a new iterative method and show that it can be used to obtain approximations to the original least-squares problem using a projection dimension proportional to the statistical complexity of the least-squares minimizer, and a logarithmic number of iterations. We illustrate our theory with simulations for both unconstrained and constrained versions of least-squares, including L1-regularization and nuclear norm constraints.

■ MD18

18- Sterlings 3

Stochastic Mixed-Integer Programming

Cluster: Stochastic Optimization

Invited Session

Chair: Simge Kucukyavuz, Ohio State University, 1971 Neil Ave, 244 Baker Systems, Columbus, OH, 43210, United States of America, kucukyavuz.2@osu.edu

1 - An Adaptive Partition-Based Approach for Solving Two-Stage Stochastic Programs with Fixed Recourse

Yongjia Song, Virginia Commonwealth University, 1015 Floyd Ave, Richmond, VA, 23284, United States of America, ysong3@vcu.edu, James Luedtke

A partition-based formulation is a relaxation of the original stochastic program, and we study a finitely converging algorithm in which the partition is adaptively adjusted until it yields an optimal solution. A solution guided refinement strategy is developed to refine the partition by exploiting the relaxation solution obtained from a partition. We also show that for stochastic linear programs with simple recourse, there exists a small partition that yields an optimal solution, whose size is independent of the number of scenarios. Computational results show that the proposed approach is competitive with the state-of-art methods for stochastic linear programs.

2 - A New Lagrangian Approach for Weakly Coupled Stochastic Dynamic Programs

Jagdish Ramakrishnan, Research Associate, Wisconsin Institute for Discovery, University of Wisconsin, Madison, WI, 53715, United States of America, jagdish.ram@gmail.com, James Luedtke

Current approaches for solving multi-stage stochastic mixed-integer programs are limited in their ability to handle multiple sample paths per stage, due to an exponential growth in the number of sample paths. We consider a weakly coupled model, which is amenable to decomposition into small Markov Decision Problems via Lagrangian relaxation. We extend previous work on this approach by allowing the Lagrange multipliers to depend on the observation history. The approach will be illustrated numerically for the stochastic unit commitment problem.

3 - Mixed-Integer Rounding for Stochastic Integer Programming

Merve Bodur, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States of America, mbodur@wisc.edu, James Luedtke

With stochastic integer programming as the motivating application, we investigate ways to use mixed-integer rounding (MIR) to obtain improved cuts within a Benders decomposition algorithm. We investigate different techniques for using MIR and conduct a computational study on a wide class of stochastic integer programming instances to understand their relative strengths. We find that the MIR enhancements significantly improve the bounds over those obtained from standard Benders cuts, even after cuts from a commercial solver are applied to the Benders formulation.

■ MD19

19- Ft. Pitt

Optimization of Non-Smooth and Complementarity-Based Systems with PDE–Constraints I

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Thomas Surowiec, Humboldt-Universitaet zu Berlin, surowiec@math.hu-berlin.de

1 - Risk-Averse Optimization with PDE Constraints

Drew Kouri, Sandia National Laboratory, P.O. Box 5800, MS 1320, Albuquerque, NM, 87185, United States of America, dpkouri@sandia.gov

In this talk, I will discuss the notion of risk aversion for optimization problems governed by PDEs with uncertain inputs. Often risk-averse quantities are not differentiable in the classic sense. To make such quantities amenable to derivative-based optimization algorithms and global quadrature approximation, I will present a theory for smooth risk measures through the risk quadrangle. Finally, I will discuss the dual formulation of coherent risk measures. Building on this dual formulation, I will provide a regularized min-max approximation. I will prove consistency of each smooth approximation and provide algorithmic details for the solution of the smoothed optimization problems. I will conclude with numerical results.

2 - Optimal Placement and Trajectories of Sensor Networks under Constraints

Carlos Rautenberg, Humboldt-Universitaet zu Berlin, carlos.rautenberg@math.hu-berlin.de

We consider the optimal estimation problem for the distribution of a quantity of interest that diffuses and is transported (or convected) by a velocity profile. Measurements are obtained with a sensor network that can be static or dynamic. We assume that stochastic perturbations are present, and numerous constraints affect the sensor network. The problem is formulated as a constrained optimization problem subject to a differential Riccati equation. New results concerning properties of the solution to the Riccati equation with respect to the sensor network location are presented. An algorithm for the approximation of optimal trajectories is introduced and several numerical tests are included.

3 - A Two-Stage Stochastic PDE-Constrained Optimization Model for Active Control of Composite Structures

Dmitry Chernikov, University of Iowa, 3131 Seamans Center, Iowa City, IA, 52242, United States of America, dmitry-chernikov@uiowa.edu, Olesya Zhupanska, Pavlo Krokhmal

We consider the problem of optimization of “smart”, or “multifunctional” mechanical structures under uncertainty. In particular, a PDE-constrained optimization model for vibration mitigation of a composite plate due to an impact load is presented. The model employs the physical phenomenon of field coupling in electrically conductive solids to control plate’s deflections using an applied electromagnetic field. To account for uncertainty in the impact load, a two-stage stochastic PDE-constrained programming problem is formulated. A solution method based on first-order black-box optimization is proposed, and a computational study is discussed.

■ MD20

20- Smithfield

Theory, Lower Bounds

Cluster: Nonsmooth Optimization

Invited Session

Chair: Martin Takac, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, United States of America, martin.taki@gmail.com

Co-Chair: Martin Jaggi, Universitaetsstr 6, Zürich, 8092, Switzerland, jaggi@inf.ethz.ch

1 - Smooth Strongly Convex Interpolation and Exact Worst-Case Performance of First-Order Methods

Adrien Taylor, Université Catholique de Louvain, Avenue Georges Lemaitre, 4, Louvain-la-neuve, Belgium, adrien.taylor@uclouvain.be, Francois Glineur, Julien Hendrickx

We show that the exact worst-case performance of fixed-step first-order methods for smooth (possibly strongly) convex functions can be obtained by solving convex programs. We apply our approach to different fixed-step first-order methods with several performance criteria, including objective function accuracy and residual gradient norm. We conjecture several numerically supported worst-case bounds on the performance of the gradient, fast gradient and optimized fixed-step methods, both in the smooth convex and the smooth strongly convex cases.

2 - Coordinate Descent for Certain Problems in Semidefinite Programming

Jakub Marecek, IBM Research – Ireland, IBM Technology Campus Damastown, B3 F14, Dublin, D7, Ireland, jakub.marecek@ie.ibm.com, Martin Takac, Wann-Jiun Ma

We present a coordinate-descent algorithm for a rank-constrained hierarchy of relaxations of semidefinite programming, using a closed-form step, and variants thereof. We present promising results both in theory and practical implementations, which exploit the structures present in relaxations polynomial optimisation, in general, and in power systems analysis, in particular [B Ghaddar, J Marecek, M Mevissen, IEEE Transactions on Power Systems, 2015].

3 - Composite Convex Minimization Involving Self-Concordant-Like Cost Functions

Yen-Huan Li, PhD Student, EPFL – LIONS Lab, EPFL-STI-IEL-LIONS, Station 11, Lausanne, 1015, Switzerland, yen-huan.li@epfl.ch, Volkan Cevher, Quoc Tran-Dinh

The self-concordant like property is a new structure of smooth convex functions. While self-concordant like functions appear in many applications, this concept has not been exploited in convex optimization theory. We develop a proximal variable metric framework for minimizing the sum of a self-concordant like function and a “simple” convex function, with analytic step-size selection procedures and rigorous convergence guarantees. Our basic proximal gradient algorithm has a better convergence behavior than accelerated first-order algorithms.

■ MD21

21-Birmingham

Recent Advances in Derivative-Free and Simulation-Based Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Anke Troeltzsch, German Aerospace Center (DLR), Linder Hˆhe, Cologne, Germany, Anke.Troeltzsch@dlr.de

1 - Trust-Region Methods without using Derivatives: Worst Case Complexity and the Non-Smooth Case

Rohollah Garmanjani, Universidade de Coimbra, nima@mat.uc.pt, Diogo Júdice, Luis Nunes Vicente

We start by analyzing the worst case complexity of general trust-region derivative-free methods for smooth functions. For the non-smooth case, we propose a smoothing approach, for which we prove global convergence and bound the worst case complexity effort. For the special case of non-smooth functions that result of the composition of smooth and non-smooth/convex components, we show how to improve the existing results of the literature and make them applicable to the general methodology.

2 - A Derivative-Free Trust-Funnel Method for Nonlinear Optimization Problems with General Constraints

Phillipe Sampaio, University of Namur, Rempart de la Vierge 8, Namur, 5000, Belgium, phillipe.sampaio@unamur.be, Philippe Toint

A trust-funnel method is proposed for solving nonlinear optimization problems with general nonlinear constraints. It extends the one presented by Gould and Toint (Math. Prog., 122(1):155-196, 2010), originally proposed for equality-constrained problems only, to problems with both equality and inequality constraints and where simple bounds are also considered. As the original one, it makes use of neither filter nor penalty functions. Finally, we exploit techniques for derivative-free optimization to obtain a final method that can also be used to solve problems without derivatives.

■ MD22

22- Heinz

New Convexification and Branching Techniques for Nonconvex Optimization

Cluster: Global Optimization

Invited Session

Chair: Amir Ali Ahmadi, Princeton University, a_a_a@princeton.edu

1 - Envelopes of Bilinear Functions over Polytopes with Application to Network Interdiction

Daniel Davarnia, University of Florida, 303 Weil Hall, Gainesville, FL, United States of America, d.davarnia@gmail.com, Jean-Philippe P Richard, Mohit Tawarmalani

We extend the convexification technique of Nguyen et. al. (2013) to obtain, in the space of their defining variables, a linear description of the convex hull of graphs of bilinear functions over the Cartesian product of a general polytope and a simplex. We apply this procedure to study various sets including those arising from unary expansions of integer variables in MIBP. For network interdiction, our procedure yields an improved set of linearization constraints for bilinear objective terms that is cognizant of paths and cycles in the network. This linearization provides a convex hull description of a suitable problem relaxation and can be shown computationally to lead to significant gap reductions over traditional McCormick linearization.

2 - Feasibility-oriented Branching Strategies for Global Optimization

Damien Gerard, University of Liège, 10 Grande Traverse, Liège, 4000, Belgium, damien.gerard@ulg.ac.be, Matthias Koeppe, Quentin Louveaux

Spatial brand-and-bound is an algorithm to solve nonlinear optimization problems to global optimality. Most spatial branch-and-bound-based solvers use a nonglobal solver at a few nodes to try to find better incumbents. We propose new strategies to use these incumbents to improve the branching rules and the node priorities. We show computationally that the new strategies find the first good incumbents and prove the global optimality faster on benchmark instances.

3 - DC Decomposition of Nonconvex Polynomials with Algebraic Techniques

Georgina Hall, Princeton University, Department of ORFE, Princeton University, Sherrerd Hall, Charlton Street, Princeton, NJ, 08540, United States of America, gh4@princeton.edu, Amir Ali Ahmadi

The concave-convex procedure is a majorization-minimization algorithm for difference of convex (DC) optimization, where the constraints and the objective function are given as the difference of two convex functions. Although several important problems (e.g., in machine learning) already appear in DC form, such a decomposition is not always available. We consider this decomposition question for polynomial optimization. We introduce LP, SOCP, and SDP based algorithms for finding optimal DC decompositions by appealing to the algebraic concepts of "DSOS-Convex, SDSOS-Convex, and SOS-Convex" polynomials. We also study structural properties of these polynomials and answer existence questions about polynomial DC decompositions.

■ MD23

23- Allegheny

Dynamic Robust Optimization

Cluster: Robust Optimization

Invited Session

Chair: Wolfram Wiesemann, Imperial College Business School, South Kensington Campus, London, United Kingdom, ww@imperial.ac.uk

Co-Chair: Daniel Kuhn, EPFL, EPFL-CDM-MTEI-RAO, Station 5, Lausanne, Switzerland, daniel.kuhn@epfl.ch

1 - Robust Data-Driven Dynamic Programming

Grani Hanasusanto, Imperial College London, South Kensington Campus, London, United Kingdom, g.hanasusanto11@imperial.ac.uk, Daniel Kuhn

In stochastic optimal control the distribution of the exogenous noise is unknown and must be inferred from limited data before dynamic programming (DP)-based schemes can be applied. If the conditional expectations in the DP recursions are estimated via kernel regression, the historical sample paths can enter the solution procedure directly. The resulting data-driven DP scheme is asymptotically consistent and admits an efficient computational solution procedure. If training data is sparse, however, the corresponding control policies perform poorly in out-of-sample tests. To mitigate these small sample effects, we propose a robust data-driven DP scheme which dominates state-of-the-art benchmark algorithms across several application domains.

2 - Learning the Uncertainty in Robust Markov Decision Processes

Huan Xu, National University of Singapore, 9, Engineering Drive 1, Singapore, 117576, Singapore, mpexuh@nus.edu.sg, Shiau Hong Lim, Shie Mannor

A standard paradigm for MDP to tackle parameter uncertainty is robust MDP, which models the parameters as arbitrary element of predefined "uncertainty sets", and seeks the minimax policy. A challenge of robust MDP is how to find appropriate description of the uncertainty. In this talk we address this using an online learning approach: we devise an algorithm that, without knowing the true uncertainty model, is able to adapt its level of protection to uncertainty, and in the long run performs as good as the minimax policy as if the true uncertainty model is known. The algorithm achieves similar regret bounds as standard MDP, showing that with little extra cost we can adapt robust learning to handle uncertainty in MDPs.

3 - Two-Stage Robust Integer Programming

Wolfram Wiesemann, Imperial College Business School, South Kensington Campus, London, United Kingdom, ww@imperial.ac.uk, Grani Hanasusanto, Daniel Kuhn

In this talk we study two-stage robust optimization problems with integer recourse, which have largely resisted solution so far. To this end, we approximate the problems by their corresponding K-adaptability problems, in which the decision maker pre-commits to K second-stage policies here-and-now and implements the best of these policies once the uncertain parameters are observed. We study the approximation quality and the computational complexity of the K-adaptability problem, and we propose two mixed-integer linear programming reformulations that can be solved with off-the-shelf software.

■ MD24

24- Benedum

Computational Aspects of MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Armin Fügenschuh, Helmut Schmidt University / University of the Federal Armed Forces Hamburg, Holstenhofweg 85, Hamburg, 22043, Germany, fuegenschuh@hsu-hh.de

1 - Global and Local Optimal Control of Dynamical Systems

Ingmar Vierhaus, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, vierhaus@zib.de, Armin Fügenschuh

We consider the optimal control of dynamical systems, given in terms of a set of ordinary differential equations. We allow non-smooth functions in the model equations. Systems of this type can be transcribed into MINLPs and can then theoretically be solved globally with standard branch-and-bound solvers. However, in practice this is only feasible for very small instances. A branch-and-cut method based on the MINLP solver SCIP with taylored components for dynamical systems will be presented and compared to a local approach with smooth interpolations of the non-smooth functions. We present System Dynamics models from literature as test instances.

2 - Theoretical and Practical Aspects of Optimal Loop Extensions in Gas Networks

Ralf Lenz, Zuse Institute Berlin, Takustrasse 7, 14195 Berlin, Germany, lenz@zib.de, Felipe Serrano, Robert Schwarz

Gas network capacity is often increased by building pipes in parallel to existing ones, called loops. This leads to a nonconvex MINLP. A major difficulty in modeling are the nonlinear and nonconvex pressure loss constraints, while the mixed-integer part is due to the active elements. Since expansion costs are very high, we solve the model to global optimality, using outer approximation and spatial branching. We further strengthen our formulation by computing the convex envelope of the nonlinearities directly.

3 - Gas Network Optimization by MINLP

Jesco Humpola, Zuse Institute Berlin, Takustrafle 7, Berlin, 14195, Germany, humpola@zib.de

An algorithm for topology optimization of large-scale real-world natural gas transport networks is presented. The problem is modeled by an MINLP. The identification of the active transmission problem (ATP), which is obtained by fixing all discrete variables, is the key for solving the MINLP. The domain relaxation of the ATP has a wide range of beneficial mathematical properties. It gives rise to sufficient conditions for proving infeasibility of the ATP; a cut for the MINLP expressing the infeasibility of the ATP in an analogue way as the max-flow-min-cut-theorem of classical network flow theory; a primal heuristic based on parametric sensitivity analysis. Computational results obtained by a combination of SCIP and IPOpt are presented.

■ MD25

25- Board Room

CP Applications in Scheduling

Cluster: Constraint Programming

Invited Session

Chair: Louis-Martin Rousseau, CIRRELT - Ecole Polytechnique de Montreal, CP 6079 Succ Centre-Ville, Montreal, Canada, louis-martin.rousseau@cirrelt.net

1 - A Constraint Programming-Based Branch-and-Price-and-Cut for Operating Room Planning and Scheduling

Seyed Hossein Hashemi Doulabi, PhD Candidate, Ecole Polytechnique de Montreal, 2900 Boulevard Edouard-Montpetit, Montreal, QC, H3T 1J4, Canada, hashemi.doulabi@polymtl.ca, Gilles Pesant, Louis-Martin Rousseau

We present an efficient algorithm to solve an integrated operating room planning and scheduling problem which combines the assignment of surgeries to operating rooms and their scheduling over a short-term planning horizon. The problem is formulated as a mathematical programming model and a branch-and-price-and-cut algorithm is developed based on a constraint programming model to solve the subproblem. Some dominance rules and a fast infeasibility detection algorithm are also developed which effectively improve the efficiency of the constraint programming model. Computational results demonstrate that the proposed method significantly outperforms a compact mathematical formulation in the literature.

2 - Stochastic Optimization of the Scheduling of a Radiotherapy Center

Antoine Legrain, Polytechnique Montreal, Département de Mathématiques et de Génie, C.P. 6079, succ. Centre-ville, Montreal, Canada, antoine.legrain@polymtl.ca, Marino Widmer, Marie-Andrée Fortin, Nadia Lahrichi, Louis-Martin Rousseau

Cancer treatment facilities can improve their efficiency for radiation therapy by optimizing the utilization of linear accelerators and taking into account patient priority, treatment duration, and preparation of the treatment (dosimetry). The future workloads are inferred: a genetic algorithm schedules future tasks in dosimetry and a constraint program verifies the feasibility of a dosimetry planning. This approach ensures the beginning of the treatment on time and thus avoids cancellations.

3 - Retail Store Scheduling for Profit

Louis-Martin Rousseau, CIRRELT - Ecole Polytechnique de Montreal, CP 6079 succ Centre-Ville, Montreal, Canada, louis-martin.rousseau@cirrelt.net, Nicolas Chapados, Marc Joliveau, Pierre L'Écuyer

This paper frames the retail scheduling problem in terms of operating profit maximization, explicitly recognizing the dual role of sales employees as sources of revenues as well as generators of operating costs. We introduce a flexible stochastic model of retail store sales, estimated from store-specific historical data, that can account for the impact of all known sales driversn. We also present solution techniques based on mixed-integer (MIP) and constraint programming (CP) to efficiently solve the complex mixed integer non-linear scheduling (MINLP) problem with a profit-maximization objective.

■ MD26

26- Forbes Room

Mathematical Programming in Tax Policy Modeling

Cluster: Finance and Economics

Invited Session

Chair: Richard Evans, Assistant Professor, Brigham Young University, Department of Economics, 167 FOB, Provo, UT, 84602, United States of America, revans@byu.edu

1 - A Big Data Approach to Optimal Income Taxation

Kramer Quist, Brigham Young University, Macroeconomics and Computational Lab, 151 FOB, Provo, UT, 84602, United States of America, kramer.quist@gmail.com, Jeremy Bejarano, Richard Evans, Ken Judd, Kerk Phillips

We characterize and demonstrate a solution method for an optimal income tax problem with heterogeneous agents and a nonconvex policy maker optimization problem. Our approach allows for more dimensions of heterogeneity than has been previously possible, incorporates potential model uncertainty and policy objective uncertainty, and relaxes some of the assumptions in the previous literature that were necessary to generate a convex optimization problem for the policy maker. Our solution technique involves creating a large database of optimal responses by different individuals for different policy parameters and using ``big data" techniques to compute policy maker objective values over these individuals.

2 - The Distributional Effects of Redistributional Tax Policy

Richard Evans, Assistant Professor, Brigham Young University, Department of Economics, 167 FOB, Provo, UT, 84602, United States of America, revans@byu.edu, Jason DeBacker, Kerk Phillips

This paper constructs a large scale overlapping generations model with heterogeneity across the life cycle and lifetime income groups. We consider the effects of two policies that have the same steady-state revenue effect: an increase in income tax rates and a progressive wealth tax. We find that a more progressive income tax does reduces measures of cross-sectional inequality in consumption, income, and wealth. In contrast, a wealth tax reduces cross sectional inequality by reducing inequality over the life cycle, but a wealth tax slightly increases inequality across lifetime income groups.

3 - A Large-Scale Macroeconomic Model for Dynamic Scoring

Jason DeBacker, Assistant Professor, Middle Tennessee State University, Department of Economics and Finance, P.O. Box 27, Murfreesboro, TN, 37132, United States of America, jason.debacker@gmail.com, Richard Evans, Kerk Phillips, Evan Magnusspon, Isaac Swift

We construct a large scaled dynamic general equilibrium model to evaluate tax policy. The model includes households with heterogeneous lifecycle earnings profiles, realistic demographics, and a rich set of production industries. Together, these features allow the model to analyze revenue, economic, and distributional impacts of a wide range of tax policies. Our solution method allows for the estimation of impacts of temporary policies and for the transition paths of permanent policy changes, not just long run analyses. A additional key feature of the model is its open source nature, which will allow policy makers and researchers to further customize and improve the model.

■ MD27

27- Duquesne Room

Sparse Optimization and Compressed Sensing

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Vincent LeclereResearcher, ENPC, 6-8 av. Blaise Pascal, Champs-sur-Marne, 77455, France, vincent.leclere@cermics.enpc.fr

1 - Fast Imbalanced Binary Classification: A Moment-based Approach

Vincent Leclere, Researcher, ENPC, 6-8 av. Blaise Pascal, Champs-sur-Marne, 77455, France, vincent.leclere@cermics.enpc.fr, Edouard Grave, Laurent El Ghaoui

We consider the problem of imbalanced binary classification in which the number of negative examples is much larger than the number of positive examples. We represent the negative class by the two first moments of its probability distribution, while still modeling the positive class by individual examples. Minimizing the probability of misclassification lead to a formulation comparable to an SVM approach. However, our formulation does not depend on the number of negative examples, making it suitable to highly imbalanced problems and scalable to large datasets.

2 - Optimization Algorithms for Model Selection in High-Dimensional Case-Control Genome-Wide Association

Kevin Keys, UCLA, Box 951766, Life Sciences #5303, 621 Charles E Young Drive South, Los Angeles, CA, 90095, United States of America, klkeysb@gmail.com, Gary Chen, Kenneth Lange

Genome-wide association studies (GWASes) examine genetic variation genotyped on microarrays between groups of patients with distinguishable phenotypes. Accurately selecting genetic markers informative for disease remains a difficult computational problem in very high dimensions. We implement iterative hard thresholding to select these informative genetic markers on full-scale GWAS data. Our implementation exploits parallel computing and data compression paradigms to facilitate GWAS analysis on desktop machines and to effectively ameliorate the computational burden of GWAS model selection.

3 - Guaranteed Matrix Completion via Non-Convex Factorization

Ruoyu Sun, University of Minnesota, 200 Union St., SE, Minneapolis, MN, 55455, United States of America, sunxx394@umn.edu, Zhi-Quan Luo

Matrix factorization based optimization is a popular approach for large-scale matrix completion. However, due to the non-convexity, there is a limited theoretical understanding of this approach. We show that under similar conditions to those in previous works, many standard optimization algorithms converge to the global optima of the factorization based formulation, thus recovering the true low-rank matrix. To the best of our knowledge, our result is the first one that provides recovery guarantee for many standard algorithms such as gradient descent, SGD and block coordinate gradient descent.

■ MD28

28- Liberty Room

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Miawjane Chen, Professor, National United University, 1, Lienda, Miaoli, 36003, Taiwan - ROC, mjchen@nuu.edu.tw

1 - Optimizing Bounds on Cell Counts in Contingency Tables of Rounded Conditional Frequencies

Stephen E. Wright, Miami University, Dept of Statistics, Oxford, OH, 45056, United States of America, wrightse@miamioh.edu, Andrew Sage

We discuss an integer linear optimization formulation for the problem of determining tightest bounds on cell counts in a multi-way contingency table, given knowledge of a corresponding two-way table of rounded conditional probabilities. The formulation admits a three-phase decomposition with master subproblem solvable in closed form and worker subproblems addressed simultaneously in a divide-and-conquer implementation of dynamic programming. The proposed procedure finds all possible counts (not just bounds) for each cell and runs fast enough to handle moderately sized tables.

2 - Network Flow Models for Project Scheduling with Discount Cash Flows under Stochastic Work Durations

Miawjane Chen, Professor, National United University, 1, Lienda, Miaoli, 36003, Taiwan - ROC, mjchen@nuu.edu.tw, Ru-San Wei, Shangyao Yan, Yi-Chun Chen, Cheng-Han Tsai

In this study, we employ a network flow technique to develop two multi-mode resource-constrained project scheduling models with discount cash flows under stochastic work durations, using the payment at activity completion times and the lump sum payment. These models are formulated as an integer network flow problem with side constraints. An evaluation method is also developed to evaluate these models in simulated operations. Finally, numerical examples are designed to test the applicability of the models. The test results are good showing that the models could be suitable planning tools for decision makers in real operations.

3 - An Integer Programming Formulation of the Polymorphic Alu Insertion Recognition Problem

Luciano Porretta, Université Libre de Bruxelles - Graphes et Optimisation Mathematique, Boulevard du Triomphe, CP 210/01, Bruxelles, Belgium, lporrett@ulb.ac.be, Bjarni V. Haldórsson, Bernard Fortz

Alu polymorphisms are some of the most common polymorphisms in the genome, yet few methods have been developed for their detection. We present an algorithm to discover Alu polymorphisms using paired-end high throughput sequencing data from multiple individuals. We consider the problem of identifying sites containing polymorphic Alu insertions. We give an efficient and practical algorithm that detect polymorphic Alus that are inserted with respect to the reference genome.

■ MD29

29- Commonwealth 1

Nonsmooth Optimization in Data Sciences

Cluster: Nonsmooth Optimization

Invited Session

Chair: Jalal Fadili, Professor, CNRS-ENSICAEN-Univ. Caen, 6 Bd Marechal Juin, Caen, 14050, France, Jalal.Fadili@ensicaen.fr

1 - Serialrank: Spectral Ranking using Seriation

Alexandre d'Aspremont, CNRS - ENS Paris, 23 av. d'Italie, Paris, France, alexandre.daspremont@m4x.org, Fajwel Fogel, Milan Vojnovic

We describe a seriation algorithm for ranking a set of n items given pairwise comparisons between these items. Intuitively, the algorithm assigns similar rankings to items that compare similarly with all others. It does so by constructing a similarity matrix from pairwise comparisons, using seriation methods to reorder this matrix and construct a ranking. We first show that this spectral seriation algorithm recovers the true ranking when all pairwise comparisons are observed and consistent with a total order. We then show sample optimality. An additional benefit of the seriation formulation is that it allows us to solve semi-supervised ranking problems. We detail experiments on both synthetic and real datasets.

2 - Convergence Analysis for Stochastic Forward-Backward Splitting

Silvia Villa, LCSL, Istituto Italiano di Tecnologia & Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 0, Italy, silvia.villa@iit.it, Bang Vu, Lorenzo Rosasco

I will analyze the convergence of a novel stochastic forward-backward splitting algorithm for solving monotone inclusions given by the sum of a maximal monotone operator and a single-valued maximal monotone cocoercive operator. This latter framework has a number of interesting special cases, including variational inequalities and convex minimization problems, while stochastic approaches are practically relevant to account for perturbations in the data. The algorithm I will discuss is a stochastic extension of the classical deterministic forward-backward method, and is obtained considering the composition of the resolvent of the maximal monotone operator with a forward step based on a stochastic estimate of the single-valued operator.

3 - A Recursive Splitting Method for Nonsmooth-Nonconvex Optimization and Application to X-ray Imaging

Russell Luke, University of Goettingen, Institute for Numerical and Applied Math, Goettingen, 39083, Germany, r.luke@math.uni-goettingen.de

We propose a general alternating minimization algorithm for nonconvex optimization problems with separable structure and nonconvex coupling between blocks of variables. To fix our ideas, we apply the methodology to the problem of blind ptychographic imaging. Compared to other schemes in the literature, our approach differs in two ways: (i) it is posed within a clear mathematical framework with practically verifiable assumptions, and (ii) under the given assumptions, it is provably convergent to critical points. A numerical comparison of our proposed algorithm with the current state-of-the-art on simulated and experimental data validates our approach and points toward directions for further improvement.

■ MD30

30- Commonwealth 2

Approximation and Online Algorithms III

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Bobby Kleinberg, Cornell University, Department of Computer Science, 402 Gates Hall, Ithaca, NY, 14850, United States of America, rdk@cs.cornell.edu

1 - Almost Matching Upper and Lower Bounds for Vector Scheduling

Tjark Vredeveld, Maastricht University, P.O. Box 616, Maastricht, 6200MD, Netherlands, t.vredeveld@maastrichtuniversity.nl, Ruben Van der Zwaan, Tim Oosterwijk, Nikhil Bansal

We consider the Vector Scheduling problem, a natural generalization of the classical makespan minimization problem to multiple resources. For fixed dimension of the vectors, the problem admits an approximation scheme, and the best known running time is double exponential in the dimension. We show that a double exponential dependence on the dimension is necessary, and give an improved algorithm with essentially optimal running time.

2 - Competitive Algorithms from Competitive Equilibria

Kamesh Munagala, Duke University, D205 LSRC Building, 308 Research Drive, Durham, NC, 27708, United States of America, kamesh@cs.duke.edu, Sungjin Im, Janardhan Kulkarni

In this talk, we introduce a general scheduling problem that we term the Packing Scheduling problem (PSP). In this problem, jobs have different arrival times and sizes, and the rates at which a scheduler can process jobs are subject to arbitrary packing constraints. The PSP framework captures many classical scheduling problems, as well as multidimensional resource requirements that arise in cluster computing. We design non-clairvoyant online algorithms for PSP. For minimizing total weighted completion time, we show a constant competitive algorithm. Surprisingly, we achieve this result by applying the well-known Proportional Fairness algorithm from economics to allocate resources each time instant.

3 - Incentivizing Exploration

Bobby Kleinberg, Cornell University, Department of Computer Science, 402 Gates Hall, Ithaca, NY, 14850, United States of America, rdk@cs.cornell.edu, Peter Frazier, David Kempe, Jon Kleinberg

Many on-line social systems depend upon accumulating information about diverse alternatives from a crowd of autonomous users. Examples include product recommendations, social news readers, and crowdsourced "citizen science". These domains suffer from misaligned incentives: the designer aims to efficiently explore a space of alternatives, while users aim to optimize the alternatives they select. We model this as a multi-armed bandit problem in which selfish agents pull arms with publically observable outcomes, and a principal may influence them with rewards contingent on their choice of arm. Our main result quantifies the trade-off between the expected payments the principal makes and the total time-discounted reward that can be achieved.

Monday, 4:35pm - 5:25pm

■ ME01

01- Grand 1

Equilibrium Routing under Uncertainty

Cluster: Plenary

Invited Session

Chair: Andrzej Ruszczynski, Rutgers University, 100 Rockefeller Road, Piscataway, NJ, 08854, United States of America, rusz@business.rutgers.edu

1 - Equilibrium Routing under Uncertainty

Roberto Cominetti, University of Chile, Republica 701, Sabtiago, Chile, rccc@dii.uchile.cl

In this talk we review several alternative models that have been used to describe traffic in congested networks, both in urban transport and telecommunications. We focus on situations where travel times are subject to random fluctuations and how this variability affects the traffic flows. We consider both atomic and non-atomic equilibrium models, and we discuss a class of adaptive dynamics that describe the behavior of agents and which provides a plausible micro-foundation for the emergence of equilibrium. We also discuss some recent ideas on how risk aversion to random travel times might be incorporated in the models. In our presentation we use convex optimization to provide a unifying framework for the different concepts of equilibrium.

■ ME02

02- Grand 2

Complexity, Approximation, and Relaxation of the Power Flow Equations

Cluster: Plenary

Invited Session

Chair: Laurence WolseyEmeritus, Professor, CORE,University of Louvain, Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, laurence.wolsey@uclouvain.be

1 - Complexity, Approximation, and Relaxation of the Power Flow Equations

Pascal Van Hentenryck, Professor, NICTA/ANU, Australia, pvh@nicta.com.au

The design, control, and operation of the power grid, probably the largest and most expansive system ever engineered, require the solving of optimization problems over the steady-state power flow equations. The resulting mixed nonconvex programs are often computationally challenging and increasingly so with the increased stochasticity in generation and load. This talk presents some new complexity results, as well as a number of advances in approximating and relaxing the power flow equations to address emerging applications in power systems, including large-scale power restoration after blackouts, the design of resilient networks, and the integration of renewable generation. Extensive computational results demonstrate some of the benefits of the proposed techniques.

Monday, 5:30pm - 7:00pm

■ MF01

01- Grand 1

Variational Analysis Techniques over Symmetric Cones

Cluster: Variational Analysis

Invited Session

Chair: Hector Ramirez, Universidad de Chile, Beauchef 851, Piso 5, Santiago, Chile, hramirez@dim.uchile.cl

1 - Commutation Principle for Variational Problems on Euclidean Jordan Algebras

David Sossa, Universidad Técnica Federico Santa Marìa, Avda España 1680, Valparaiso, Chile, dsossa@dim.uchile.cl, Hector Ramirez, Alberto Seeger

We establish a commutation result for variational problems involving spectral sets and spectral functions. The discussion takes places in the context of a general Euclidean Jordan algebra.

2 - Self-Duality and Non-Expansiveness of the Resolvent Average on JB-Algebras

Sangho Kum, Professor, Chungbuk National University, 1 Chungdae-ro, Seowon-Gu, Cheongju, 362-763, Korea, Republic of, shkum@chungbuk.ac.kr

We establish self-duality of the resolvent average dened on the symmetric cone of a JB-algebra. It induces the monotonicity of the resolvent average and the geometric mean of arithmetic and harmonic means for parameters. Nonexpansive property of these means for the Thompson metric on the cone and its applications to nonlinear equations are given.

3 - Characterization of Qb-Transformations for Linear Complementarity Problems over Symmetric Cones

Julio Lopez, Universdad Diego Portales, Av. Ejército 441, Santiago, Chile, julio.lopez@udp.cl, Reuben López, Hector Ramirez

In this work, our aim is to characterize the class of linear transformations for which the symmetric cone linear complementarity problem (SCLCP) has always a nonempty and bounded solution set in terms of larger classes. For this, we introduce a couple of new classes of linear transformations in this SCLCP context. Then, we study them for concrete particular instances (such as second-order and semidefinite linear complementarity problems) and for specific examples (Lyapunov, Stein functions, among others).

■ MF02

02- Grand 2

Equilibrium and Stochastic Models for Energy Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Miguel Anjos, Professor and Canada Research Chair, Polytechnique Montreal, C.P. 6079, succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, miguel-f.anjos@polymtl.ca

1 - Value of Flexible Resources in Wind-Integrated Electricity Markets: A Stochastic Equilibrium Analysis

Venkat Prava, Ph D Candidate, Johns Hopkins University, 3400 North Charles Street, Baltimore, MD, 21218, United States of America, vprava1@jhu.edu, S. Jalal Kazempour, Benjamin Hobbs, Judith Cardell, Lindsay Anderson

We analyze the value of diverse operational flexible resources (peak units, demand response and virtual bidding) in a two-settlement wind-integrated electricity market (including day-ahead and real-time). To this end, a stochastic equilibrium model is characterized through a simultaneous clearing of day-ahead and real-time markets. Wind power uncertainty is represented by a set of scenarios. The upward and downward demand responses are considered in both markets.

2 - Stochastic Market Clearing: An Adequate Pricing Scheme Per Scenario

S. Jalal Kazempour, Postdoc, Technical University of Denmark, Department of Electrical Engineering, Akademivej, Building 358, Room 132, Kgs. Lyngby, 2800, Denmark, seykaz@elektro.dtu.dk, Pierre Pinson

The available stochastic market clearing tools in the literature guarantee revenue adequacy in the market and non-negative profit for all producers (conventional and renewable) in expectation only. This has been criticized since those criteria are not guaranteed per scenario. We propose an equilibrium model rendering a MILP that is revenue adequate per scenario and for which each producer’s profit is also non-negative per scenario.

3 - Partially Adaptive Stochastic Optimization for Electric Power Generation Expansion Planning

Jikai Zou, Research Assistant, Georgia Institute of Technology, 765 Ferst Drive, Room 446 Main Bld., Atlanta, GA, 30309, United States of America, jikai.zou@gatech.edu, Shabbir Ahmed, Andy Sun

We consider a stochastic optimization approach for power generation expansion planning problem under demand and fuel price uncertainty. We propose a partially adaptive stochastic mixed integer optimization model in which the capacity expansion plan is fully adaptive to the uncertainty evolution up to a certain period, and future plan are determined prior to further uncertainty realizations. We provide analytical bounds on solution quality. We also propose an algorithm that solves a sequence of partially adaptive models, to recursively construct an approximate multistage solution. We identify sufficient conditions under which this algorithm recovers an optimal multistage solution. Computational results on a realistic instance are discussed.

■ MF03

03- Grand 3

Optimization under Uncertainty II

Cluster: Combinatorial Optimization

Invited Session

Chair: Marc Uetz, University of Twente, P.O. Box 217, Enschede, 7500AE, Netherlands, m.uetz@utwente.nl

1 - Packing a Knapsack of Unknown Capacity

Yann Disser, TU Berlin, Institut für Mathematik, Sekr. MA 5-2, Strasse des 17. Juni 136, Berlin, Germany, disser@math.tu-berlin.de, Max Klimm, Nicole Megow, Sebastian Stiller

We study the problem of packing a knapsack without knowing its capacity. Whenever we attempt to pack an item that does not fit, the item is discarded; if the item fits, we have to include it in the packing. We show that there is always a policy that packs a value within factor 2 of the optimum packing, irrespective of the actual capacity. If all items have unit density, we achieve a factor equal to the golden ratio 1.618. Both factors are shown to be best possible. We give efficient algorithms computing the above policies and show that the problem of deciding whether a given policy achieves a factor of a>1 or whether a "universal" policy achieving this factor exists is coNP-complete.

2 - Two-stage Stochastic and Robust Scheduling

Nicole Megow, Technische Universitaet Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, nmegow@math.tu-berlin.de, Lin Chen, Roman Rischke, Leen Stougie

We propose a natural model for two-stage scheduling under uncertainty. Reserving a time unit for processing jobs incurs some cost, which depends on when the reservation is made: a priori decisions, based only on distributional information, are much cheaper than on-demand decisions when the actual scenario is known. We consider both stochastic and robust versions of scheduling unrelated machines with the objectives of minimizing the sum of weighted completion times and the makespan. We give constant-factor approximations which hold for an arbitrary scenario distribution given by means of a black-box. Our techniques also yield approximation algorithms for robust two-stage scheduling.

3 - Robust Randomized Matchings

Martin Skutella, Professor. Dr., TU Berlin, Strafle des 17. Juni 136, Fak, II, Mathematik, Sekr. MA 5-2, Berlin, 10623, Germany, martin.skutella@tu-berlin.de, Jose Soto, Jannik Matuschke

The following zero-sum game is played on a weighted graph G: Alice selects a matching M and Bob selects a number k. Then, Alice receives a payoff equal to the ratio of the weight of the top k edges of M to the maximum weight of a matching of size at most k in G. If M guarantees a payoff of at least α, then it is called α-robust. Hassin and Rubinstein (2002) gave an algorithm that returns a $1/\sqrt{2}$-robust matching, which is best possible for this setting. We give a new, LP-based proof of their result. Moreover, we show that Alice can improve her payoff by playing a randomized strategy. For this setting, we devise a simple algorithm that returns a $1/\ln(4)$-robust randomized matching.

■ MF04

04- Grand 4

Advances and Applications in Conic Optimization Part I

Cluster: Conic Programming

Invited Session

Chair: Makoto YamashitaDr, Tokyo Institute of Technology, 2-12-1-W8-29, Oookayama, Meguro-ku, Tokyo, 152-8552, Japan, Makoto.Yamashita@is.titech.ac.jp

Co-Chair: Akiko Yoshise, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki, Tsukuba, Ib, 305-8573, Japan, yoshise@sk.tsukuba.ac.jp

1 - Optimization Model for Estimating Quantum Yield Distribution in Photochromic Reaction

Mirai Tanaka, Tokyo University of Science, 2641 Yamazaki, Noda, Chiba, 278-8510, Japan, mirai@rs.tus.ac.jp, Takashi Yamashita, Mizuho Nagata, Natsuki Sano, Aya Ishigaki, Tomomichi Suzuki

In this talk, an optimization model arising from photochemistry is proposed. In a photochromic reaction, the ratio of the number of reacted molecules and that of absorbed photon is called the quantum yield. The quantum yield of a photochromic reaction in solid polymer has distribution. The estimation of the quantum yield distribution has the importance in material engineering. To estimate the distribution, the authors formulate the minimization of the L2-distance between measured values of absorbance in the reaction and theoretical ones as a convex quadratic optimization problem over a functional space with ODE constraints derived from a reaction rate equation. The authors derive a convex quadratic optimization model with discretization.

2 - Feature Subset Selection for Linear/Logistic Regression via Mixed Integer Optimization

Yuichi Takano, Senshu University, 2-1-1 Higashimita, Tama-ku, Kawasaki-shi, 214-8580, Japan, ytakano@isc.senshu-u.ac.jp

This talk deals with the methods of selecting a subset of features for linear/logistic regression models. The subset selection problem for linear regression is formulated as a mixed integer second-order cone optimization problem by employing information criteria (e.g., AIC and BIC) as a goodness-of-fit measure. The problem for logistic regression is posed as a mixed integer linear optimization problem by using a piecewise linear approximation.

3 - Rank Minimization Approach to Collaborative Filtering Based on the Nuclear Norm Minimization

Tomotaka Yokoo, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki, Tsukuba-shi, Japan, s1420495@sk.tsukuba.ac.jp, Akiko Yoshise

Recht, Fazel and Parrilo(2010) gave a theoretical characterization of the nuclear norm minimization relaxation of the affine rank minimization problem and suggested many applications of the result including collaborative filtering.However, very few results have been reported on collaborative filtering using the rank minimization approach.In this talk, we will present some numerical results using this approach and compare them with the results using singular value decomposition approach.

■ MF05

05- Kings Garden 1

Higher Order Methods for Regularization Problems

Cluster: Nonlinear Programming

Invited Session

Chair: Kimon Fountoulakis, The University of Edinburgh, k.fountoulakis@sms.ed.ac.uk

1 - In-Network Nonconvex Optimization

Gesualdo Scutari, Assistant Professor, SUNY Buffalo, North Campus, Buffalo, NY, 14260, United States of America, gesualdo@buffalo.edu, Paolo Di Lorenzo, Francisco Faccinei

Consider a network composed of agents aiming to distributively minimize a (nonconvex) smooth sum-utility function plus a nonsmooth (nonseparable), convex one. The agents have access only to their local functions but not the whole objective, and the network is modeled as a directed, time-varying, B-strongly connected graph. We propose a distributed solution method for the above optimization wherein the agents in parallel minimize a convex surrogate of the original nonconvex objective while using consensus to distribute the computations over the network. Convergence to stationary solutions is established. Numerical results show that our new algorithm outperforms current schemes on both convex and nonconvex problems.

2 - Conic Geometric Optimisation on the Manifold of Positive Definite Matrices

Suvrit Sra, MIT, 77 Massachusetts Ave, Cambridge, MA, 02139, United States of America, suvrit@mit.edu

We develop geometric optimisation on the manifold of positive definite (PD) matrices. In particular, we consider two types of cost functions: (i) geodesically convex (g-convex); and (ii) log-nonexpansive (LN). G-convex functions are nonconvex in the Euclidean sense, but convex along the manifold, and thus globally optimisable. LN functions may fail to be g-convex, but are still globally optimisable due to their special structure. We develop theoretical tools to recognise and construct g-convex and LN functions. To optimise them, we develop both manifold BFGS and fixed-point algorithms (the latter outdo manifold methods). Remarkably, even in the case of certain convex PD problems, our algorithms greatly outperform the usual SDP solvers.

3 - Preconditioners for Higher Order Methods in Big Data Optimization

Jacek Gondzio, Professor, University of Edinburgh, King's Buildings, Edinburgh, Edinburgh, EH9 3FD, United Kingdom, J.Gondzio@ed.ac.uk, Kimon Fountoulakis

We address efficient preconditioning techniques for the second-order methods applied to solve various sparse approximation problems arising in big data optimization. The preconditioners cleverly exploit special features of such problems and cluster the spectrum of eigenvalues around one. The inexact Newton Conjugate Gradient method excels in these conditions. Numerical results of solving L1-regularization problems of unprecedented sizes will be presented.

■ MF06

06- Kings Garden 2

Optimizing Network Design

Cluster: Telecommunications and Networks

Invited Session

Chair: Austin Buchanan, Texas A&M University, TAMU-3131, College Station, TX, United States of America, buchanan@tamu.edu

1 - Capacity Planning for the Google Backbone Network

Emilie Danna, Google, 1600 Amphitheatre Pkwy, Mountain View, CA, 94043, United States of America, edanna@google.com, Ajay Bangla, Wenjie Jiang, Bikash Koley, Ben Preskill, Xiaoxue Zhao, Christoph Albrecht, Alireza Ghaffarkhah

Google operates one of the largest backbone networks in the world. In this talk, we present optimization and simulation techniques we use to design the network topology and provision its capacity to achieve conflicting objectives such as scale, cost, availability, and latency.

2 - Virtual Network Embedding Problems with Time Windows

Andreas Bley, Universitaet Kassel, Heinrich-Plett-Str. 40, Kassel, Germany, andreas.bley@mathematik.uni-kassel.de, Frank Fischer

The goal of the classical virtual network (VN) embedding problem (VNEP) is to embed a graph representing a VN in a physical substrate network. Edges of the VN must be mapped to paths in the substrate network. The embedding must observe certain capacity constraints at the nodes and edges of the substrate network like CPU power or bandwidth. Whereas in the VNEP all requests are embedded at the same time, we consider requests that have a time window and a duration specifying when and how long they should be embedded. All capacity constraints must be satisfied at each point in time. This combines the VNEP with a scheduling problem. We present and compare first mixed integer programming models and provide some preliminary computational results.

3 - Computational Experiments for the Simple Cycle Problem

Abilio Lucena, Dr., Federal University of Rio de Janeiro, Cidade Universitaria, Centro Tec., Bloco H, sala 319, Rio de Janeiro, RJ, 21941-972, Brazil, abiliolucena@globo.com, Alexandre Salles da Cunha, Luidi Simonetti

Given an edge weighted connected undirected graph G, two different formulations are investigated for the Simple Cycle Problem, the problem of finding a least cost simple cycle of G. Additionally, we also consider extensions of these formulations to the Prize Collecting Traveling Salesman Problem and the Ring-Star Problem. Computational results are presented for Branch and Cut algorithms for these three problems.

■ MF07

07- Kings Garden 3

Large-Scale Machine Learning

Cluster: Nonsmooth Optimization

Invited Session

Chair: Martin Takac, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, United States of America, martin.taki@gmail.com

Co-Chair: Martin Jaggi, Universitaetsstr 6, Zürich, 8092, Switzerland, jaggi@inf.ethz.ch

1 - Efficient Hierarchical Multi-Label Learning

Xiaocheng Tang, Lehigh University, 200 West Packer Avenue, Bethlhem, PA, United States of America, xiaocheng.t@gmail.com

Hierarchical Multi-label Learning (HML) has found applications in ad targeting or document classification where labels are organized in a connected (tree) structure. Existing approaches, however, do not adequately address the keys of HML: 1) how to exploit the hierarchy structure during training; and 2) how to preserve the same structure during prediction. Here we propose a novel, efficient two-stage HML model that directly addresses both of these problems, and we demonstrate HML on large-scale real-world data sets from document classification, as well as ad targeting domains that involves two million users' daily activities. The results indicate that the proposed approach outperforms traditional multi-label learning models on both tasks.

2 - SAGA: A Fast Incremental Gradient Method with Support for Non-Strongly Convex Composite Objectives

Simon Lacoste-Julien, INRIA, 23 avenue d'Italie, Paris, 75013, France, simon.lacoste-julien@inria.fr, Aaron Defazio, Francis Bach

Minimizing the sum of n functions where n can be very large has been a central optimization problem appearing in machine learning and other fields. Several incremental gradient algorithms were proposed in the last few years where every step is cheap (accessing only one function), while still obtaining a fast global linear convergence rate that can improve over batch gradient methods. In this talk, I will present an overview of these methods, using the unifying perspective of variance reduction. I will also present an incremental gradient method that supports composite optimization (with a prox operator) and that is adaptive to any strong convexity in the problem (the same step-size can be used for strongly and non-strongly convex problems).

3 - mS2GD: Mini-Batch Semi-Stochastic Gradient Descent in the Proximal Setting

Jie Liu, Lehigh University, Industrial and Systems Engineering Dept., 200 West Packer Ave., Bethlehem, PA, 18015, jild13@lehigh.edu, Martin Takac, Peter Richtarik, Jakub Konecny

We propose mS2GD method applied to minimizing a strongly convex composite function represented as the sum of an average of large numbers of smooth convex functions, and a simple nonsmooth convex function. Our mS2GD method benefits from two speedup effects. First, as long as mini-batch size is below a certain threshold, we can reach predefined accuracy with less overall work than without mini-batching. Second, our mini-batching scheme admits a simple parallel implementation for further acceleration.

■ MF08

08- Kings Garden 4

Resilience in Network Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Neil Olver, VU University Amsterdam & CWI, De Boelelaan 1105, 1081 HV, Amsterdam, Netherlands, olver@cwi.nl

1 - An O(1)-Approximation for Minimum Spanning Tree Interdiction

Rico Zenklusen, ETH Zurich, Ramistrasse 101, HG G 21.3, Zurich, 8092, Switzerland, ricoz@math.ethz.ch

Network interdiction studies the maximum impact that a removal of a limited number of edges or vertices can have on a graph optimization problem. Most interdiction problems are NP-hard, and only little is known about their approximability. One of the oldest and most-studied interdiction problems is minimum spanning tree (MST) interdiction. Here, an MST problem is given together with positive edge costs and a budget B. The goal is to remove edges of total cost at most B such that an MST in the resulting graph is as heavy as possible. So far, the best approximation was a nearly two-decades-old O(log(n))-approximation by Frederickson and Solis-Oba (SODA 1996). In this talk we show that MST interdiction admits an O(1)-approximation.

2 - Packing Interdiction and Partial Covering Problems

Michael Dinitz, Johns Hopkins University, United States of America, mdinitz@cs.jhu.edu, Anupam Gupta

In the Packing Interdiction problem we are given a packing LP together with a separate interdiction cost for each LP variable and a global interdiction budget. Our goal is to harm the LP: which variables should we forbid the LP from using (subject to staying within the budget) in order to minimize the value of the resulting LP? We give an O(log q min{q, log k})-approximation to Packing Interdiction, where q is the row-sparsity of the packing LP and k is the column-sparsity. As a corollary, we give the first O(1)-approximation to weighted matching interdiction in graphs.

3 - Stable and b-stable Set interdiction on Bipartite Graphs

Stephen Chestnut, Johns Hopkins University, 3400 N. Charles St., Baltimore, MD, 21218, United States of America, schestn2@jhu.edu, Rico Zenklusen

One way to evaluate the robustness of a system is to understand interdiction, or attack, strategies. Given is an optimization problem along with some rules and a budget for modifying the feasible set with the goal of inducing the worst possible change in the objective. In this talk I will outline efficient algorithms for solving stable set interdiction and approximating b-stable set interdiction when the underlying graph is bipartite. Along the way we will come across a polyhedral tool, first used by Burch et al. (2003), that can be applied for pseudo-approximation algorithms to many other combinatorial optimization problems.

■ MF09

09- Kings Garden 5

Semidefinite Hierarchies for Approximations in Combinatorial Optimization I

Cluster: Combinatorial Optimization

Invited Session

Chair: Nikhil Bansal, Dr., Technical University Eindhoven, Eindhoven, Netherlands, bansal@gmail.com

Co-Chair: Monique Laurent, CWI & Tilburg University, Science Park 123, Amsterdam, Netherlands, M.Laurent@cwi.nl

1 - Sparsest Cut on Bounded Treewidth Graphs: Algorithms and Hardness Results

David Witmer, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, dwitmer@cs.cmu.edu, Anupam Gupta, Kunal Talwar

We give a 2-approximation algorithm for Non-Uniform Sparsest Cut on bounded treewidth graphs. Our algorithm rounds the Sherali-Adams lift of the standard Sparsest Cut LP. We show that even for treewidth-2 graphs, the LP has an integrality gap close to 2. Hence our approach cannot be improved even on such restricted graphs without using a stronger relaxation. We also show the following hardness results: If Non-Uniform Sparsest Cut has an r-approximation for treewidth-2 graphs, then Max Cut has a 1/r approximation. Hence, even for such restricted graphs, Sparsest Cut is NP-hard to approximate better than 17/16. For graphs with large (but constant) treewidth, we show a hardness of 2 assuming the Unique Games Conjecture.

2 - A Comparison of SDP Hierarchies and Mixed SDP/LP Hierarchies

Eden Chlamtac, Dr., Ben-Gurion University of the Negev, Dept of Computer Science, P.O. Box 653, Beer-Sheva, 84105, Israel, chlamtac@cs.bgu.ac.il

We consider mixed hierarchies of relaxations. That is, hierarchies derived by taking an LP hierarchy (e.g. Sherali-Adams), and adding a PSD constraint on the second moment matrix (indexed by singletons and by the empty set). These hierarchies have been shown to be algorithmically useful, and for some problems, they represent the strongest relaxations for which we can provably construct strong integrality gaps. Despite the evident strength of mixed-hierarchies, we note two instances where proper SDP hierarchies, such as LS+ or Lasserre, give qualitatively better approximations than mixed hierarchies (either by giving a good approximation at a fixed level, or by giving a PTAS where mixed hierarchies require a linear number of rounds).

3 - Learning and Optimization via the Sum of Squares Algorithm

Boaz Barak, Dr., Microsoft Research New England, 1 Memorial Drive, Cambridge, MA 02142, United States of America, b@boazbarak.org

The Sum-of-Squares (SOS) Algorithm is a powerful framework for polynomial optimization using semidefinite programming. I will present some recent results using the SOS algorithm to obtain approximation algorithms and solve various unsupervised learning tasks, including sparse coding (aka dictionary learning) tensor prediction. I will discuss how the SOS algorithm yields a different viewpoint on algorithm design, where instead of focusing on finding a solution to a given instance, we try to find a “hay in a haystack” in the sense of extracting a single solution from the low order moments of a distribution over all solutions. Talk will be based on joint works with Jonathan Kelner, Ankur Moitra, and David Steurer.

■ MF10

10- Kings Terrace

Logistics Traffic and Tranportation

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Laurent Daudet, PhD Student, Ecole des Ponts Paris Tech, 6,8 av. Blaise Pascal, Marne-la-Vallée, 77455, France, laurent.daudet@cermics.enpc.fr

1 - POP-based Approximation Method Enabled by Physical ILP Model for Static Elevator Operation Problems

Tsutomu Inamoto, Ehime University, Bunkyo 3, Matsuyama, Japan, inamoto@ehime-u.ac.jp, Yoshinobu Higami, Shin-ya Kobayashi

In this paper, we propose an approximation method for an integer linear programming model for the problem of scheduling elevator movements. The ILP model is based on trips each of which represents one directional movement of an elevator, and in that model movements of elevators are scheduled by assigning passengers to trips. That model brings such a difficulty that we have to specify minimum required numbers of trips, but brings such a POP characteristic that if we have two settings which are similar in numbers of given trips, then assignments of passengers are also similar between optimal solutions of those two settings. The proposed method is numerically evaluated by solving many problem instances using a mathematical solver.

2 - Optimized Scheduling of Trains and Shuttles in the Channel Tunnel

Laurent Daudet, PhD Student, Ecole des Ponts Paris Tech, 6,8 av. Blaise Pascal, Marne-la-Vallée, 77455, France, laurent.daudet@cermics.enpc.fr, Frédéric Meunier

Facing a continuous growth of demand, Eurotunnel wishes to increase the capacity of the Tunnel without modifying the current infrastructures. In collaboration with this company, we propose optimization problems modeling this objective. We mainly focus on the problem of finding the shuttles departure times that minimize the longest waiting time. The motivation is to minimize the congestion in the terminals. Roughly speaking, the input is the forecasted demand, the number of shuttles, their capacity, and the loading speed. If both directions are assumed to be independent, we prove this problem to be polynomial. Otherwise, we get a nonlinear integer program which is approached via Lagrangian heuristics. The preliminary results are promising.

3 - Capacitated Facility Location with Assignment Connectivity and Distance Requirements

Kai Hennig, Zuse Institute Berlin, Takustr. 7, Berlin, Germany, hennig@zib.de

We consider a generalization of the Capacitated Facility Location problem where the assignments of each client are given as a set of nested paths in an undirected graph. Assignment connectivity requires that chosen assignments containing a common edge terminate at the same open facility node. Furthermore, we demand that predefined percentages of clients are assigned to facilities within given maximum distances. The task is to minimize the sum of facility opening and assignment realization cost. This kind of problem arises, for example, when designing profitable Fiber-To-The-Curb networks using VDSL2-Vectoring technology. We investigate structural properties of the problem, introduce MIP formulations, and present computational results.

■ MF11

11- Brigade

Enhancing Branch-and-Bound Type Methods

Cluster: Combinatorial Optimization

Invited Session

Chair: Marcus Poggi, PUC-Rio Informatica, R. M.S. Vicente 225, Rio de Janeiro, Brazil, poggi@inf.puc-rio.br

1 - Alpha-Critical Constraints for the Stable Set IP

Craig Larson, Associate Professor, Mathematics, Virginia Commonwealth University, 4106 Grace E. Harris Hall, 1015 Floyd Ave, Richmond, VA, 23284-2014, United States of America, clarson@vcu.edu

The independence (or stability) number of a graph is the cardinality of a maximum set of non-adjacent vertices. Useful cutting planes for the corresponding IP are given by clique and odd-hole constraints. An alpha-critical graph is one where the removal of any edge increases the independence number of the graph; these include cliques and odd-holes. Many other alpha-critical graphs exist besides cliques and odd-holes. We discuss experiments with a variety of alpha-critical graph constraints, and present new theoretical results.

2 - Benders Decomposition Based Hybrid Approach for the Coil Allocation and Retrieval Problem

Yuan Yuan, Institute of Industrial Engineering & Logistics Optimization, Northeastern University, Shenyang, 110819, China, yyuan.tli@gmail.com, Lixin Tang

The coil allocation and retrieval problem is to allocate coils to orders and also to schedule the retrieval of the allocated coils. We model the problem considering the constraints of the practical technological requirements and the special stacking structure of coils in the warehouses. To solve the problem, we propose a hybrid approach combining Benders decomposition and branch-and-cut where Benders decomposition acts as the main framework and employs branch-and-cut to handle its integer subproblem. Various valid inequalities are developed by exploiting the problem structure to accelerate the solution process.

3 - The Minimum Spanning Forest with Balance Constraints Problem (MSFBC)

Marcus Poggi, PUC-Rio Informatica, R. M.S. Vicente 225, Rio de Janeiro, Brazil, poggi@inf.puc-rio.br, Ian Herszterg, Thibaut Vidal

The MSFBC considers a graph where edges have nonnegative costs and vertices have weights either one or minus one. We seek for a minimum cost spanning forest where in each tree the vertices' total weight is zero. Branch-and-cut and branch-and-price algorithms are devised. Speed-ups are obtained by variable fixing based on bounds from a dual ascent procedure and primal heuristics. Experiments are carried over instances from the application of the MSFBC to the 2D-Phase Unwrapping Problem (2DPU) in the L 0-Norm, where discontinuities of the wrapped phase image (residues) are associated to the vertices that have either positive or negative polarity. Possible improvements with a branch-cut-and-price algorithm are discussed.

■ MF13

13- Rivers

Semidefinite Programming and Polynomial Optimization I

Cluster: Conic Programming

Invited Session

Chair: Cordian Riener, Aalto University, Aalto, Helsinki, Finland, Cordian.Riener@aalto.fi

1 - Gram Spectrahedra

Cynthia Vinzant, North Carolina State University, Department of Mathematics, Raleigh, NC, United States of America, cynthia.vinzant@gmail.com, Daniel Plaumann, Rainer Sinn, Emmanuel Tsukerman

Many problems in polynomial optimization can be approximated using sums of squares relaxations, which can be solved efficiently via semidefinite programming. The collection of sums of squares representations of a given polynomial is a slice of the cone of positive semidefinite matrices called a Gram spectrahedron. I will talk about the interesting convex and algebraic structure of these spectrahedra and some consequences for sums of squares optimization.

2 - Symmetry Reduction for Sums of Squares on the Hypercube

Greg Blekherman, Georgia Tech, 686 Cherry Street, Atlanta, GA, United States of America, greg@math.gatech.edu

Let p be a symmetric polynomial, i.e. a polynomial fixed under permutations of variables, and let H be the discrete hypercube {0,1}^n. The question of whether p is a sum of squares of polynomials of low degree on H can be reduced to a univariate sum of squares problem. I will present this reduction and explain how some known results on the Lasserre sum of squares hierarchy on H easily follow from it.

3 - A Semidefinite Hierarchy for Disjointly Constrained Bilinear Programming

Kai Kellner, Goethe University, Germany, kellner@math.uni-frankfurt.de

Bilinear programming concerns the problem of maximizing a bilinear function over the product of two polyhedra. While maximizing a linear function (linear programming) is known to be solvable in polynomial time, bilinear programming is NP-hard. Based on a reformulation of the problem in terms of sum-of-squares polynomials, we study a hierarchy of semidefinite relaxations to the problem. As our main result, we show that the semidefinite hierarchy converges generically in finitely many steps to the optimal value of the bilinear problem.

■ MF14

14- Traders

Network Economics

Cluster: Game Theory

Invited Session

Chair: Azarakhsh Malekian, Assistant Professor, University of Toronto, 105 saint George, toronto, On, M4Y 3G4, Canada, azarakhshm@gmail.com

1 - Privacy-Aware Network Formation: Triadic Closure and Homophily

Azarakhsh Malekian, Assistant Professor, University of Toronto, 105 Saint George, Toronto, On, M4Y 3G4, Canada, azarakhshm@gmail.com, Daron Acemoglu, Ali Makhdoumi, Asu Özdaglar

We consider a network formation game in which agents must collectively form a network in the face of the following trade-off: each agent receives benefits from the direct interactions she forms to others, but these links expose her to the risk of her information leaking to others unintentionally. We formulate the problem in terms of strategic network formation, and study the properties of its Nash equilibrium. We establish that this model explains triadic closure and high clustering that are common features of many real-world networks. We further show the emergence of clustered networks in the presence of homophily.

2 - Intermediation and Voluntary Exposure to Counterparty Risk

Maryam Farboodi, Princeton Univeristy, 11 East Merwick Court, Princeton, NJ, 08540, United States of America, farboodi@princeton.edu

I develop a model of the financial sector in which endogenous intermediation among debt financed banks generates excessive systemic risk. Financial institutions have incentives to capture intermediation spreads through strategic borrowing and lending decisions. By doing so, they tilt the division of surplus along an intermediation chain in their favor, while at the same time reducing aggregate surplus. A core-periphery network - few highly interconnected and many sparsely connected banks - endogenously emerges in my model. The equilibrium network is inefficient since banks who make risky investments "overconnect", exposing themselves to excessive counterparty risk, while banks who mainly provide funding end up with too few connections.

3 - Spread of Epidemics on Random Graphs: A Modified Bass Model for Product Growth in Networks

Vahideh Manshadi, Assistant Professor, Yale School of Management, 165 Whitney Ave, New Haven, United States of America, vahideh.manshadi@yale.edu, Ramesh Johari, Sidhant Misra

Many products and innovations become widespread through the social interaction of individuals in a population. Bass model has been widely used to model the temporal evolution of the adoption in such social systems. Bass model implicitly assumes a global interaction among all individuals in the network. Such global interactions, however, do not exists in many large social networks. To quantify the growth rate in networks with limited interactions, we study the evolution of a simple epidemic model on random k-regular graphs. We analyze the adoption timing for k-regular random graphs and present the limit results for the time it takes for a fraction of the population to adopt. Further, we provide the timing of early adoptions at finer scales.

■ MF15

15- Chartiers

Implementations and Software

Cluster: Implementations and Software

Invited Session

Chair: Jesús VelasquezMathematical Programming Entrepreneur - CEO and Chief Scientist, DecisionWare International Corp., Finca la Antigua, Tabio, Bogotá, Cu, Colombia, jesus.velasquez@decisionware.net

1 - A Numerical Comparative Study of Steepest Descent Methods for Strongly Convex Quadratic Minimization

Mituhiro Fukuda, Tokyo Institute of Technology, 2-12-1-W8-41 Oh-okayama, Meguro-ku, Tokyo, 152-8552, Japan, mituhiro@is.titech.ac.jp, Kensuke Gotoh

We have investigated the behaviors of various step-sizes utilized in the steepest descent method for different patterns of eigenvalue distributions of the strongly convex quadratic function coefficient matrices. As one can expect, some strategies are advantageous than others and they depend on the eigenvalue distribution. We also compared with the conjugate gradient method for general trends.

2 - Optex Mathematical Modeling System: The Meta-Framework for Mathematical Programming

Jesús Velasquez, Mathematical Programming Entrepreneur - CEO and Chief Scientist, DecisionWare International Corp., Finca la Antigua, Tabio, Bogota, Cu, Colombia, jesus.velasquez@decisionware.net, Andrés Insuasty

What Optimization technology should I choose? Use OPTEX MATHEMATICAL MODELING SYSTEM that includes all of them in just one algebraic formulation. OPTEX separates the algebraic formulation of the source code of any language programming and generates mathematical models in C or in other modeling language like GAMS, IBM-OPL, MOSEL, AIMMS, AMPL – OPTEX supports every stage of mathematical modeling process; data model definition and validation, algebraic model definition (with its own unique database algebraic language), numerical model generation, problem solution (with third party solvers) and results visualization (with third party software). Due to its relational data base nature, OPTEX generates SQL statements to connect any DBMS.

■ MF16

16- Sterlings 1

News in High Performance MIP and MINLP Software

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

1 - Recent Advances in CPLEX for Mixed Integer Nonlinear Optimization

Pierre Bonami, CPLEX Optimization, IBM Spain, Sta. Hortensia 26-28, Madrid, Spain, pierre.bonami@es.ibm.com

We present some of the new algorithmic techniques that have been recently added to the IBM CPLEX solver. We focus in particular on mixed integer second order cone programming and quadratic optimization. We present extensive computational analysis to assess the performance gain compared to previous CPLEX versions.

2 - Recent Developments in BARON

Mustafa Kilinc, Postdoctoral Researcher, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, mkilinc@andrew.cmu.edu, Nikolaos Sahinidis

We report recent developments in the integer arsenal of branch-and-reduce and their implementation in the global optimization software BARON. In addition to convex nonlinear and linear programming, usage of mixed-integer and piecewise linear programming provides a portfolio of relaxations aimed to provide tight relaxations for global optimization problems. New features include more aggressive preprocessing, probing, bound tightening from duals, and new tree management techniques. Specific cutting plane generation now produces knapsack cover, knapsack with GUB cover, clique, implication, and flow cuts. Extensive computational results will be presented on problems from a collection of test sets.

3 - Presolving Methods for MIQCQP and MISOCP in the Xpress Optimizer

Pietro Belotti, Xpress Optimizer Team, FICO, Starley Way, Birmingham, United Kingdom, pietrobelotti@fico.com

We discuss some techniques used in the FICO Xpress Optimizer 7.9 to reduce bounds, eliminate variables, and otherwise reduce the complexity of mixed integer quadratically constrained and conic optimization problems. While some techniques are only useful at root presolve, other techniques are fast and can be used at any BB node. We present computational results on a large set of instances to show the impact of the presolver in these problems.

■ MF17

17- Sterlings 2

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Olga Brezhneva, Associate Professor, Miami University, 123 Bachelor Hall, Department of Mathematics, Oxford, OH, 45056, United States of America, brezhnoa@miamioh.edu

1 - Variable Sample Line Search Method for Distributed Optimization

Natasa Krklec Jerinkic, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovica 4, Novi Sad, 21000, Serbia-Montenegro, natasa.krklec@dmi.uns.ac.rs, Natasa Krejic, Dragana Bajovic, Dusan Jakovetic

We consider optimization problems related to structures with a large number of nodes where each of them aims to minimize its local cost function while the overall cost (sum of the nodes' local costs) is controlled by the fusion center. In order to decrease the overall optimization cost, algorithm performs line search iteration only with an information from the subset (sample) of nodes. The subset is governed by the parameter which represents the probability of activating each node. The probability parameter is related to the measure of progress in the objective function. Eventually, the whole set is activated almost surely providing the solution of the same quality as the one obtained by taking the whole sample from the start.

2 - Riemannian Newton's Method for Optimization Problems on the Stiefel Manifold

Hiroyuki Sato, Assistant Professor, Tokyo University of Science, 1-3, Kagurazaka, Shinjuku-ku, Tokyo, 1628601, Japan, hsato@ms.kagu.tus.ac.jp, Kensuke Aihara

Riemannian Newton's equation for an optimization problem on the Stiefel manifold, which is equivalent to the truncated singular value decomposition, is difficult to solve in its original form. In this talk, we rewrite the Newton's equation into a large sparse symmetric linear system. We also consider matrix-free Krylov subspace methods for solving the linear system. Numerical experiments show the effectiveness of our proposed method.

3 - KKT-type Optimality Conditions for Nonregular Optimization Problems

Olga Brezhneva, Associate Professor, Miami University, 123 Bachelor Hall, Department of Mathematics, Oxford, OH, 45056, United States of America, brezhnoa@miamioh.edu, Alexey Tret'yakov

The focus of this talk is on optimization problems with inequality constraints. We are interested in the case when classical regularity assumptions (constraint qualifications) are not satisfied at a solution. We start with discussion of constraint qualifications that imply the Karush-Kuhn-Tucker (KKT) optimality conditions. Then we propose new constraint qualifications and present generalized KKT-type optimality conditions for nonregular optimization problems. The results are illustrated by some examples.

■ MF18

18- Sterlings 3

Stochastic Optimization in Energy Systems

Cluster: Stochastic Optimization

Invited Session

Chair: David Morton, Professor, Northwestern University, IEMS Department, 2145 Sheridan Road, Evanston, Il, 60208, United States of America, morton@mail.utexas.edu

1 - Computing Feasible Solutions in Dual Decomposition Method Applied to Stochastic Integer Programming

Kibaek Kim, Aronne National Laboratory, 9700 South Cass Avenue, Argonne, IL, 60439, United States of America, kimk@anl.gov, Victor Zavala

The dual decomposition method can be used to obtain good lower bounds for stochastic mixed integer programs. The method, however, cannot guarantee to recover feasible solutions unless the problem has (relatively) complete recourse. We present algorithmic enhancements to effectively recover feasible solutions and to obtain upper bounds. Numerical results are provided on benchmark and unit commitment instances.

2 - Stochastic Dynamic Programming Models for Co-Optimizing Storage Operations

Ramteen Sioshansi, Associate Professor, The Ohio State University, 240 Baker Systems, 1971 Neil Avenue, Columbus, OH, 43210, United States of America, sioshansi.1@osu.edu

Energy storage, especially distributed storage, has the potential to provide many grid-related services. This inherent flexibility makes storage operations planning a challenging optimization problem. This talk introduces a stochastic dynamic programming model that co-optimizes the use of distributed storage to provide multiple services. An approximation algorithm that can efficiently find near-optimal decision policies is also presented. An illustrative case study and results are also given.

3 - Optimal Microgrid Design under Load and Photovoltaic Uncertainty

Alexander Zolan, PhD Student, Department of Operations Research and Industrial Engineering, University of Texas at Austin, 204 E. Dean Keeton Street, Stop C2200, ETC 5.160, Austin, TX, 78757, United States of America, alex.zolan@utexas.edu, Alexandra Newman, David Morton

We present a model for establishing the design and energy dispatch for a microgrid that minimizes cost and fuel requirements given a set of available technologies (diesel generators, solar arrays and batteries) and the probability model that governs the photovoltaic power availability on location and load profile at a forward operating base. We introduce a policy-based restriction of the problem that allows for the tractable solution of a multiple scenario problem while preserving solution quality.

■ MF19

19- Ft. Pitt

Theory and Applications of Multi-Objective Optimization

Cluster: Multi-Objective Optimization

Invited Session

Chair: Matthias Ehrgott, Professor and Head of Department, Lancaster University, Bailrigg, Lancaster, 00, LA1 4YX, United Kingdom, m.ehrgott@lancaster.ac.uk

1 - Stability Aspects for the Maxcut Problem with Multiple Criteria

Yury Nikulin, University of Turku, Finland, Assistentinkatu 7, 20014 Turku, Finland, yurnik@utu.fi, Kiril Kuzmin

We consider a multiple criteria version of the maxcut problem with uncertain input data. The stability is understood as some property of invariance for the set of efficient (Pareto optimal) solutions (cuts). We obtain analytical formulae of the qualitative measures of stability, the so-called stability radii, and scrutinize their properties. Computational complexity is also discussed. It is shown that, even in a single criterion case, the problem of finding exact values of the radius with any stability property cannot be solved polynomially unless P=NP.

2 - Optimisation over the Non-Dominated Set of a Multi-Objective Linear Programme

Matthias Ehrgott, Professor and Head of Department, Lancaster University, Bailrigg, Lancaster, 00, LA1 4YX, United Kingdom, m.ehrgott@lancaster.ac.uk, Zhengliang Liu

We present two new algorithms for the maximisation of a linear function over the non-dominated set of a multi-objective linear programme (MOLP). The algorithms are based on primal and dual variants of Benson's outer approximation algorithm to solve MOLPs in objective space. We compare the new algorithms with algorithms from the literature on a set of randomly generated instances. The results show that the new algorithms outperform the existing ones. As a special case, we consider the adaptation of our algorithms for the computation of the nadir point of an MOLP which is given by the worst values over the non-dominated set. We numerically compare the algorithms with a known exact algorithm from the literature to show their superiority.

3 - Finding Representations of the Nondomoniated Set in Multiobjective Optimization

Serpil Sayin, Koc University, Rumeli Feneri Yolu, Sariyer, Istanbul, 34450, Turkey, ssayin@ku.edu.tr, Gokhan Kirlik

One way to solve multiobjective optimization problems is by obtaining a representation which is a finite discrete subset of the true nondominated set. Ideally, the representation should meet a quality specification given by the decision maker. We present an algorithm for generating a representation that meets a specified coverage error. The algorithm partitions the outcome space into subsets and solves a bilevel programming subproblem for each partition element. The subproblem either finds a nondominated solution in the partition or reports that no such solution exists. Partitions are refined accordingly. We demonstrate the algorithm on a multiobjective linear programming problem using rectangular partition elements.

■ MF20

20- Smithfield

Nonsmooth Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Vinay Singh, Assistant Professor, National Institute of Technology, Department of Mathematics, NIT Mizoram, Chaltlang, Aizawl-796012 M, Aizawl, 796012, India, vinaybhu1981@gmail.com

1 - Accelerated L-BFGS for Large Scale Nonsmooth Convex Optimization

Lorenzo Stella, PhD Student, IMT Institute for Advanced Studies Lucca, Piazza San Francesco 19, Lucca, Italy, lorenzo.stella@imtlucca.it, Panagiotis Patrinos

We propose L-BFGS algorithms for nonsmooth convex composite optimization problems. These rely on the concept of forward-backward envelope (FBE), a smooth function whose unconstrained minimizers are solutions to the original problem. The complexity per iteration of our algorithms is similar to the one of the proximal gradient method, which makes them suitable for large scale applications. We show that the proposed algorithms enjoy the optimal convergence rate of FISTA, but are much faster in practice.

2 - An SQP-Inspired Algorithm for Nonsmooth Nonconvex Optimization

Hermann Schichl, A.Professor, University of Vienna, Oskar-Morgenstern-Platz 1, Vienna, 1090, Austria, hermann.schichl@univie.ac.at, Hannes Fendl, Arnold Neumaier

This talk will be about the first step on a roadmap towards an algorithm for solving general nonsmooth nonconvex programs. Taking inspiration from the SQP-method for smooth optimization we develop a strictly feasible second order bundle method for minimizing a nonsmooth objective function with respect to nonsmooth inequality constraints. The search direction is determined by solving a convex quadratically constrained quadratic program to obtain good iteration points. Furthermore, global convergence of the method is proved under certain mild assumptions. For an implementation numerical results will be presented, as well as an application to certificates of infeasibility and exclusion boxes for numerical constraint satisfaction problems.

3 - On Constraint Qualifications in Nonsmooth Mathematical Programs with Vanishing Constraints

Vinay Singh, Assistant Professor, National Institute of Technology, Department of Mathematics, NIT Mizoram, Chaltlang, Aizawl-796012 M, Aizawl, 796012, India, vinaybhu1981@gmail.com, Vivek Laha, S. K. Mishra

This paper studies mathematical programs with vanishing constraints (MPVC) under the assumptions of differentiability or Lipschitz continuity. We derive nonsmooth Karush-Kuhn-Tucker (KKT) type necessary optimality conditions for the MPVC in terms of Michel-Penot (M-P) subdifferentials. Several modifications of some known constraint qualifications like Abadie constraint qualification, Cottle constraint qualification, Slater constraint qualification, Mangasarian-Fromovitz constraint qualification and linear independence constraint qualification for the MPVC have also been studied.

■ MF21

21-Birmingham

Recent Advances in Derivative-Free Optimization II: Software and Applications

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Zaikun Zhang, Dr., CERFACS-IRIT Joint Lab, CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, 31057, France, zaikun.zhang@irit.fr

1 - Derivative-Free Optimization Methods for a Surface Structure Inverse Problem

Juan C. Meza, Prof., University of California, Merced, 5200 N. Lake Road, Merced, Ca, 95343, United States of America, jcmeza@ucmerced.edu

We will describe the use of pattern search methods and simplified physics surrogates for determining the surface structure of nanosystems. Pattern search methods have the ability to handle both continuous and categorical variables, which arises in the optimization of the coordinates and chemical identity of atoms on surfaces. We demonstrate these methods on an inverse problem arising from the simulation of nanostructures using the low energy electron diffraction (LEED) method for simulating material properties.

2 - Derivative-Free Bilevel Optimization in Road Design

Yves Lucet, Associate Professor, University of British Columbia, ASC 350, Computer Science unit 5, 3187 University Way, Kelowna, BC, V1V 1V7, Canada, yves.lucet@ubc.ca, Sukanto Mondal, Warren Hare

We split the road design problem (building the cheapest road that satisfies safety and regulation constraints) in 2 subproblems: the horizontal alignment (computing a satellite view of the road), and the vertical alignment and earthwork (determining where to cut or fill material and deciding what material to move where). We report numerical results on using derivative-free optimization to compute the horizontal alignment and a mixed-integer linear program to compute the vertical alignment and earthwork.

3 - GC-ES: A Globally Convergent Evolution Strategy for Unconstrained and Constrained Optimization

Youssef Diouane, Dr., CERFACS, 42 av. Garspard Coriolis, Toulouse Cedex 01, 31057, France, youssef.diouane@cerfacs.fr, Serge Gratton, Luis Nunes Vicente

We present a new DFO software for unconstrained and constrained optimization problems. The proposed software equips an evolution strategy (ES) with known techniques from deterministic DFO. The modified ES achieves rigorously a form of global convergence. Using feasible approaches, the software is extended to handle general constrained optimization problems. Our solver is compared to others, and the numerical results confirm its competitiveness in terms of efficiency and robustness.

■ MF22

22- Heinz

Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Christine Edman, University of Trier, Department of Mathematics, Trier, 54286, Germany, edman@uni-trier.de

1 - A Pull System's Inventory Model with Carbon Tax Policy

Tien-Yu Lin, Dr., Overseas Chinese University, 100, Chiao Kwang Rd., Taichung, 40721, Taiwan - ROC, admtyl@ocu.edu.tw

This paper aims at developing a new inventory model with carbon tax policy and imperfect quality items in which buyer has exerted power over its supplier. Four considerations are included in this new model. Moreover, this paper employs the order overlapping scheme to rectify a flaw appeared in Lin's (2010) and Chang's (2011) works. An efficient algorithm is then developed to find the optimal solution. This paper further investigated the effects of different carbon tax mechanisms on the optimal solution. Numerical examples are available in this paper to illustrate the proposed model and algorithm. Managerial insights are also explored.

2 - A Global Optimization Method for a Quadratic Reverse Convex Programming Problem by Listing FJ Points

Syuuji Yamada, Dr., Niigata University, 8050 Ikarashi 2-no-cho, Nishi-ku, Niigata, 9502181, Japan, yamada@math.sc.niigata-u.ac.jp

In this talk, we consider a quadratic reverse convex programming problem (QRC) whose feasible set is expressed as the area excluded the interior of a convex set from another convex set. It is known that many global optimization problems can be transformed into such a problem. One of the difficulties for solving (QRC) is that all locally optimal solutions do not always satisfy KKT conditions. In order to overcome this drawback, we introduce a procedure for listing FJ points of (QRC). Further, we propose an algorithm for finding a globally optimal solution of (QRC) by incorporating such a procedure into a branch and bound procedure.

3 - Solution Methods for Black-Box Optimization Problems

Christine Edman, University of Trier, Department of Mathematics, Trier, 54286, Germany, edman@uni-trier.de, Mirjam Dür

We consider expensive optimization problems, that is, problems, where each evaluation of the objective function is expensive in terms of computation time, consumption of ressources, or costs. This happens in situations where the objective is not available in analytic form, but evaluations are the result of a simulation. Therefore it is important to use as few evaluation points as possible. We discuss response surface methods which use a sophisticated strategy to determine evaluation points.

■ MF23

23- Allegheny

Adjustable and Nonlinear Robust Optimization

Cluster: Robust Optimization

Invited Session

Chair: Dick den Hertog, Tilburg University, P.O. Box 90153, Tilburg, Netherlands, D.denHertog@uvt.nl

1 - Robust Optimization of Uncertain Multistage Inventory Systems with Inexact Data in Decision Rules

Frans de Ruiter, Tilburg university, Warandelaan 2, Tilburg, Netherlands, f.j.c.t.deruiter@uvt.nl, Ruud Brekelmans, Dick den Hertog, Aharon Ben-Tal

Adjustable Robust Optimization (ARO) is a method to solve multistage decision problems. In this paper we show that ARO models may show poor performance if the revealed data is of poor quality. We remedy this weakness of ARO by introducing a methodology that treats past data itself as an uncertain model parameter. Our methods maintain the computational tractability of ARO models. The benefits of our new approach are demonstrated on a well-known production-inventory problem.

2 - When are Static and Adjustable Robust Optimization Equivalent?

Ahmadreza Marandi, Tilburg University, Haseltstraat 282, Tilburg, 5041MB, Netherlands, a.marandi@uvt.nl, Dick den Hertog

Adjustable Robust Optimization (ARO) yields, in general, better worst-case solutions than static Robust Optimization (RO). However, ARO is computationally more difficult than RO. We derive conditions under which the worst-case objective values of ARO and RO problems with constraint-wise uncertainty are equal. Additionally, we show that omitting one of the assumptions can make the worst-case objective values different. Furthermore, we extend these results to problems that also contain uncertain parameters that are not constraint-wise.

3 - Solving Robust Nonlinear Optimization Problems via the Dual

Dick den Hertog, Tilburg University, P.O. BOX 90153, Tilburg, Netherlands, D.denHertog@uvt.nl, Bram Gorissen

We show how to solve a robust nonlinear (convex-concave) optimization problem by explicitly deriving its dual. Given an optimal solution of this dual, we show how to recover the primal optimal solution. The fascinating and appealing property of our approach is that any convex uncertainty set can be used. We obtain computationally tractable robust counterparts for many new robust nonlinear optimization problems, including problems with robust quadratic constraints, second order cone constraints, and SOS-convex polynomials.

■ MF24

24- Benedum

Optimization and Variational Problems with Applications I

Cluster: Multi-Objective Optimization

Invited Session

Chair: Akhtar Khan, Associate Professor, Rochester Institute of Technology, Center for Applied and Comp. Math., School of Mathematical Sciences, Rochester, NY, 14623, United States of America, aaksma@rit.edu

Co-Chair: Baasansuren Jadamba, Rochester Institute of Technology, School of Mathematical Sciences, Rochester, NY, 14623, United States of America, bxjsma@rit.edu

1 - A Generalized Mean Value Inequality with Applications to Dynamic Optimization

Robert Kipka, Queen's University, Department of Math & Stats, Jeffery Hall, University Ave., Kingston, ON, K7L 3N6, Canada, robert.kipka@queensu.ca, Yuri Ledyaev

In this talk we introduce a multi-directional mean value inequality which includes variations originating in topological vector spaces. Examples of dynamic optimization problems in which topological vector spaces play an important role and some applications of this inequality will be given.

2 - Minimization of a Principal Eigenvalue of a Mixed Dispersal Model

Baasansuren Jadamba, Rochester Institute of Technology, School of Mathematical Sciences, Rochester, NY, 14623, United States of America, bxjsma@rit.edu

We consider an indefinite weight linear eigenvalue problem of a mixed dispersal model. The model describes organisms that disperse locally and non-locally. We investigate the minimization of the positive principal eigenvalue under the constraint that the weight is bounded from above and below, and the total weight is a fixed negative constant.

■ MF25

25- Board Room

Disease Surveillance

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Nedialko Dimitrov, The University of Texas at Austin, 1 University Station, Engineering Teaching Center 5., Austin, TX, 78712, United States of America, ned@austin.utexas.edu

1 - Optimal Data Source Selection in Disease Surveillance Networks

Ravi Srinivasan, Research Fellow, The University of Texas at Austin, Dept. of Statistics and Data Sciences, 1 University Station G2500, Austin, TX, 78712, United States of America, rav@math.utexas.edu

We present several methods for selecting data sources to best satisfy a given surveillance objective. In particular, we focus on the use of readily available online data streams for situational awareness and early detection of seasonal influenza. A comparison of these methods and their relative advantages and disadvantages is also provided.

2 - Designing Multifaceted Dengue Surveillance Systems

Samuel Scarpino, Santa Fe Insitute, 1399 Hyde Park Road, Santa Fe, NM, 87501, United States of America, scarpino@santafe.edu, Lauren Meyers, Michael Johansson

Surveillance systems are often shaped by historical, logistical, and economic constraints rather than optimized to address specific objectives. Here, we advance the systematic optimization developed by Scarpino, Dimitrov, & Meyers (2012) to evaluate and improve dengue surveillance in Puerto Rico with respect to three objectives: real-time estimation of island-wide incidence, regional incidence, and viral serotype incidence. Using data from 1991 to 2005, we identified subsets of clinics that efficiently achieved these objectives independently and in combination. We then compared these surveillance systems to systems designed using alternative methods. Finally, we assessed the robustness of this optimized system with data from 2006 to 2012.

3 - Fast, Approximate Inference on Graphical Models with Almost Independent Nodes

Areesh Mittal, Graduate Student, University of Texas at Austin, 2900 Cole Street, # 209, Austin, TX, 78705, United States of America, areesh0612@gmail.com, Nedialko Dimitrov

In some graphical models, distant nodes have little influence on each other. We show that this property, called almost independence, allows us to perform fast, approximate inference by reducing the size of the graph. We demonstrate results on discrete and Gaussian graphical models. One application of our fast, approximate inference methods is intelligence collection on a social network, where nodes are people and intercepted communications provide information on a person's suspicious activity level.

■ MF26

26- Forbes Room

Stochastic Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: John Siirola, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States of America, jdsiiro@sandia.gov

1 - Monitoring and Accelerating Progressive Hedging with Cross-scenario Information

John Siirola, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States of America, jdsiiro@sandia.gov, David L. Woodruff, Jean-Paul Watson

Progressive Hedging (PH) is a scalable and effective approach for solving large stochastic programming problems through scenario-based decomposition. However, PH is sensitive to the selection of key tuning parameters (notably rho) and for many real-world problems can exhibit slow convergence. In this work we present new approaches for accelerating convergence and improved tuning of PH by propagating key information among the scenarios. This includes cross-scenario feasibility cuts, tracking overall lower and upper objective bounds, and new heuristics for automatically determining appropriate rho values.

2 - Distributionally Robust Two-Stage Stochastic Linear Programming with a WKS-Type of Ambiguity Set

Bin Li, Curtin University, Department of Mathematics and Statistics, Australia, bin.li@curtin.edu.au, Jie Sun, Kok Lay Teo, Changjun Yu

In this paper, we consider a distributionally robust version of a two-stage stochastic linear program that incorporates the worst-case recourse function over a set of possible probability distributions. Other than analyzing these new models case by case for different ambiguity sets, we generalize the different ambiguity sets into a unified framework proposed by Wiessmann, Khun and Sim, and extend their analysis from a single constraint to two-stage stochastic linear programming.

3 - A Note on Complexity of Multistage Stochastic Programs

Marcus Reaiche, IMPA, Estrada Dona Castorina, 110, Rio de Janeiro, RJ, 22460-320, Brazil, mmcr@impa.br

In Shapiro [2006], estimates of the sample sizes required to solve a multistage stochastic programming problem with a given accuracy by the conditional sample average approximation method were derived. In this presentation we construct an example in the multistage setting that shows that these estimates cannot be significantly improved.

■ MF27

27- Duquesne Room

Coping with Dynamics and Uncertainty in Energy Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Daniel Kuhn, EPFL, EPFL-CDM-MTEI-RAO, Station 5, Lausanne, Switzerland, daniel.kuhn@epfl.ch

Co-Chair: Andy Sun, Assistant Professor, Georgia Institute of Technology, 765 Ferst Drive, Room 444 Groseclose Bld., Atlanta, GA, 30332, United States of America, andy.sun@isye.gatech.edu

1 - A Multi-Scale Decision Rule Approach for Multi-Market Multi-Reservoir Management

Napat Rujeerapaiboon, École Polytechnique Fédérale de Lausanne, EPFL CDM MTEI RAO, ODY 1 19, Station 5, Lausanne, 1015, Switzerland, napat.rujeerapaiboon@epfl.ch, Daniel Kuhn, Wolfram Wiesemann

Peak/off-peak spreads on European electricity spot markets are eroding due to the nuclear phaseout and the recent growth in photovoltaic capacity. The reduced profitability of peak/off-peak arbitrage thus forces hydropower producers to participate in the balancing markets. We propose a two-layer stochastic programming model for the optimal operation of a cascade of hydropower plants selling energy on both spot and balancing markets. The master problem optimizes the reservoir management over a yearly horizon with weekly granularity, and the slave problems optimize the market transactions over a weekly horizon with hourly granularity. We solve both the master and slave problems in linear decision rules to achieve computational tractability.

2 - Multistage Adaptive Robust Optimization for the Unit Commitment Problem

Alvaro Lorca, Georgia Institute of Technology, 755 Ferst Drive NW, Atlanta, GA, United States of America, alvarolorca@gatech.edu, Eugene Litvinov, Tongxin Zheng, Andy Sun

Motivated by the increasing penetration of wind and solar power generation in power systems, we present a multistage adaptive robust optimization model for the unit commitment problem, considering uncertainty in nodal net electricity loads. The proposed model takes into account the time causality of the hourly unfolding of nodal net loads. To deal with large-scale systems, we explore the idea of simplified affine policies and develop a solution method based on constraint generation. Computational experiments demonstrate that the proposed algorithm is effective in handling large-scale power systems and that the proposed model can outperform both deterministic and two-stage models.

3 - Connections between Least Squares Monte Carlo and Math Programming Based ADP

Selvaprabu Nadarajah, Assistant Professor of Operations Management, College of Business, University of Illinois at Chicago, 601 South Morgan Street, Chicago, IL, 60607, United States of America, selvan@uic.edu, Nicola Secomandi

Least squares Monte Carlo (LSM) methods are popular in financial engineering, including energy real option applications, while math programming ADP methods are widespread in operations research. We connect recent LSM and math programming ADP methods using an approximate linear programming (ALP) relaxation approach. This research provides a new perspective on LSM, insights into existing ALP relaxations, and motivates methodological extensions. We also discuss numerical results comparing these methods on an energy real option application.

■ MF28

28- Liberty Room

Complementarity/Variational Inequality II

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Michael Hintermüller, Prof., Humboldt-Universitaet zu Berlin, Room 2.426 (House 2, 4th floor), Rudower Chaussee 25, Berlin, 12489, Germany, hint@math.hu-berlin.de

1 - Non-Smooth Cahn-Hilliard / Navier-Stokes Problems

Michael Hintermüller, Prof., Humboldt-Universitaet zu Berlin, Room 2.426 (House 2, 4th floor), Rudower Chaussee 25, Berlin, 12489, Germany, hint@math.hu-berlin.de

Phase separation phenomena modelled by the Cahn-Hilliard (CH) system with an obstacle potential, leading to a class of complementarity problems, are considered. For modelling two-phase flows, this system is further coupled with the Navier-Stokes (NS) equations. Besides semi-smooth Newton solvers based on adaptive methods for CH/NS, optimization problems with CH/NS as constraints are discussed analytically as well as numerically.

2 - Analysis and Numerics of Optimization Problems with Variational Inequality Constraints

Thomas Surowiec, Humboldt-Universitaet zu Berlin, surowiec@math.hu-berlin.de

We present new techniques for the sensitivity analysis of variational inequalities of the second-kind. These results lead to the derivation of stationarity conditions similar to what is known for mathematical programs with complementarity constraints. Furthermore, the sensitivity results allow us to develop new types of numerical methods that do not require us to smooth the original optimization problem. The strength of the methods are illustrated by several examples.

3 - Extra-Gradient Method with Reduced Variance for Pseudo-Monotone Stochastic Variational Inequalities

Philip Thompson, IMPA and CMM, Estrada Dona Castorina, 110, Rio de Janeiro, RJ, 22460-320, Brazil, philipthomp@gmail.com, Roberto Oliveira, Alfredo Iusem, Alejandro Jofre

We give an extra-gradient method with constant stepsize for pseudo-monotone stochastic variational inequalities. We prove a.s. convergence and show the sequence is bounded in Lp. We allow an unbounded set and a non-uniform error variance with no regularization. Under the above assumptions, we achieve an accelerated rate with near-optimal complexity in terms of the natural residual. The estimates depend on the distance from initial points to the solution set (with sharper constants in case the variance is uniform). In a second part, we present incremental one-projection methods under monotonicity. The first variant requires weak-sharpness. The second uses a regularization procedure with partial step-size coordination in a multi-agent system.

■ MF29

29- Commonwealth 1

Operator Splitting Methods and Alternating Direction Method of Multipliers

Cluster: Nonsmooth Optimization

Invited Session

Chair: Shiqian Ma, Assistant Professor, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, William M.W.Mong Engineering Building, Shatin, N.T., Hong Kong - PRC, sqma@cuhk.edu.hk

Co-Chair: Shuzhong Zhang, Professor, University of Minnesota, Department of Industrial and Systems Eng, Minneapolis, MN, 55455, United States of America, zhangs@umn.edu

1 - A New Operator Splitting Scheme and its Applications

Wotao Yin, Professor, University of California, Los Angeles, Box 951555, 520 Portola Plz, MS 7620B, Los Angeles, CA, 90095, United States of America, wotaoyin@math.ucla.edu, Damek Davis

We introduce a new operator-splitting scheme for solving monotone inclusion and optimization problems of 3 blocks. The scheme includes the existing forward-backward, Douglas-Rachford, and forward-Douglas-Rachford splitting schemes as its special cases. The new scheme reduces problems into a series simpler steps. It easily applies to (split) feasibility problems, nonnegative SDPs, color image inpainting via tensor completion, 3-block monotropic programs, and so on. The scheme solves monotone inclusions: 0 in (A+B+C)x, where A and B are (single or set-valued) monotone operators and C is a cocoercive operator, with guaranteed convergence and rate.

2 - Convergence Analysis of Alternating Direction Method of Multipliers for a Family of Nonconvex Problems

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The alternating direction method of multipliers (ADMM) is widely used to solve large-scale linearly constrained optimization problems, convex or nonconvex, in many engineering fields. However there is a general lack of theoretical understanding of t he algorithm when the objective function is nonconvex. In this paper we analyze the convergence of the ADMM for solving certain nonconvex consensus and sharing problems, and show that the classical ADMM converges to the set of stationary solutions, provided that the penalty parameter in the augmented Lagrangian is chosen to be sufficiently large. For the sharing problems, we show that the ADMM is convergent regardless of the number of variable blocks.

3 - On Convergence Rate of ADMM and Its Variants for Convex Optimization with Coupled Objectives

Xiang Gao, PhD Candidate, University of Minnesota, Shepherd Lab 485, 111 Church Street SE, Minneapolis, MN, 55455, United States of America, gaoxx460@umn.edu, Shuzhong Zhang

In this talk we shall discuss the ADMM (Alternating Direction Method of Multipliers) and its variants to solve multi-block convex optimization where the objective function involves a term coupling all the variables. We show that under mild conditions the ADMM and its variants are guaranteed to converge at a rate of O(1/N), where N stands for the number of iterations.

■ MF30

30- Commonwealth 2

Approximation and Online Algorithms IV

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Hyung-Chan An, EPFL, EPFL IC IIF THL2, Station 14, Lausanne, 1015, Switzerland, hyung-chan.an@epfl.ch

1 - Approximation Algorithms for the Redundancy-Aware Facility Location Problem

Chaoxu Tong, Cornell University, 296 Rhodes Hall, 136 Hoy Road, Ithaca, NY, 14853, United States of America, blackchaoxu@gmail.com, David Shmoys, Chaitanya Swamy

We consider Redundancy Aware Facility Location problem, an extension of classical facility location.Each client has a set of sevices on demand and we need to assign every client to a facility with all requiredservices installed. The goal is to minimize the total service installation cost and clients routing cost. Wecome up with a noval dual ascent schema and extend the classical Jain-Vazirani primal dual algorithmto the special case where the demand sets of all clients form a laminar family. Combining with othertechniques, we obtain the current best approximation guarantee for this problem.

2 - An Improved Approximation for k-median, and Positive Correlation in Budgeted Optimization

Khoa Trinh, University of Maryland, A.V. Williams, College Park, MD, 20782, United States of America, khoa@cs.umd.edu, Jaroslaw Byrka, Bartosz Rybicki, Thomas Pensyl, Aravind Srinivasan

Dependent rounding is a useful technique for optimization problems with hard budget constraints. We develop algorithms that guarantee the known properties of dependent rounding, but also have nearly best-possible behavior — near-independence, which generalizes positive correlation — on "small" subsets of the variables. We improve upon Li-Svensson's approximation ratio for k-median from $2.732 + \epsilon$ to $2.611 + \epsilon$ by developing an algorithm that improves upon various aspects of their work. Our dependent-rounding approach helps us improve the dependence of the runtime on the parameter ϵ from Li-Svensson's $N^{O(1/\epsilon^2)}$ to $N^{O((1/\epsilon) \log(1/\epsilon))}$.

3 - Dynamic Facility Location via Exponential Clocks

Hyung-Chan An, EPFL, EPFL IC IIF THL2, Station 14, Lausanne, 1015, Switzerland, hyung-chan.an@epfl.ch, Ashkan Norouzi-Fard, Ola Svensson

We present a new LP-rounding algorithm for facility location problems, which yields the first constant approximation algorithm for the dynamic facility location problem. This 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. Our algorithm is based on competing exponential clocks and exhibits 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. We demonstrate that these properties enable us to apply our new algorithm to the dynamic problem.