Tuesday, 9:00am - 9:50am

■ TA01

01- Grand 1

Optimization in the Age of Big Data

Cluster: Plenary

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 - Optimization in the Age of Big Data Sparsity and Robustness at Scale

Laurent El Ghaoui, Professor, University of California, Berkeley, 421 Sutardja Dai Hall, Berkeley, CA, United States of America, elghaoui@berkeley.edu

The term "big data" is too often associated with the sole task of applying machine learning analytics to large data sets. It seems that optimization has been concerned with large data sets for a long time already, not just as purveyor of algorithms for analytics but also as models for decision-making. What is changing in the interface between learning and decision-making? What is the impact of big data on optimization? I will present various approaches and perspectives stemming from the application of optimization models in a big data context. The talk will focus on sparsity and robustness, both in statistical learning and decision-making problems. Some case studies involving online retail problems, finance and energy resource management will be presented. The emerging picture is that of an ever closer integration between the two fields, at both practical and fundamental levels.

Tuesday, 10:20am - 11:50am

■ TB01

01- Grand 1

Nonsmooth Analysis and Applications

Cluster: Variational Analysis

Invited Session

Chair: Alejandro Jofre, Professor, Universidad de Chile/Center Mathematical Modeling, Beauchef 851, edificio Norte, 7mo piso, Santiago, Santiago, Chile, ajofre@dim.uchile.cl

1 - Integration and Approximate Subdifferentials Calculus for Nonconvex Functions

Rafael Correa, Profesor, Center for Mathematical Modeling, Beauchef 850 Piso 7, Santiago de Chile, 852000, Chile, rcorrea@dim.uchile.cl, Yboon Garcia, Abderrahim Hantoute

We present three integration theorems of the epsilon subdifferential of nonconvex functions in locally convex spaces. We prove that an inclusion relationship between the epsilon subdifferentials of two any functions yet yields the equality of the closed convex envelopes up to an additive constant. When this relation only involves small values of epsilon, the integration criterion as well as the conlcusion of the integration theorems also take into account the behaviour at infinity of the functions.

2 - On the Subdifferential of Convex Integrals

Abderrahim Hantoute, Dr, Center for Mathematical Modeling, Beauchef 850 Piso 7, Santiago de Chile, 852000, Chile, ahantoute@dim.uchile.cl, Abderrahim Jourani, Rafael Correa

We provide new characterizations for the subdifferential of convex integrals whose normal integrand are defined in locally convex Suslin spaces. This setting is very convenient since it includes, from one hand, the most important settings for many applications, and, on the other hand, allows the use of the machinery of integration of vector- valued functions and multi-functions. These characterizations are given by means of the approximate subdifferential of the involved functions, and do not require any qualiffcation conditions. As a result, in the Banach setting we recover some recent results due to L. Thibaut - O. López and to A. Ioffe.

■ TB02

02- Grand 2

Intermittent Resources and Demand Response I

Cluster: Optimization in Energy Systems

Invited Session

Chair: Alfredo Garcia, Professor, Department of Industrial and Systems Engineering, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611-6595, United States of America, alfredo.garcia@ufl.edu

1 - Personalized Pricing for Demand Response

Alfredo Garcia, Professor, Department of Industrial and Systems Engineering, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611-6595, United States of America, alfredo.garcia@ufl.edu

In order to encourage consumers to reduce consumption and/or to alter their consumption patterns, most demand response programs rely on offering a menu of incentive contracts. Designing these contracts is a difficult task as consumers differ widely in their ability and willingness to shift and/or reduce electricity consumption over time. We present an iterative pricing mechanism which is guaranteed to implement (in dominant strategies) an efficient inter-temporal consumption profile.

2 - Mechanism Design for Pricing in Electricity Markets

Benjamin Heymann, Ecole Polytechnique, Route de Saclay, Palaiseau, France, benjamin.heymann@polytechnique.edu, Alejandro Jofre

We consider an incomplete information wholesale electricity market model. We derive an optimal regulation mechanism, and compare its performance to an auction setting, for which we numerically compute the Nash equilibrium, prove the theoretical convergence of the algorithm and explore the structure of the equilibrium strategies. We extend the results to the more general case.

3 - Decentralized Efficient PEV Charging Coordination

Ian Hiskens, Professor, University of Michigan, 1301 Beal Avenue, Ann Arbor, MI, 48109, United States of America, hiskens@umich.edu

Coordinated charging of large numbers of plug-in electric vehicles (PEVs) will be considered. The formulation of interest seeks to capture the tradeoffs inherent in delivering maximum energy at minimum cost, over a fixed time horizon, whilst ensuring the charge rate (power) remains reasonable. A decentralized algorithm will be presented. This process consists of PEVs determining the charge profile that minimizes their cost relative to a prespecified price curve. The aggregator collects these charge profiles and determines an updated price curve which is rebroadcast to all PEVs. The process then repeats. It will be shown that this procedure converges to the unique, efficient (socially optimal) solution.

■ TB03

03- Grand 3

Large-Scale Transportation Networks

Cluster: Combinatorial Optimization

Invited Session

Chair: Sebastian Stiller, TU Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, sebastian.stiller@tu-berlin.de

1 - Solving Train Timetabling Problems by Combining Configuration Networks and Ordering Constraints

Frank Fischer, Dr., University of Kassel, Heinrich-Plett-Str. 40, Kassel, 34132, Germany, frank.fischer@mathematik.uni-kassel.de

Given an infrastructure network and a set of trains with predefined routes, the train timetabling problem asks for conflict free schedules of those trains such that capacity restrictions in the stations and on the tracks are satisfied. One popular modelling approach is based on time expanded networks. We present an extension that strengthens the associated models by combining the configuration networks modelling technique with additional ordering constraints that allow including further combinatorial properties of the network into the model. Finally, we present promising computational results that demonstrate the superior effect of the new approach.

2 - The Block Plan Visualization Problem

Boris Grimm, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, grimm@zib.de, Thomas Schlechte, Markus Reuther

The Block Plan Visualization Problem (BPVP) is a sub problem arising during the optimization process of a large scale Rolling Stock Rotation Problem (RSRP). This is done in cooperation with DB Fernverkehr the biggest German railway company. The BPVP is the linking step between the RSRP solution, i.e., a set of cycles and its practical operation. Its task is to group elements of cycles into equally sized blocks while minimizing an objective function. This can be seen as a quadratic assignment problem. We compare heuristic and exact approaches based on Mixed Integer Linear Programming to tackle the problem. Finally, we provide computational results for real world data scenarios.

3 - Strategic Planning in Large-Scale Logistic Networks

Alexander Richter, Technische Universitaet Berlin, Institut für Mathematik, Sekr. MA 5-1, Strafle des 17. Juni 136, Berlin, 10623, Germany, arichter@math.tu-berlin.de, Sebastian Stiller

We consider hub networks from the perspective of a logistics' customer using different freight forwarders to serve its demands between several sources and sinks. We devise a robust optimization method for hub rental and routing under involved, realistic cost. Arc cost depend on the maximum demand in multiple properties. Such strategic decisions are made before actual demand is known. We seek robust solutions with lowest cost under a restricted worst-case of fluctuating demands. Using budgeted interval uncertainty, we derive a carefully relaxed MILP suitable for large instances due to its strong LP-relaxation. Results on real-world data show that robust optimization significantly reduces worst-case cost, while keeping historic average cost.

■ TB04

04- Grand 4

Computational Issues in Semidefinite Programming

Cluster: Conic Programming

Invited Session

Chair: Henry Wolkowicz, Professor, University of Waterloo, Faculty of Mathematics, Waterloo, ON, N2L3G1, Canada, hwolkowi@uwaterloo.ca

1 - Singularity Degree in Semi-definite Programming

Dmitriy Drusvyatskiy, Professor, University of Washington, Box 354350, Seattle, 98195, United States of America, ddrusv@uw.edu, Nathan Krislock, Gabor Pataki, Yuen-Lam Voronin, Henry Wolkowicz

Degenerate semi-definite programs — those without a strictly feasible point —- often arise in applications. The singularity degree of an SDP, introduced by Sturm, is an elegant complexity measure of such degeneracies. I will revisit this notion and its relationship to basic concepts, such as nonexposed faces of conic images, facial reduction iterations, and error bounds. Matrix completion problems will illustrate the ideas.

2 - Computational Aspects of Finding Lyapunov Certificates for Polynomial System via SOS Relaxation

Yuen-Lam Voronin, Dr, University of Colorado, Boulder, CO, United States of America, Yuen-Lam.Voronin@colorado.edu, Sriram Sankaranarayanan

We consider the problem of finding polynomial Lyapunov functions that certify the stability of polynomial systems. Using SOS relaxation, we often arrive at large scale semidefinite (SDP) feasibility problem instances even for polynomial systems with only modest amount of variables. We discuss some numerical difficulties that arise when solving those SDP instances. We explore several strategies for efficiently and accurately solving the SDP relaxation for finding polynomial Lyapunov functions: (1) understanding the linear maps associated with the SOS-Lyapunov stability, (2) facial reduction techniques for regularization, if necessary, and (3) specialized solution methods for finding polynomial Lyapunov certificates.

3 - Conic Optimization over Nonnegative Univariate Polynomials

Mohammad Ranjbar, PhD Student, Rugers University, 100 Rockafeller RD, New Brunswick, NJ, 08854, United States of America, 59ranjbar@gmail.com, Farid Alizadeh

We consider the conic optimization problem over nonnegative univariate polynomials and the dual moment cone; both polynomials nonnegative on an interval and on the real line are considered. It is well-known that such optimization problems can be reduced to semidefinite programming. However, this transformation may require squaring the number of variables. In addition, working with polynomials in the standard basis is notoriously ill-conditioned. We propose dual algorithms which express polynomials in the numerically stable basis of Chebyshev polynomials, and reduce cost of forming the Schur complement in interior point methods by using Fast Fourier Transform and other techniques. Concrete numerical results will be presented.

■ TB05

05- Kings Garden 1

Methods and Applications of Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

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

1 - A Derivative-Free Method for Nonlinear Optimization Problems with Deterministic Noise

Andreas Waechter, Northwestern University, 2145 Sheridan Road, Room E280, Evanston, IL, 60208, United States of America, waechter@iems.northwestern.edu, Alvaro Maggiar, Irina Dolinskaya

We present a new derivative-free method to optimize functions that are subject to numerical noise. The algorithm smoothes the objective using a Gaussian kernel, and computes a local model by regression for a trust-region step. The method employs Monte-Carlo approximations where multiple importance sampling makes it possible to reuse objective function evaluations across optimization iterates. Numerical results on a set of test problems will be presented.

2 - Efficient Inexact Strategies for Subproblem Solutions in QP, NLP, and LCP

Daniel P. Robinson, Assistant Professor, Johns Hopkins Univeristy, 3400 N. Charles Street, 100 Whitehead Hall, Office 202B, Baltimore, MD, 21218-2682, United States of America, daniel.p.robinson@jhu.edu, Frank E. Curtis

Active-set methods for quadratic problems (QP), nonlinear problems (NLP), and complementarity problems (CP) aim to identify the constraints that are active at a solution. In the large-scale case, iterative method such as linear or nonlinear CG are often used to optimize over a "face", i.e., a subspace formed by forcing certain inequality constraints to hold as equalities. It is important to design computational conditions that reliably and quickly identify when the active-set estimate is incorrect, and moreover how to proceed. A great example of this is the work by Dostal and Schoberl for minimizing a strictly convex QP subject to bound-constraints. In this talk, I consider related ideas for nonconvex QPs, NLPs, and asymmetric LCPS.

3 - A Proximal Gradient Method for Ensemble Density Functional Theory

Michael Ulbrich, Professor, TU Muenchen, Dept. of Mathematics, Boltzmannstr. 3, Garching, 85747, Germany, mulbrich@ma.tum.de, Chao Yang, Dennis Kloeckner, Zaiwen Wen, Zhaosong Lu

The ensemble density functional theory for electronic structure calculations (especially metallic systems) yields a nonconvex optimization problem with a matrix variable and orthogonality constraints. Extensions of the widely used self-consistent field (SCF) iteration to this problem exist, but their convergence theory is limited. We consider an equivalent model involving a spectral function (entropy) that has one matrix variable and a single spherical constraint. A proximal gradient method is developed by keeping the entropy term and linearizing the remaining energy terms. Convergence to stationary points is established. Numerical results in the KSSOLV toolbox show that the new method can outperform SCF on many metallic systems.

■ TB06

06- Kings Garden 2

Network Design

Cluster: Telecommunications and Networks

Invited Session

Chair: Eli Olinick, Associate Professor, SMU, P.O. Box 750123, Dallas, TX, 75275, United States of America, olinick@lyle.smu.edu

1 - Compact Formulation of Multicommodity Flow with Applications to Telecommunications Network Design

Eli Olinick, Associate Professor, SMU, P.O. Box 750123, Dallas, TX, 75275, United States of America, olinick@lyle.smu.edu

We present a new formulation of multicommodity flow inspired by the old adage that ``every journey starts with a first step". That is, flow on a non-trivial path between i and j must pass through a node k adjacent to i, and then be adjoined to the flow from k to j. The flow variable for node triple (i, j, k) represents the sum of path flows over all paths that include a subpath from i to j with edge {i, k} as the first edge. This characterization of flow yields a more compact formulation allowing more efficient solutions including instances either too large or too time consuming to solve by the standard edge-path and node-edge formulations. We present an empirical study applying our new formulation of the network design problem.

2 - Dynamic Inequalities for Capacitated Survivable Network Design

Richard Chen, Principal Member of Technical Staff, Sandia National Laboratories, Quantitative Modeling & Analysis Dept, Sandia National Labs, 7011 East Avenue, Livermore, United States of America, rlchen@sandia.gov, Cynthia Phillips

We consider a capacitated survivable network design problem that requires a feasible multicommodity flow to exist after any k edge failures. Existing approaches generate violated inequalities based on a fixed (static) failure scenario. We present new valid inequalities that dynamically cover all failure scenarios pertaining to a given network vulnerability. We then present a branch-column-cut algorithm and empirical studies on SNDlib and randomly generated instances to demonstrate the effectiveness of dynamic inequalities.

3 - Multi-Source Multi-Commodity Capacitated Facility Location Problem (cFLP) with Dynamic Demands

Dimitri Papadimitriou, Alcatel-Lucent, Copernicuslaan 50, 2018, Antwerp, 2018, Belgium, dimitri.papadimitriou@alcatel-lucent.com, Piet Demeester

The dynamic content replication and placement problem generalizes the cFLP to multiple commodities as various content objects of different size may be available at different locations. Demands dynamics may lead to consider replication of content objects at multiple locations and assignments other than the closest facility depending on the capacity allocation model and associated constraints. Topology dynamics may also induce changes in the distance between clients and facilities which imposes to include as part of the objective function the cost of rerouting when clients change their connected facilities. In this paper, we compare different formulations and resolution methods for the resulting problem together with numerical experiments.

■ TB07

07- Kings Garden 3

Computational Linear Programming I

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Stephen Maher, Zuse Institute Berlin, Takustr. 7, Berlin, Germany, maher@zib.de

1 - Symmetry in Linear Programming

Roland Wunderling, IBM, Annenstrasse 9, Graz, 8020, Austria, roland.wunderling@at.ibm.com, Jean-Francois Puget

Symmetry has long been identified as a problem for Mixed Integer Programming solvers, because it can cause a combinatorial explosion of the tree by exploring symmetric areas of the search space. Consequently, techniques have been developed to avoid such combinatorial explosion. In contrast, Linear Programming does not suffer such combinatorial explosion, and hence the effect of symmetry is expected to be much less severe. In this presentation we quantitatively explore how much symmetry affects LP and if performance improvements can be gained from exploiting symmetry.

2 - SoPlex: A New Exact LP Solver

Ambros Gleixner, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, gleixner@zib.de, Daniel Steffy, Kati Wolter

We present the underlying theory and the implementational aspects of SoPlex's new algorithms for solving linear programs exactly over the rational numbers: a high-level iterative refinement strategy, a rational LU factorization, and an output-sensitive reconstruction routine for rounding approximate solution candidates to exact solutions with bounded denominators. Our computational study shows major performance improvements over the state-of-the-art. The implementation is publically available in source code and on the NEOS server for optimization.

3 - Initial Basis Selection for LP Crossover

Christopher Maes, Gurobi Optimization Inc., 125 Beacon St. #4, Boston, MA, 02116, United States of America, maes@gurobi.com

Singular and ill-conditioned bases arise frequently when crossing over from an interior solution of a linear program. These ill-conditioned bases can slow the crossover algorithm and even cause it to fail. The sparsity and condition of later bases, and the total number of crossover steps, is influenced by the choice of the initial basis. The ideal initial basis is sparse, well-conditioned, and has few artificial variables. However, these properties often conflict with one another. We present a sparse LU factorization and ordering algorithm for selecting an initial basis that balances these different factors. We compare this new method to the approach used in version 5 of the Gurobi Optimizer on a test set of linear programming problems.

■ TB08

08- Kings Garden 4

Approximation Algorithms for Network Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Rico Zenklusen, ETH Zurich, Ramistrasse 101, HG G 21.3, Zurich, 8092, Switzerland, ricoz@math.ethz.ch

1 - Improved Region-Growing and Combinatorial Algorithms for k-Route Cut Problems

Laura Sanitá, University of Waterloo, 200 University Ave W, Waterloo, Canada, laura.sanita@uwaterloo.ca, Chaitanya Swamy, Guru Guruganesh

We study the k-route generalizations of various cut problems, the most general of which is k-route multicut, wherein we have r source-sink pairs and the goal is to delete a minimum-cost set of edges to reduce the edge-connectivity of every pair to below k. We present various approximation and hardness results that improve the state-of-the-art for these problems in several cases. Our algorithms are based on combinatorial techniques and on a new powerful region-growing approach.

2 - On Approximating Storage Allocation Problems as Good as Their Siblings

Andreas Wiese, MPI for Informatics, Campus E 1.4, Saarbruecken, 66123, Germany, awiese@mpi-inf.mpg.de, Jatin Batra, Tobias Moemke

Three particularly important and well-studied packing problems are the Unsplittable Flow on a Path problem (UFP), the Maximum Weight Independent Set of Rectangles problem (MWISR), and the 2-dimensional geometric knapsack problem. We study the storage allocation problem (SAP) which is a natural combination of those three problems. We present a (2+epsilon)-approximation algorithm for SAP and additionally a quasi-PTAS if the edge capacities can be increased by an arbitrarily small factor. Also, we construct a PTAS for the dynamic storage allocation problem (DSA) in an resource-augmentation setting where we are allowed to reject an epsilon-fraction of the input task, according to an arbitrary weight function.

3 - Online Network Design Algorithms via Hierarchical Decompositions

Seeun William Umboh, University of Wisconsin-Madison, 1210 W. Dayton St., Madison, WI, 53706, United States of America, seeun@cs.wisc.edu

We develop a new approach for network design, and apply it to obtain optimal (up to constants) competitive ratios for several online optimization problems. At the heart of this work is an analysis framework based on embeddings into hierarchically well-separated trees (HSTs): we show that the cost of the algorithm can be charged to the cost of the optimal solution on any HST embedding of the terminals. Unlike the usual algorithmic application of tree embeddings, the embeddings are used only for the analysis, not in the algorithm. Our approach yields simple greedy algorithms and straightforward analyses for the online Steiner network with edge duplication, rent-or-buy, connected facility location and prize-collecting Steiner forest problems.

■ TB09

09- Kings Garden 5

Exact Methods for Mixed-Integer Optimization Problems with Uncertainties

Cluster: Combinatorial Optimization

Invited Session

Chair: Frauke LiersProf., Friedrich-Alexander Universitaet Erlangen-Nürnberg, Department Mathematik, Cauerstrasse 11, Erlangen, Germany, frauke.liers@math.uni-erlangen.de

1 - A Frank-Wolfe Based Branch-and-Bound Algorithm for Mean-Risk Portfolio Optimization Problems

Marianna De Santis, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, marianna.de.santis@math.tu-dortmund.de, Long Trieu, Francesco Rinaldi, Christoph Buchheim

A commonly used model for portfolio optimization problems is the so called "risk-averse capital budgeting problem". In this talk, we propose a generalized version of this model, that leads to a convex mixed-integer nonlinear programming problem. The continuous relaxation of the problem is solved by a properly designed Frank-Wolfe type algorithm, that is then inserted into a branch-and-bound scheme. Experimental results on real-world instances are presented.

2 - Solving Mixed-Integer Semidefinite Programs for Robust Truss Topology Design

Tristan Gally, TU Darmstadt, Department of Mathematics, Dolivostr. 15, Darmstadt, 64293, Germany, gally@mathematik.tu-darmstadt.de, Marc Pfetsch

In this talk we will describe techniques for solving mixed-integer semidefinite programs coming from robust truss topology design with a branch-and-bound algorithm. We will deal with binary variables arising from choosing bars out of a discrete set for a given ground structure. The goal is to create a stable truss of minimal volume. We discuss general techniques like dual fixing and problem specific methods, e.g. heuristics and branching rules.

3 - Robust Time-Window Assignment for Runway Utilization

Frauke Liers, Prof., Friedrich-Alexander Universitaet Erlangen-Nürnberg, Department Mathematik, Cauerstrasse 11, Erlangen, Germany, frauke.liers@math.uni-erlangen.de, Andreas Heidt, Manu Kapolke, Alexander Martin

Efficient planning of runway utilization is one of the main challenges in Air Traffic Management. We develop an optimization approach for the pre-tactical planning phase in which time windows are assigned to aircraft. Mathematically, this leads to a b-matching problem with side constraints. In reality, uncertainty and inaccuracy almost always lead to deviations from the actual schedule. We present several robust optimization approaches together with computational results that show their effectiveness.

■ TB10

10- Kings Terrace

Advances in Quantification of Financial Data, Distributions, and Risk

Cluster: Finance and Economics

Invited Session

Chair: Jörgen Blomvall, Associate Professor, Linköping University, Linköping 58183, Sweden, jorgen.blomvall@liu.se

1 - High Quality Measurement of Financial Market Data

Jörgen Blomvall, Associate Professor, Linköping University, Linköping, 58183, Sweden, jorgen.blomvall@liu.se

High quality measurement of financial properties such as interest rate curves and volatility surfaces from market data is challenging due to noise, yet crucial to e.g. avoid arbitrage in investment models. The central choice is the choice of decision variables which impact the convexity and the regularization of the inverse problem. Both aspects can be very important for the resulting quality of the measurement, as will be illustrated with examples from the interest rate and option markets.

2 - Simultaneous Default Intensity Estimation from Bonds by a Generalized Optimization-based Framework

Johan Gustafsson, Linköpings universitet, IEI, Linköping, 581 83, Sweden, johan.gustafsson@liu.se, Jörgen Blomvall

The estimation of default intensity curves from corporate bonds is complicated by the fact that market data contain noise arising from e.g. illiquidity and indicative prices. This difficulty is addressed by estimating the default intensity curves for different credit risks simultaneously through modelling the relations between them in a generalized optimization-based framework. Results from a cross-section of Swedish and US companies are compared with results from traditional models. Preliminary results from a time series study are also presented.

3 - Optimal Expectation Inequalities for Structured Distributions

Bart Van Parys, PhD, ETH Zurich, Physikstrasse 3, Zurich, Switzerland, bartvan@ethz.ch

Quantifying the risk of unfortunate events occurring, despite limited distributional information, is a problem underlying many practical questions. Indeed, quantifying violation probabilities in distributionally robust programming or judging the risk of financial positions can be seen to involve risk quantification. We discuss worst-case probability and conditional value-at-risk problems, where the information is limited to second-order moment information and structural information such as unimodality and monotonicity. We indicate how exact and tractable reformulations can be obtained using tools from Choquet and duality theory. We make our results concrete with a stock portfolio pricing problem and a financial risk aggregation case study.

■ TB11

11- Brigade

Paths

Cluster: Combinatorial Optimization

Invited Session

Chair: Marco Blanco, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, blanco@zib.de

1 - On a Shortest 2-Path Problem

Haotian Song, University of Calgary, 2500 University Drive NW, Calgary, AB, T2N1N4, Canada, hasong@ucalgary.ca, Yuriy Zinchenko

An electric power supplier needs to build a transmission line between 2 jurisdictions. Ideally, the design of the new electric power line would be such that it maximizes some user-defined utility function, for example, minimizes the construction cost or the environmental impact. Due to reliability considerations, the power line developer has to install not just one, but two transmission lines, separated by a certain distance from one-another, so that even if one of the lines fails, the end user will still receive electricity along the second line. We discuss how such a problem can be modeled, and in particular, demonstrate a setting that allows to solve this problem in polynomial time.

2 - Solving the Quadratic Shortest Path Problem

Borzou Rostami, Technische Universitaet Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, brostami@mathematik.tu-dortmund.de, Emiliano Traversi, Christoph Buchheim

This talk addresses the Quadratic Shortest Path problem (QSPP). We prove strong NP-hardness of the problem and analyze polynomially solvable special cases, obtained by restricting the distance of arc pairs in the graph that appear jointly in a quadratic monomial of the objective function. Based on these special cases we compute separable quadratic global underestimators of the objective function to compute a lower bound and embed the bounding procedure into a Branch-and-ound framework.

3 - The Course Constrained Shortest Path Problem

Marco Blanco, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, blanco@zib.de, Ralf Borndoerfer, Nam Dung Hoang, Thomas Schlechte

The Course Constrained Shortest Path Problem arises as a major challenge in flight trajectory optimization. It consists of computing a shortest s,t-path on a graph, subject to restrictions defined by CNF boolean formulas on the node and arc variables. We present polyhedral results for the special case of the Path Avoiding Forbidden Pairs Problem. We also introduce novel solution algorithms for the general case, and test them on real-world instances.

■ TB12 10:30am - 11:00am

12- Black Diamond

AMPL – New Developments in the AMPL Modeling Language

Cluster: Software Presentations

Invited Session

Chair: David Gay, AMPL Optimization, Inc., 900 Sierra Place SE, Albuquerque, NM, 87108-3379, United States of America, dmg@ampl.com

1 - AMPL – New Developments in the AMPL Modeling Language

David Gay, AMPL Optimization, Inc., 900 Sierra Place SE, Albuquerque, NM, 87108-3379, United States of America, dmg@ampl.com, Victor Zverovich

We describe a recently developed AMPL API that provides seamless access to the AMPL modeling system from popular general-purpose programming languages, which may help you to embed optimization models in your applications. We also discuss various solver-interface issues that are to be documented in an updated "Hooking Your Solver to AMPL", and we introduce new AMPL interfaces to Baron, LGO, and LocalSolver. Finally, we sketch some forthcoming AMPL features.

■ TB13

13- Rivers

Second-Order Cones, SDP and P-Norm Cones

Cluster: Conic Programming

Invited Session

Chair: Ellen Hidemi FukudaAssistant professor, Kyoto University, Sakyo-ku Yoshida Honmachi, Graduate School of Informatics, Kyoto, 606-8501, Japan, ellen@i.kyoto-u.ac.jp

1 - Novel Approach for Singly Constrained QCQP

Rujun Jiang, Chinese University of Hong Kong, C323,PGH1, Hong Kong, Hong Kong - PRC, rjjiang@se.cuhk.edu.hk, Duan Li

We investigate in this paper a general class of singly constrained quadratically constrained quadratic programming (QCQP) problem. We characterize all possible situations for the QCQP in the matrix sight, which, as to our knowledge, hasn't been done in the existing literature. Applying simultaneous block diagonalization, we obtain the congruent canonical form for both symmetric matrices in the objective function and in the constraint. We derive necessary conditions for the solvability of QCQP. For all solvable QCQP problems, we can transform them into their corresponding SOCP formulation. Compared to the state-of-the-art in formulating as semidefinite programming (SDP), our formulation delivers a much faster solution algorithm.

2 - Studies on Squared Slack Variables for Nonlinear Second-Order Cone and Semidefinite Programming

Ellen Hidemi Fukuda, Assistant professor, Kyoto University, Sakyo-ku Yoshida Honmachi, Graduate School of Informatics, Kyoto, 606-8501, Japan, ellen@i.kyoto-u.ac.jp, Masão Fukushima, Bruno Lourenco

The use of squared slack variables in nonlinear programming is well-known, but hardly considered in the optimization community. Usually, the advantage of having only equality constraints do not compensate for the disadvantages, like the increase of the dimension of the problem and the numerical instabilities. The situation is different for nonlinear second-order cone and nonlinear semidefinite programming cases. Since the reformulated problem has no longer conic constraints, we can solve the problem by using a general-purpose nonlinear programming solver. Here, we are concerned with the theoretical analysis of the squared slack variables approach, establishing the relation between KKT points of the original and the reformulated problems.

■ TB14

14- Traders

Resource Allocation Games with Structures

Cluster: Game Theory

Invited Session

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

1 - Price of Anarchy for Mechanisms with Admission

Bojana Kodric, MPI Informatik, Campus E 1 4, Saarbrücken, Germany, bojana@mpi-inf.mpg.de, Martin Hoefer, Thomas Kesselheim

We study repeated games with allocation mechanisms. In each round each mechanism is available for each player only with a certain probability. This is an elementary case of simple mechanism design with incomplete information, where availabilities are player types. It captures natural applications in online markets and for channel access in wireless networks. We propose an approach where each player uses a single no-regret learning algorithm and applies it independently of availability. This addresses some major concerns about learning outcomes in Bayesian settings. We show small bounds on the price of anarchy via novel composition theorems for smooth mechanisms, which rely on a new connection to the notion of correlation gap.

2 - Matroids are Immune to Braess Paradox

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

The famous Braess paradox describes the following phenomenon: It might happen that the improvement of resources, like building a new street within a congested network, may in fact lead to larger costs for the players in an equilibrium. In this paper we consider general nonatomic congestion games and give a characterization of the maximal combinatorial property of strategy spaces for which Braess paradox does not occur. In a nutshell, bases of matroids are exactly this maximal structure. We prove our characterization by two novel sensitivity results for convex separable optimization problems over polymatroid base polyhedra which may be of independent interest. This is joint work with S. Fujishige, M.X. Goemans, B. Peis and R. Zenklusen.

3 - Coordination Games on Graphs

Mona Rahn, CWI, Science Park 123, Amsterdam, Netherlands, rahn@cwi.nl, Guido Schaefer, Krzysztof Apt, Sunil Simon

We introduce natural strategic games on graphs, which capture the idea of coordination in a local setting. We show that these games have an exact potential and have strong equilibria when the graph is a pseudoforest. We also exhibit some other classes of games for which a strong equilibrium exists. However, in general strong equilibria do not need to exist. Further, we study the (strong) price of stability and anarchy. Finally, we consider the problems of computing strong equilibria and of determining whether a joint strategy is a strong equilibrium. We also consider some extensions, in particular to weighted graphs.

■ TB15

15- Chartiers

Multilevel Algorithms for Large-Scale Optimisation

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

Invited Session

Chair: Panos Parpas, Imperial College London, 180 Queens Gate, SW6 6DZ, London, United Kingdom, panos.parpas@imperial.ac.uk

1 - A Multilevel Approach for l1 Regularized Convex Optimization: Application to Covariance Selection

Eran Treister, Post-Doctoral Fellow, University of British Columbia, 408-3515 Wesbrook Mall, UBC,, Vancouver, BC, V6T1Z4, Canada, eran@cs.technion.ac.il, Irad Yavneh, Javier S. Turek

We present a multilevel framework for solving l1 regularized convex optimization problems, which are widely popular in the fields of signal processing and machine learning. Such l1 regularization is used to find sparse minimizers of the convex functions. The framework is applied for solving the Covariance Selection problem, where a sparse inverse covariance matrix is estimated from a only few samples of a multivariate normal distribution. Numerical experiments demonstrate the potential of this approach, especially for large-scale problems.

2 - Fast Multilevel Support Vector Machines

Talayeh Razzaghi, Postdoc, Clemson University, 100 McAdams Hall, Clemson, SC, 29634, United States of America, trazzag@g.clemson.edu, Ilya Safro

Solving optimization models (including parameters fitting) for support vector machines on large-scale data is often an expensive task. We propose a multilevel algorithmic framework that scales efficiently to very large data sets. Instead of solving the whole training set in one optimization process, the support vectors are obtained and gradually refined at multiple levels of data coarseness. Our multilevel framework substantially improves the computational time without loosing the quality of classifiers. The algorithms are demonstrated for both regular and weighted support vector machines for (im)balanced classification problems. Quality improvement on several imbalanced data sets has been observed.

3 - A Multilevel Proximal Algorithm for Large Scale Composite Convex Optimization

Panos Parpas, Imperial College London, 180 Queens Gate, SW6 6DZ, London, United Kingdom, panos.parpas@imperial.ac.uk

Composite convex optimization models consist of the minimization of the sum of a smooth convex function and a non-smooth convex function. Such models arise in many applications where, in addition to the composite nature of the objective function, a hierarchy of models is readily available. We adopt an optimization point of view and show how to take advantage of the availability of a hierarchy of models in a consistent manner. We do not use the low fidelity model just for the computation of promising starting points but also for the computation of search directions. We establish the convergence and convergence rate of the proposed algorithm and discuss numerical experiments.

■ TB16

16- Sterlings 1

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Jan Hackfeld, TU Berlin, Strafle des 17. Juni 136, Berlin, 10623, Germany, hackfeld@math.tu-berlin.de

1 - Variable Sized Bucket Indexed Formulations for Nonpreemptive Single Machine Scheduling Problems

Hamish Waterer, University of Newcastle, University Dr, Callaghan, Australia, hamish.waterer@newcastle.edu.au, Riley Clement, Natashia Boland

The authors recently proposed a bucket indexed (BI) mixed integer linear programming formulation for nonpreemptive single machine scheduling problems. The BI model generalises the classical time (TI) indexed formulation to one in which at most two jobs can be processing in each period. The planning horizon is divided into periods of equal length, but unlike the TI model, the length of a period is a parameter of the model and can be chosen to be as long as the processing time of the shortest job. In this talk we present new BI formulations in which the lengths of each period are not required to be identical. Computational experiments comparing the performance of these models to those from the literature will be presented.

2 - The Complexity of the Matching Extension Problem in General Graphs

Jan Hackfeld, TU Berlin, Strafle des 17. Juni 136, Berlin, 10623, Germany, hackfeld@math.tu-berlin.de, Arie M.C.A. Koster

A simple graph G with 2n vertices is said to be k-extendable for an integer k with $0 < k < n$ if G contains a perfect matching and every matching of cardinality k in G is a subset of some perfect matching. Lakhal and Litzler (1998) discovered a polynomial algorithm that decides whether a bipartite graph is k-extendable. For general graphs, however, it has been an open problem whether there exists a polynomial algorithm. In the talk, we will show that the extendability problem is coNP-complete. Moreover, we present an integer program together with a separation algorithm for the extendability problem.

3 - Extended Formulations for 2-D Cutting with 4-stage Restricted Guillotine and Rotation

Quentin Viaud, Université Bordeaux, Institut de Mathématiques, 351 cours de la Libération, IMB - B,t. A33, Talence, 33405, France, quentin.viaud@u-bordeaux.fr, Ruslan Sadykov, François Vanderbeck, François Clautiaux

We consider the two-dimensional bin packing problem where the cutting process is 4-stage and restricted to exact guillotine cuts, while piece rotation is allowed. For this NP-hard problem, combinatorial methods or compact MIP models are known to be weak. But so-called extended formulations can provide good approaches. The formulation we use is based on a hypergraph flow reformulation. We compare experimentally several methods (column generation, direct MIP approach) for solving efficiently this pseudo-polynomial-size model.

■ TB17

17- Sterlings 2

Numerical Methods for Structured Nonlinear Programs I

Cluster: Nonlinear Programming

Invited Session

Chair: Christian KirchesJunior Research Group Leader, TU Braunschweig / Heidelberg University, Im Neuenheimer Feld 368, Heidelberg, 69120, Germany, christian.kirches@iwr.uni-heidelberg.de

1 - Multilevel Iterations for Optimal Feedback Control

Ekaterina Kostina, University of Heidelberg, INF 293, Heidelberg, 69120, Germany, ekaterina.kostina@iwr.uni-heidelberg.de

We are interested in computing feedback optimal controls by simultaneous on-line MHE of the system states and parameters and re-optimization of the optimal control, as in NMPC. A bottleneck in practical applications is real time feasible implementation of the algorithm. One way to substantially reduce the response time are so-called multilevel iterations. However, today's state-of-the-art is to perform MHE and NMPC separately. A next logical step is the development of a simultaneous MHE and NMPC in one step. In this talk we present an efficient generalization of multilevel iterations based on coupling of the MHE and NMPC with inexact Newton methods which allows for further reduction of response times.

2 - An Elastic Active Set Approach for Large Structured QPs

Daniel Rose, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, rose@ifam.uni-hannover.de, Marc C. Steinbach

We consider SQP methods for large structured QPs where a specialized sparse solver is available for the KKT system in an active set QP solver. Our goal is a generic active set algorithm that employs any custom KKT solver in a slack relaxation of the QP to avoid a phase 1. This involves a partial projection that preserves the NLP sparse structure in the KKT system. The talk discusses the structural properties of our approach and of the subproblems on several levels. As a concrete example we consider NLPs on trees arising, e.g., in robust model predictive control. We also discuss relevant aspects of the software design.

3 - Sequential Linear Equality Constrained Programming for Application in Mixed-Integer NMPC

Felix Lenders, Interdisciplinary Center for Scientific Computing, Heidelberg University, Im Neuenheimer Feld 368, Heidelberg, 69120, Germany, felix.lenders@iwr.uni-heidelberg.de, Christian Kirches, Georg Bock

In Mixed-Integer Model Predictive Control Applications similar Mathematical Programs with Equilibrium Constraints (MPEC) have to be solved. Methods for Nonlinear Programs as SQP may fail when applied to these problems. Sequential Linear Equality Constrained Programming (SLEQP) Methods are Active Set Methods using a Linear Program for active set determination. These methods can be extended towards MPEC and guarantee termination in Bouligand stationary points. In this talk a preliminary SLEQP Algorithm for MPEC will be presented.

■ TB18

18- Sterlings 3

Risk-Averse Stochastic Programming

Cluster: Stochastic Optimization

Invited Session

Chair: Guzin Bayraksan, Associate Professor, Ohio State University, 1971 Neil Ave., Columbus, OH, 43210, United States of America, bayraksan.1@osu.edu

1 - Distributionally Robust Stochastic Programs with Recourse with Variation Distance

Hamed Rahimian, The Ohio State University, 1971 Neil Ave., Columbus, OH, 43210, United States of America, rahimian.1@osu.edu, Guzin Bayraksan, Tito Homem-de-Mello

Traditional stochastic programs assume that data uncertainty is governed by a known probability distribution, and optimize the expected cost. When the probability distribution is unknown, an alternative modeling approach—-distributionally robust stochastic program—-hedges against the worst probability distribution in an ambiguity set. We focus on the variation distance to form the ambiguity set of distributions, and explore the properties of two-stage and multi-stage models. We propose a decomposition-based algorithm to obtain the optimal policy and the worst probability distribution. Finally, we characterize a minimal scenario tree, where the presence of every scenario is critical in determining the optimal objective function.

2 - Risk Aversion in Multistage Stochastic Programming: A Modeling and Algorithmic Perspective

Bernardo Pagnoncelli, Universidade Adolfo Ibanez, Diagonal las Torres 2640 oficina 533-C, Santiago, Chile, bernardo.pagnoncelli@uai.cl, Tito Homem-de-Mello

In this presentation I will discuss the incorporation of risk measures into multistage stochastic programs. Much attention has been recently devoted in the literature to this type of model, but there is no consensus on the best way to accomplish that goal. I will discuss pros and cons of the existing approaches, and propose a novel definition of consistency. A class of risk measures which we call expected conditional risk measures is discussed, and a pension fund example illustrates the use of this risk measure in practice.

3 - A Decomposition Method for Two-Stage Stochastic Programs with Risk-Averse Utilities

Tito Homem-de-Mello, Universidad Adolfo Ibanez, Diagonal las Torres 2640 Penalolen, Santiago, Chile, tito.hmello@uai.cl, Sebastian Arpon, Bernardo Pagnoncelli, Rodrigo Carrasco

We discuss a decomposition method for two-stage stochastic programs with risk-averse utilities. Our algorithm is based on the Alternating Direction Method of Multipliers (ADMM) developed in the literature, and decomposes the problem by scenarios. Some attractive features of the algorithm are its simplicity of implementation and its suitability for parallelization. We discuss some aspects related to convergence of the method and present results from numerical experiments to illustrate the ideas.

■ TB19

19- Ft. Pitt

Hybrid Optimization I

Cluster: Constraint Programming

Invited Session

Chair: Michele Lombardi, DISI, University of Bologna, Viale del Risorgimento 2, Bologna, 40136, Italy, michele.lombardi2@unibo.it

1 - Variable Branching in MIPs: A Machine Learning approach

Elias Khalil, Georgia Institute of Technology, 1062 Hemphill Avenue NW, Atlanta, GA, 30318, United States of America, lyes@gatech.edu, Bistra Dilkina, Le Song

A machine learning (ML) framework for variable branching in Mixed Integer Linear Programs is proposed. In phase I, our method observes the decisions made by Strong Branching (SB), an effective yet inefficient strategy, and collects features that characterize variables at each search tree node. Based on the collected data, we learn an easy-to-evaluate surrogate function to mimic SB by solving a "learning-to-rank" problem, common in ML. The learned strategy is a linear function of the features which is likely to assign higher scores to "good" variables. In phase II, the learned ranking function is used for branching. Preliminary results indicate that our method is competitive with SB and state-of-the-art strategies in commercial solvers.

2 - Constraint Programming in Data Mining

Tias Guns, KU Leuven, Celestijnenlaan 200A, Leuven, 3000, Belgium, tias.guns@cs.kuleuven.be

The use of constraints is prevalent in data mining, most often to express background knowledge or feedback from the user. Computationally, constraints have been studied for many years by the constraint programming community. In recent years, such technology is increasingly applied in the field of (symbolic) data mining. Many challenges exist though, at the level of modelling the problem (encodings, high-level languages, new primitives) as well as at the solving level (scalability, redundant constraints, search strategies). We review recurring motivations and highlight some of the challenges with MiningZinc, a high-level pattern mining language with solving mechanism that can hybridize specialised algorithms and CP solvers.

3 - Discrete Optimization with Decision Diagrams

Willem-Jan van Hoeve, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, United States of America, vanhoeve@andrew.cmu.edu, David Bergman, Andre Augusto Cire, John Hooker

We present an exact solution approach for discrete optimization problems where decision diagrams play the role of the traditional LP relaxation. Relaxed decision diagrams provide bounds and guidance for branching, while restricted decision diagrams supply a primal heuristic. The search scheme branches within relaxed decision diagrams instead of individual variables. We show that our approach is competitive with, or superior to, a leading MIP solver for the independent set, maximum cut, and maximum 2-SAT problem.

■ TB20

20- Smithfield

Fast Proximal–Based Algorithms and Dynamical Systems for Structured Optimization: Applications to Signal/Imaging Processing

Cluster: Nonsmooth Optimization

Invited Session

Chair: Hedy Attouch, Professor, Place Eugène Bataillon, Montpellier, 34095, France, attouch@math.univ-montp2.fr

1 - Large Scale Optimization using Multiresolution Analysis and Proximity Operators

Bruce Suter, Air Force Research Laboratory, Rome, NY, 13441-4505, United States of America, bruce.suter@us.af.mil, Lixin Shen

Multiresolution analysis has been widely used for representing data as linear combinations of multiscale basis functions and it facilitates in the designing of fast computational algorithms. Proximity operator has been used extensively in nonlinear optimization. We shall present how multiresolution analysis and proximity operators can be synthesized in a highly innovative fashion to solve large scale optimization problems. Numerical experiments for image deblurring will be presented to show the efficiency of this approach for large scale optimization.

2 - Fast Convergence of an Inertial Gradient-like System with Vanishing Viscosity

Juan Peypouquet, PhD, Univesidad Tecnica Federico Santa Maria, Av Espana 1680, Valparaiso, Chile, juan.peypouquet@sansano.usm.cl, Patrick Redont, Hedy Attouch

We study the fast convergence of the trajectories of a second-order gradient-like system with a vanishing viscosity coefficient depending on a parameter. When the underlying potential has minimizers, each trajectory converges weakly to one of them. Strong convergence occurs in various practical situations. Surprisingly, in the strongly convex case, convergence is arbitrarily fast depending on the values of the parameter. When the solution set is empty, the minimizing property still holds, but the rapid convergence of the values may not be satisfied. Time discretization of this system provides new fast converging algorithms, expanding the field of rapid methods for structured convex minimization.

3 - Dynamics for Multicriteria Optimization

Guillaume Garrigos, PhD, Université de Montpellier, Place Eugène Bataillon, Montpellier, 34095, France, guillaume.garrigos@gmail.com

We present some new results about a continuous dynamic in the context of the multicriteria analysis. It is called the MultiObjective Gradient dynamic (MOG), and can be seen as a vectorial analog of the classic steepest descent. It is a cooperative dynamic whose trajectories makes all the involved functions decrease along time. Moreover, under a convex assumption, the trajectories converge to a weak Pareto point. So, our aim is to introduce the basic tools used in multicriteria analysis, and study the properties of (MOG). We will compare it to a recently studied algorithm, which can be seen as a discretization in time of our dynamic. Finally, we will discuss a second order continuous dynamic, by introducing in (MOG) an inertial term.

■ TB21

21-Birmingham

Constrained and Multi-Objective Expensive Black-Box Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Rommel Regis, Associate Professor, Saint Joseph's University, Department of Mathematics, 5600 City Avenue, Philadelphia, PA, 19131, United States of America, rregis@sju.edu

1 - GOSAC: Global Optimization with Surrogate Approximation of Constraints

Juliane Mueller, Postdoc, Lawrence Berkeley National Lab, 1 Cyclotron Road, Berkeley, CA, 94720, United States of America, JulianeMueller@lbl.gov

We introduce GOSAC, a global optimization algorithm for problems with computationally expensive black-box constraint functions. GOSAC uses computationally cheap surrogate models to approximate the constraints. We iteratively select new sample points by minimizing the cheap objective function subject to the surrogate constraint approximations. GOSAC is able to deal with continuous, pure integer, and mixed-integer variables. Numerical experiments show that GOSAC is able to find near optimal solutions for a wide variety of problems.

2 - Parallel Single Objective Surrogate Global Optimization with Multi-Objective and Tabu Search

Christine Shoemaker, Professor, Cornell University, Civil and Environmental Engr., Operations Res. and Info. Engr., Ithaca, NY, 14853, United States of America, cas12@cornell.edu, Tipaluck Krityakierne, Taimoor Akhtar

A parallel surrogate-based continuous global optimization method for computationally expensive, black box objective functions is introduced. Algorithm blends multi-objective non-dominated sorting and tabu search into single objective surrogate optimization. SOP outperformed alternatives on most multimodal test functions. Sufficient conditions for convergence are presented. Sometimes SOP with 8 processors finds an accurate answer in less wall-clock time than the other algorithms get with 32 processors. In four cases, SOP with 32 processors got speedups greater than 32.

3 - Derivative-Free and Surrogate-Based Approaches for Expensive Multi-Objective Black-Box Optimization

Rommel Regis, Associate Professor, Saint Joseph's University, Department of Mathematics, 5600 City Avenue, Philadelphia, PA, 19131, United States of America, rregis@sju.edu

This talk reviews some of the current derivative-free and surrogate-based approaches for the multi-objective optimization of expensive black-box objective functions possibly subject to expensive black-box constraints. It will include provably convergent approaches, including trust-region methods and direct search methods, as well as heuristics such as NSGA-II and methods that use surrogate models for the objective and constraint functions. It will also present numerical results using some of these approaches on test problems with bound constraints only and also on test problems with black-box inequality constraints.

■ TB22

22- Heinz

Recent Advances in Deterministic Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Christodoulos FloudasDirector, Texas A&M Energy Institute, Erle Nye '59 Chair, Professor for Engineering Excellence, Department of Chemical Engineering, College Station, TX, 77843, United States of America, floudas@tamu.edu,floudas@princeton.edu

1 - Convergence Rate of Multivariate McCormick Relaxations

Alexander Mitsos, Professor, RWTH Aaachen University, Turmstr. 46, Aachen, 52064, Germany, alexander.mitsos@avt.rwth-aachen.de, Angelos Tsoukalas, Agustin Bompadre, Jaromil Najman

We consider a recently proposed extension of the McCormick's composition theorem to multi-variate outer functions. In addition to extending the framework, the multi-variate McCormick relaxation is a useful tool for the proof of relaxations: by direct application to the product, division and minimum/maximum of two functions, we obtain improved relaxations when comparing with uni-variate McCormick. We then extend a recently proposed framework for the analysis of convergence rate of convex relaxations to the Multivariate McCormick relaxations. Finally we compare the convergence rate of the new relaxations to established relaxations.

2 - Logic-based Outer-approximation for Global Optimization of GDP

Francisco Trespalacios, PhD Student, Carnegie Mellon University, Department of Chemical Engineering, Doherty Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, ftrespal@andrew.cmu.edu, Ignacio Grossmann

An alternative way to represent MINLP problems is Generalized Disjunctive Programming (GDP) that involves algebraic equations, disjunctions and logic propositions. In this work we present a logic-based outer-approximation algorithm to find the global solution of GDPs involving nonconvex functions in the continuous variables. The algorithm iteratively solves a master MILP and a reduced nonconvex NLP subproblem. The basic algorithm is improved with two main features: a novel derivation of new cuts and a two-stage partition. Numerical results are reported.

3 - Solving MINLP with Heat Exchangers: Special Structure Detection and Large-Scale Global Optimisation

Ruth Misener, Lecturer and RA Engr. Research Fellow, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom, r.misener@imperial.ac.uk, Miten Mistry

Optimising heat exchangers networks (HEN) may increase efficiency in industrial plants; we develop deterministic global optimisation algorithms for a MINLP model that simultaneously incorporates utility cost, equipment area, and hot / cold stream matches. In this work, we automatically recognise and exploit special mathematical structures common in HEN including log mean temperature difference and Chen approximation; we computationally demonstrate the impact on the global optimisation solver ANTIGONE and benchmark large-scale test cases against heuristic approaches.

■ TB23

23- Allegheny

Robust Optimization Applications

Cluster: Robust Optimization

Invited Session

Chair: Melvyn Sim, Professor, Singapore, melvynsim@gmail.com

1 - Data-Driven Learning in Dynamic Pricing using Adaptive Optimization

Phebe Vayanos, MIT Sloan School of Management, MIT ORC, Office E40-111, 77 Massachusetts Ave, Cambridge, MA, 02139, United States of America, pvayanos@mit.edu, Dimitris Bertsimas

We consider the pricing problem faced by a retailer endowed with a finite inventory of a product offered to price-sensitive customers. The parameters of the demand curve are unknown to the seller who has at his disposal a history of sales data. We show that the seller's problem can be formulated as an adaptive optimization problem with policy-dependent uncertainty set. We obtain a conservative approximation in the form of mixed-binary conic optimization problem that is practically tractable. We present computational results that show that the proposed policies: yield higher profits compared to commonly used policies, and can be obtained in modest computational time for large-scale problems.

2 - Risk-averse Scheduling with Random Service Durations and No-shows under Ambiguous Distributions

Siqian Shen, Assistant Professor, Department of Industrial and Operations Engineering, University of Michigan, 2793 IOE Building, 1205 Beal Avenue, Ann Arbor, MI, 48103, United States of America, siqian@umich.edu, Ruiwei Jiang

We investigate distributionally robust scheduling problems that assign arrival time under random service durations and no-shows, of which the joint distribution is bounded by a confidence set using marginal means. We discuss models that minimize/constrain the worst-case expected cost or CVaR of waiting, idleness, and overtime. We classify three cases of the support of no-shows, each following a prior belief of maximum number of consecutive no-shows. For each case, we either propose a cutting-plane algorithm or derive the convex hull as polynomial-size LPs. We compute diverse instances to demonstrate the efficacy of our approaches and insights of risk hedging in scheduling under heterogeneous uncertainties.

3 - Robust Design of Waste-to-Energy Systems

Adam Ng, Associate Professor, National University of Singapore, 1 Engineering Drive 2, Singapore, Singapore, isentsa@nus.edu.sg, Shuming Wang

Sustainable waste management is an important environmental-energy-economic issue, and various waste treatment technologies capable of recovering useful energy efficiently from different waste stream components are now commercially available. Sound decision-making under uncertainty of future waste generation characteristics is critical, since installing new treatment technologies often involve very high investment costs. We introduce how robust optimization modelling can be used to provide effective support for the analysis and design of sustainable waste-to-energy solutions.

■ TB24

24- Benedum

Mixed-Integer Quadratic Programming

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Jeff Linderoth, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53711, United States of America, linderoth@wisc.edu

1 - Compact Mixed-Integer Formulations of Nonconvex Quadratically Constrained Quadratic Programs

James Foster, Postdoctoral Research Associate, University of Wisconsin-Madison, 330 North Orchard Street, Madison, WI, 53715, United States of America, jfoster@discovery.wisc.edu, James Luedtke

We show how to reformulate a nonconvex quadratically constrained quadratic program (QCQP) into a mixed-integer program composed of linear constraints and second-order cone equations. We then describe the construction of mixed-integer linear programs that approximate the original QCQP to high precision while only introducing a small number of additional variables and constraints. Application to the solution of optimal power flow problems will be presented.

2 - Towards the Exact Solution of Biobjective Mixed Integer Quadratic Programs

Nathan Adelgren, Clemson University, Department of Mathematical Sciences, Clemson, SC, 29634, United States of America, nadelgr@clemson.edu, Margaret Wiecek, Akshay Gupte

In this work we present an algorithm for solving a multiparametric convex QP with parameters in general locations by reformulation of the problem as a multiparametric linear complementarity problem. We use this method to obtain the Pareto set of a multiobjective QP. This method and new branching, fathoming, cutting plane and node relaxation techniques are incorporated into a branch and bound framework designed for computing the complete Pareto set of a biobjective mixed-integer QP.

3 - A Feasible Active Set Method with Reoptimization for Convex Quadratic Mixed-Integer Programming

Long Trieu, TU Dortmund, Vogelpothsweg 87, 44227, Dortmund, Germany, long.trieu@math.tu-dortmund.de, Stefano Lucidi, Christoph Buchheim, Marianna De Santis, Francesco Rinaldi

We present a fast branch-and-bound scheme for solving strictly convex quadratic mixed-integer programs with linear constraints. In each node we solve the continuous relaxation of the dual quadratic program with an effective feasible active set algorithm to get a lower bound. Experimental results for randomly generated instances of several types are presented. Compared with the MIQP solver of CPLEX 12.6, it turns out to be competitive for instances with a small number of constraints.

■ TB25

25- Board Room

Applications in Energy

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Jan Thiedau, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, thiedau@ifam.uni-hannover.de

1 - Adaptive Discretization of Nonlinear Optimization Models for Energy Supply Systems

Sebastian Goderbauer, RWTH Aachen University, Lehrstuhl II für Mathematik, Pontdriesch 14/16, Aachen, 52062, Germany, goderbauer@math2.rwth-aachen.de, Björn Bahl, André Bardow, Arie M.C.A. Koster, Marco Lübbecke

Energy supply systems are highly integrated and complex systems to be designed to meet time-varying energy demands in, e.g., heating, cooling, and electricity. Various types of energy conversion units with different capacites, nonlinear investment costs, and nonlinear part-load performances can be chosen. This leads to mixed-integer nonlinear programming (MINLP) problems. We present an adaptive discretization algorithm for such problems containing an iterative interaction between mixed-integer linear programms (MIPs) and nonlinear programms (NLPs), which outperformes state-of-the-art MINLP solvers with regard to solution quality and computation times.

2 - Nonlinear Optimization for Storage of Electric Energy in Gas Networks

Jan Thiedau, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, thiedau@ifam.uni-hannover.de, Marc C. Steinbach

The need for storage for highly volatile generated renewable energy can be addressed by electric compressor stations storing energy in terms of pressure increase. We present a transient optimization model that incorporates gas dynamics and technical network elements. Direct discretization leads to an NLP that is solved by interior point methods. We present an analysis on the structure of the arising linear systems as well as results for simple pipelines.

■ TB26

26- Forbes Room

Optimization with Stochastic Preference Constraints

Cluster: Stochastic Optimization

Invited Session

Chair: Nilay Noyan, Associate Professor, Sabanci University, Istanbul, Turkey, nnoyan@sabanciuniv.edu

1 - Robust Multicriteria Risk-Averse Stochastic Programming

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

We study risk-averse models for multicriteria optimization problems under uncertainty. We use a weighted sum-based scalarization and consider a set of scalarization vectors to address the ambiguity and inconsistency in the relative weights of each criterion. We introduce a model that optimizes the worst-case multivariate CVaR and develop a finitely convergent cut generation algorithm for finite probability spaces. We show that this model can be reformulated as a compact LP for certain scalarization sets. We give a stronger formulation for the cut generation MIP for the equiprobable case, which is also useful for a related class of CVaR-constrained problems. Our computational study illustrates the effectiveness of the proposed methods.

2 - Two-Stage Optimization Problems with Multivariate Stochastic Dominance Constraints

Eli Wolfhagen, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, ewolfhagen@gmail.com

This talk will present methods for solving two-stage stochastic optimization problems with multivariate stochastic dominance constraints. A two-stage portfolio optimization application will be discussed and the numerical performance of the methods will be analyzed.

■ TB27

27- Duquesne Room

Optimization Models for Renewable Energy

Cluster: Optimization in Energy Systems

Invited Session

Chair: Suvrajeet Sen, Professor, University of Southern California, Industrial and Systems Eng, Los Angeles, CA, 90403, United States of America, s.sen@usc.edu

1 - Regularized Decomposition Method for Multistage Stochastic Programs

Tsvetan Asamov, Postdoctoral Research Assocua, Princeton University, ORFE, Princeton, NJ, United States of America, tasamov@princeton.edu, Warren Powell

Stochastic Dual Dynamic Programming is one of the best known algorithms for the solution of convex multistage stochastic optimization problems. Despite its growing popularity, SDDP can exhibit slow convergence and lead practitioners to a difficult choice between solution quality and computational time. In this work, we develop the first quadratic regularization method for the SDDP framework. Unlike existing regularization techniques on scenario trees, our approach remains computationally tractable even for problems with long time horizons. Our numerical results indicate that the proposed solution exhibits significantly faster convergence than classical SDDP and is especially useful for problems with high-dimensional value functions.

2 - Assessment of Reservoir Aggregation in the Long-Term Hydrothermal Scheduling

Vitor de Matos, Plan 4 Engenharia, Rua Lauro Linhares, 2055, sala 707-Max, Florianopolis, SC, 88036003, Brazil, vitor@plan4.com.br, Erlon Finardi, Paulo Larroyd

The Long-Term Hydrothermal Scheduling plays an important role in power systems that rely heavily on hydroelectricity as its goal is to define a policy for the use of water. The Brazilian system has hundreds of hydro plants and some simplifications are made in their modeling in order to reduce the computational burden. As a result, this paper assesses the consequences of those simplifications in the operation policies. Results are shown considering the Brazilian power system.

3 - Multiple Timescale Stochastic Optimization for Integrating Renewable Resources

Harsha Gangammanavar, Visiting Assistant Professor, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089, United States of America, gangamma@usc.edu, Suvrajeet Sen

We will present a multiple timescale stochastic economic dispatch model to capture a decision process with coarse timescale for thermal generation, and a fine timescale for network, storage and renewable utilization. This model will be tackled using two solution approaches: a joint stochastic decomposition-approximate dynamic programming (SD-ADP) algorithm for centralized storage systems (scalar states), and a time-staged stochastic decomposition(TSD) algorithm for systems with distributed storage (vector valued states). The TSD algorithm can be interpreted as a recursive contraction mapping similar to the DP operator. We will present convergence properties and computational results for both these algorithmic frameworks.

■ TB28

28- Liberty Room

Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Tibor Csendesprof., University of Szeged, Arpad ter 2, Szeged, 6720, Hungary, csendes@inf.u-szeged.hu

1 - Globally Solving Non-Convex Quadratic Programming Problems via Linear Integer Programming Techniques

Wei Xia, Lehigh University, 312 Brodhead Ave, Apt. C, Bethlehem, PA, 18015, United States of America, wex213@lehigh.edu, Juan Vera, Luis Zuluaga

A quadratic programming (QP) problem is a well-studied and fundamental NP-hard optimization problem in which the objective is quadratic and the constraints are linear on the decision variables. In this paper, we propose an alternative way of globally solving non-convex quadratic optimization problems by taking advantage of the Karush-Kuhn-Tucker (KKT) problem's conditions to linearize its objective. Then, the problem is reformulated as a mixed integer linear problem (MILP) by using binary variables to model the KKT complementary constraints. To illustrate this, we compare the performance of this solution approach with the current benchmark global QP solver QuadprogBB on a large variety of test QP instances.

2 - Optimization in Surgical Operation Design

Tibor Csendes, Prof., University of Szeged, Arpad ter 2, Szeged, 6720, Hungary, csendes@inf.u-szeged.hu, Istvan Szalay, Istvan Barsony

A treatment of oncological diseases is brachytherapy that is the insertion of low level radiation isotopes into the organ to be healed. The problem is to determine how to position the 40-90 capsules in such a way that the tissue to be healed should obtain at least a given level of dose, while the surrounding other organs should absorb a dose less than a prescribed level. The related nonlinear optimization problem is of medium dimensionality (120-270). The global optimization problem is very redundant, and symmetric. The present work aims to speed up the optimization, to allow different intensity radiation capsules, and to decrease the cost of the treatment. The first test results obtained for artificial models are reported.

3 - Disjunctive Programming and Global Optimization

Peter Kirst, Karlsruhe Institute of Technology (KIT), Institute of Operations Research, Kaiserstrasse 12, Karlsruhe, 76131, Germany, peter.kirst@kit.edu, Oliver Stein, Fabian Rigterink

We propose a new branch-and-bound algorithm for global optimization of disjunctive programs with general logical expressions. In contrast to the widely used reformulation as a mixed-integer program we propose to directly process the logical expression in the construction of the lower bounds. Thus we do not only reduce the size of the problem but also have purely continous variables which is advantageous for computations.

■ TB29

29- Commonwealth 1

Algorithms for Nonsmooth-Nonconvex Optimization: Theory and Practice

Cluster: Nonsmooth Optimization

Invited Session

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

1 - A Dual Method for Minimizing a Nonsmooth Objective over One Smooth Inequality Constraint

Marc Teboulle, Professor, School of Mathematical Sciences, Tel Aviv University, Ramat Aviv, Tel Aviv, IL, 69978, Israel, teboulle@post.tau.ac.il, Ron Shefi

We consider the class of nondifferentiable convex problems which minimizes a nonsmooth convex objective over a smooth inequality constraint. Exploiting the smoothness of the feasible set and using duality, we introduce a simple first order algorithm proven to globally converge to an optimal solution with a sublinear rate. The performance of the algorithm is demonstrated by solving large instances of the convex sparse recovery problem.

2 - An Alternating Semi-Proximal Method for Nonconvex Problems

Shoham Sabach, Assistant Professor, Technion - Israel Institute of Technology, Faculty of Industrial Engineering, Technion City, Haifa, IL, 32000, Israel, ssabach@ie.technion.ac.il, Marc Teboulle, Amir Beck

We consider a broad class of regularized structured total-least squares problems (RSTLS) encompassing many scenarios in image processing. This class of problems results in a nonconvex and often nonsmooth model in large dimension. To tackle this difficult class of problems we introduce a novel algorithm which blends proximal and alternating minimization methods by beneficially exploiting data information and structures inherently present in RSTLS. The proposed algorithm which can also be applied to more general problems is proven to globally converge to critical points, and is amenable to efficient and simple computational steps.

3 - Finite Identification and Local Linear Convergence of Proximal Splitting Algorithms

Jalal Fadili, Professor, CNRS-ENSICAEN-Univ. Caen, 6 Bd Marechal Juin, Caen, 14050, France, Jalal.Fadili@ensicaen.fr, Gabriel Peyré, Jingwei Liang

Convex nonsmooth optimization has become ubiquitous in most quantitative disciplines of science. Proximal splitting algorithms are very popular to solve structured convex optimization problems. Within these algorithms, the Forward-Backward and its variants (e.g. inertial FB, FISTA, Tseng's FBF), Douglas-Rachford and ADMM are widely used. The goal of this work is to establish the local convergence behavior of these schemes when the involved functions are partly smooth relative to their active manifolds. We show that all these splitting methods correctly identify the active manifolds in a finite time, and then enter a local linear convergence regime, which we characterize precisely. This is illustrated by several numerical experiments.

■ TB30

30- Commonwealth 2

Approximation and Online Algorithms V

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Mohit Singh, Microsoft Research, One Microsoft Way, Redmond, United States of America, mohits@microsoft.com

1 - Approximation Algorithms for (Citi)Bike Sharing Operations

Eoin O'Mahony, Cornell University, Upson Hall, Ithaca, NY, 14853, United States of America, eoindom@gmail.com, David Shmoys

Bike-sharing systems are becoming increasingly prevalent in urban environments. The management of these systems requires dealing with the issue of bicycle rebalancing. Users imbalance the system by creating demand in an asymmetric pattern; this necessitates intervention to restore balance and facilitate future use. This talk presents a 3-approximation algorithm used to target limited available rebalancing resources during rush-hour periods. The goal is to ensure that users are never too far from a station that will be rebalanced when looking for a bike or a spot to return one. We formulate this as a variant of the k-center problem and provide a linear programming-based algorithm with a performance guarantee of 3.

2 - How to Round Subspaces: A New Spectral Clustering Algorithm

Ali Kemal Sinop, Postdoc, Simons Institute for the Theory of Computing, 121 Calvin Lab, UC Berkeley, Berkeley, CA, 94720, United States of America, asinop@cs.cmu.edu

Consider the problem of approximating a k-dimensional linear subspace with another k-piecewise constant subspace in spectral norm. Our main contribution is a new spectral clustering algorithm: It can recover a k-partition such that the subspace corresponding to the span of its indicator vectors is square root of OPT close to the original subspace in spectral norm, with OPT being the minimum possible. Previously, no algorithm was known which could find a k-partition closer than o(k OPT). We present two applications for our algorithm. First one approximates a given graph in terms of disjoint union of k-expanders. The second one approximates a k-partition provided its clusters have expansion less than (k+1)th smallest eigenvalue of Laplacian.

3 - LP-Based Algorithms for Capacitated Facility Location

Mohit Singh, Microsoft Research, One Microsoft Way, Redmond, WA, United States of America, mohits@microsoft.com, Ola Svensson, Hyung-Chan An

Many of our best (approximation) algorithms for hard combinatorial optimization problems rely on linear programming relaxations. A typical example is the uncapacitated facility location problem for which a sequence of LP-based algorithms have resulted in close to optimal algorithms. For the more general capacitated facility location problem, the situation is drastically different as all proposed relaxations fail to give any reasonable guarantees on the value of an optimal solution. In fact, the only known algorithms with good performance guarantees are based on the local search paradigm. We overcome this difficulty by giving the first relaxation of the capacitated facility location with a constant integrality gap.

Tuesday, 1:10pm - 2:40pm

■ TC01

01- Grand 1

Open-Source Tools for Optimization

Cluster: Implementations and Software

Invited Session

Chair: Matthew Saltzman, Clemson University, Mathematical Sciences Department, Martin Hall, Box 340975, Clemson, SC, 29634, United States of America, mjs@clemson.edu

1 - Distributed Parallel Greedy Block Coordinate Descent for Graphical Lasso

Alireza Yektamaram, Lehigh University, Department of Industrial Engineering, Bethlehem, PA, 18015, United States of America, sey212@lehigh.edu, Katya Scheinberg

Among various problems in Machine learning, Graphical Lasso aims to recover Sparse Inverse Covariance Matrix of a Markov random field which corresponds to discovering structure of the underlying dependency graph of random variables. In this setting as the problem size grows larger, efficiency of most solution approaches reduces significantly, hence use of distributed parallel techniques become essential. In this study, we propose a coordinate descent approach with new update formulas that converges faster using parallel libraries.

2 - Pyomo 5.0

William Hart, Manager, Sandia National Laboratory, P.O. Box 5800, Albuquerque, MI, 87185, United States of America, wehart@sandia.gov

This presentations describes recent advances in the Pyomo optimization modeling software. Pyomo is a Python-based optimization and modeling framework that includes sophisticated meta-solvers and model transformations. The Pyomo 5.0 release includes maturation of bilevel program and MPEC modeling components, a generic Benders solver, and support for JIT Python implementations (PyPy, Jython and IronPython).

3 - RLT-POS: Reformulation-Linearization Technique-based Optimization Software for POPs

Evrim Dalkiran, Assistant Professor, Wayne State University, 4815 4th St. MEB # 2149, Detroit, MI, 48202, United States of America, evrimd@wayne.edu, Hanif Sherali

We introduce a Reformulation-Linearization Technique-based open-source optimization software for solving polynomial programming problems (RLT-POS). We present algorithms that form the backbone of RLT-POS, including constraint filtering techniques, reduced RLT representations, and semidefinite cuts. The coordination between different model enhancement techniques becomes critical for an improved overall performance. We discuss the coordination between 1)constraint elimination via filtering techniques and reduced RLT representations, and 2)SDP cuts for sparse problems. We present computational results to demonstrate the improvement over a standard RLT implementation and to compare the performances of BARON, COUENNE, and SparsePOP with RLT-POS.

■ TC02

02- Grand 2

Maintenance, Restoration, and Reliability in Electric Energy Systems

Cluster: Optimization in Energy Systems

Invited Session

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 - Power System Restoration with Integrated Sectionalization and Generator Start-up Sequencing

Feng Qiu, Researcher, Argonne National Lab, Chicago, IL, United States of America, fqiu@anl.gov, Jianhui Wang, Chen Chen

During power system restoration, the system is normally first sectionalized into a set of subsystems in which the generators are started afterwards. We propose an integer programming formulation to model the sectionalization problem as a graph partition problem with connectivity constraints. We propose a continuous-time representation of the generator start-up sequencing problem. Then, we integrate the two formulations into a single model that minimizes the restoration duration for the overall system. Our case study shows that the proposed model can achieve a global optimization solution effectively.

2 - A New Optimization Framework for Sensor-Driven Generation Maintenance Scheduling

Murat Yildirim, Research Assistant, Georgia Institute of Technology, Atlanta, GA, United States of America, murat@gatech.edu, Andy Sun, Nagi Gebraeel

We provide a unified framework that links low-level performance and condition monitoring data with high-level operational and maintenance decisions for generators. The operational decisions identify the optimal commitment and dispatch to satisfy demand and transmission constraints. Maintenance decisions focus on arriving at an optimal condition based maintenance (CBM) schedule that accounts for optimal asset-specific CBM schedules driven by the condition monitoring data. We propose new mixed-integer optimization models and efficient algorithms that exploit the special structure of the proposed formulation. We present extensive computational experiment results to show proposed models achieve significant improvements in cost and reliability.

3 - Minimal Reschedules in Security-Constrained Optimal Power Flow via Sparsity Regularization

Dzung Phan, Research Staff Member, IBM Watson Research Center, 1101 Kitchawan Rd, Yorktown Heights, NY, 10598, United States of America, phandu@us.ibm.com, Andy Sun

We present a new mathematical formulation for the corrective security-constrained optimal power flow problem. The goal is to produce a generation schedule which has a minimal number of post-contingency corrections as well as a minimal amount of total MW rescheduled. We also propose an efficient decomposition algorithm to solve the problem.

■ TC03

03- Grand 3

Resource Sharing and Routing in Chip Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Stephan Held, Bonn University, Lennestr. 2, Bonn, Germany, held@or.uni-bonn.de

1 - Global Routing with Timing Constraints

Daniel Rotter, University of Bonn, Lennestr. 2, Bonn, 53113, Germany, rotter@or.uni-bonn.de, Stephan Held, Dirk Müller, Vera Traub, Jens Vygen

One of the most successful approaches for the classical global routing problem is the min-max resource sharing algorithm, generalizing the multi-commodity flows. We show how to extend this algorithm to incorporate global static timing constraints and respect them similarly to congestion constraints. The resource sharing algorithm trades off wiring congestion and timing, and balances slacks along the timing graph such that the maximum overall violation is minimized. Our algorithm works for most common delay models and yields the first compact resource sharing formulation of a global routing problem with timing constraints. We demonstrate the benefit of a timing-driven global router by experimental results on industrial VLSI instances.

2 - Detailed Routing Algorithms for Advanced Technology Nodes

Dirk Müller, Research Institute for Discrete Mathematics, University of Bonn, Lennestr. 2, Bonn, 53113, Germany, mueller@or.uni-bonn.de, Gustavo Tellez, Sven Peyer, Markus Ahrens, Michael Gester, Niko Klewinghaus, Christian Schulte

We present algorithms for efficient and almost design rule clean VLSI routing in advanced technology nodes, in presence of dense standard cell libraries and complex industrial design rules, with a special focus on multiple patterning lithography. Our key contributions are a multi-label interval-based shortest path algorithm for long connections, and a dynamic program for computing packings of pin access paths and short connections between closely spaced pins. We combine our algorithms with an industrial router for cleaning up the remaining design rule violations, and demonstrate superior results over that industrial router in our experiments in terms of wire length, number of vias, design rule violations and runtime.

3 - Algorithms for the Gate Sizing Problem in Chip Design

Ulrike Schorr, Research Institute for Discrete Mathematics Bonn, Lennestr. 2, Bonn, Germany, schorr@or.uni-bonn.de, Stephan Held, Nicolai Haehnle

In chip design, a discrete set of physical layouts (sizes) is available for each gate/transistor on the chip, which differ in their power consumption and influence the speed of electrical signals. The gate sizing problem consists of choosing gate sizes minimizing power consumption subject to speed constraints. A popular approach is based on Lagrange relaxation of a geometric program and the subgradient method, converging (slowly) to the optimum in the continuous relaxation. In practice, variants are used that update the Lagrange multiplier multiplicatively without any convergence guarantees. We show that a multiplicative update rule following the resource sharing paradigm gives a fast approximation of the continuous relaxation.

■ TC04

04- Grand 4

Structured Semidefinite Programs and Their Applications

Cluster: Conic Programming

Invited Session

Chair: Etienne de Klerk, Tilburg University, 1 Warandelaan, Tilburg, Netherlands, e.deklerk@uvt.nl

1 - Keller's Cube Tiling Conjecture: An Approach through SDP Hierarchies

Dion Gijswijt, Delft University of Technology, Mekelweg 4, Delft, Netherlands, D.C.Gijswijt@tudelft.nl

Keller's conjecture states that any tiling of Euclidean space by unit cubes must contain a pair of cubes sharing a full face. For any dimension, the problem can be formulated as a stable set problem in a very large and highly symmetric graph. In this talk we show how the symmetry can be used to approach Keller's conjecture through semidefinite programming hierarchies.

2 - New Upper Bounds for the Density of Translative Packings of Superspheres

Frank Vallentin, University of Köln, Köln, Germany, frank.vallentin@uni-koeln.de

In this talk I provide new upper bounds for the maximal density of translative packings of superspheres in three dimensions (unit balls for the l^p_3-norm). I present some strong indications that the lattice packings found in 2009 by Jiao, Stillinger, and Torquato are indeed optimal among all translative packings. For this I apply the linear programming bound of Cohn and Elkies which originally was designed for the classical problem of packings of spheres. The proof of the new upper bounds is computational and rigorous. The main technical contribution is the use of invariant theory of reflection groups in polynomial optimization. (joint work with Maria Dostert, Cristobal Guzman, and Fernando Oliveira)

3 - On the Turing Model Complexity of Interior Point Methods for SDP

Etienne de Klerk, Tilburg University, 1 Warandelaan, Tilburg, Netherlands, e.deklerk@uvt.nl, Frank Vallentin

Semidefinite programming (SDP) is used in many polynomial-time approximation algorithms, like the Goemans-Williamson algorithm for the maximum cut problem. To give a rigorous proof of the polynomial running time, the ellipsoid method of Yudin and Nemirovski is usually invoked, since the Turing model complexity of the more practical interior point methods (IPMs) is not well-understood. In this talk we show how one may obtain rigorous complexity results for IPMs in the SDP case.

■ TC05

05- Kings Garden 1

Algorithms for Large-Scale Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Joshua Griffin, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC, United States of America, Joshua.Griffin@sas.com

1 - Compact Representations of Quasi-Newton Matrices

Roummel Marcia, Associate Professor, University of California, Merced, 5200 N. Lake Road, Merced, Ca, 95343, United States of America, rmarcia@ucmerced.edu, Jennifer Erway

Very large systems of linear equations arising from quasi-Newton methods can be solved efficiently using the compact representation of the quasi-Newton matrices. In this paper, we present a compact formulation for the entire Broyden convex class of updates for limited-memory quasi-Newton methods and how they can be used to solve large-scale trust-region subproblems with quasi-Newton Hessian approximations.

2 - Extension of the Multi-Start Algorithm to Mixed Integer Nonlinear Programming

Tao Huang, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC, 27513, United States of America, Tao.Huang@sas.com

We present an implementation of the multi-start algorithm for continuous nonlinear optimization as is extended to handle integer variables. Schemes to generate sample points under integer requirements are discussed. In the cases where no feasible integer sample point is generated, an algorithm is proposed to seek feasible integer points. The properties of the integer-seeking algorithm is discussed. Our multi-start algorithm exploits parallelism in different phases of the algorithm and as a result the solution times are drastically reduced. Preliminary numerical results are presented to show its efficacy.

3 - Optimization on Riemannian Manifolds: Methods and Applications to Matrix Manifolds

Murugiah Muraleetharan, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC, 27513, United States of America, M.Muraleetharan@sas.com

We discuss Riemannian optimization methods for optimizing functions over manifolds. Algorithms, such as steepest descent, nonlinear conjugate-gradients, and Newton-based trust-region methods can be re-derived in the Riemannian setting and consequently applied to constrained optimization problems whose constraints can be interpreted as Grassmann and Stiefel manifolds. These manifolds represent the constraints that arise in such areas as singular value decomposition, matrix completions, and extreme eigen-pairs of a symmetric matrix. Riemannian optimization methods lead to practical globally convergent algorithms that scale to large-scale matrix problems while providing a gateway to modify solution requirements on classical decompositions.

■ TC06

06- Kings Garden 2

Novel Applications of Mathematical Programming to Communication and Social Networks

Cluster: Telecommunications and Networks

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 - The Positive Influence Dominating Set Polytope

S. Raghavan, University Of Maryland-College Park, The Smith School Of Business, College Park, MD, 20742, United States of America, raghavan@umd.edu, Rui Zhang

We study the Positive Influence Dominating Set (PIDS) problem that is motivated by applications connected to social networks. In particular, we study the PIDS problem and polytope on trees. First, we show that the PIDS problem on trees can be solved in linear time via a dynamic programming algorithm. Next, we provide a tight and compact extended formulation, and derive the PIDS polytope for trees. We then obtain a strong formulation for the PIDS problem on general graphs. Computational experience will be discussed.

2 - Column Generation Models for Chromatic Scheduling

Olaf Maurer, olaf.maurer@mathematik.uni-kassel.de, Heinrich-Plett-Strafle 40B, Kassel, 34132, Germany, olaf.maurer@mathematik.uni-kassel.de, Andreas Bley, Benjamin Müller, Mohsen Rezapour

We address the chromatic scheduling problem, which arises in the planning of flexgrid fiber optic communication networks. Given a set of fixed paths with integer demands, the task is to assign to each path an interval of length equal to the path's demand such that intervals that correspond to paths sharing an edge are disjoint. We present an exact two-stage algorithm based on branch-and-price. We employ ILP-based heuristics in the first stage. If this stage fails to prove optimality, we run a branch-and-price algorithm based on an exact ILP formulation for interval coloring. We present the results of our computational experiments in which this approach turns about to be efficient, solving instances of realistic size in seconds.

3 - Virtual Network Embedding: Computational Complexity and Valid Inequalities

Martin Tieves, RWTH Aachen University, Lehrstuhl II für Mathematik, Pontdriesch 14/16, Aachen, 52062, Germany, tieves@math2.rwth-aachen.de, Arie M.C.A. Koster, Stefano Coniglio

Network virtualization techniques are introduced to separate offered services from the operation of the physical network they base on. In this talk, we focus on the virtual network embedding problem (VNE), i.e., the optimal admission of virtual networks to a physical network. We investigate it's computational complexity for several special cases. Further, we show how an MILP formulation can be improved by deriving valid inequalities.

■ TC07

07- Kings Garden 3

Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Friedrich Eisenbrand, EPFL, Station 8, Lausanne, 1015, Switzerland, friedrich.eisenbrand@epfl.ch

1 - On Approximating the Knapsack Polytope

Yuri Faenza, EPFL, EPFL SB MATH AA MA C1 573, Lausanne, 1015, Switzerland, yuri.faenza@gmail.com, Laura Sanita

The knapsack polytope P is the convex hull of the characteristic vectors of feasible solutions to the 0-1 knapsack problem. Recent results showed that P cannot be described using only a polynomial number of inequalities. But what if we want to describe a polytope P' containing P and approximating it in such a way that, for each objective function c, the maximum of c over P' is at most (1+ epsilon) times the maximum of c over P, for some arbitrarily nonnegative epsilon? In this talk, we present some results on this question, focusing on the case when we require P' to be described via inequalities in the original space. Joint work with Laura Sanita.

2 - Polyhedrality of Maximal S-free Sets

Marco Di Summa, Universite degli Studi di Padova, Dipartimento di Matematica, Via Trieste 63, Padova, PD, 35121, Italy, disumma@math.unipd.it, Michele Conforti

The theory of cut generating functions is a powerful tool for the polyhedral study of integer and mixed integer programming problems, as well as many generalizations of those problems. For a given feasible region S, a key concept in this context is that of maximal S-free sets, i.e., convex sets that do not contain points of S in their interior and are maximal with this property. Since the theory of cut generating functions proves particularly useful when maximal S-free sets are polyhedra, it is natural to ask when this is the case and when it is possible to bound the number of facets of these sets. We present several new results in this direction. (Joint work with Michele Conforti.)

3 - Center-points: A Link between Discrete Geometry and Optimization

Timm Oertel, ETH Zurich, Raemistrasse 101, Zurich, 8092, Switzerland, timm.oertel@ifor.math.ethz.ch

In this talk, I will consider mixed-integer convex minimization problems. First, I will present optimality conditions for this class of optimization problems. Then, I will introduce the concept of center-points, a generalization of the median from the one dimensional space to vector spaces. Through the theory of center-points I will show how to extend the general cutting plane scheme from the continuous setting to the mixed-integer setting. Further, I will present several properties of center-points and how to compute them approximately.

■ TC08

08- Kings Garden 4

TSP and Graph Connectivity

Cluster: Combinatorial Optimization

Invited Session

Chair: Alantha Newman, CNRS, G-SCOP, 46 Avenue Fèlix Viallet, Grenoble, 38000, France, alantha.newman@grenoble-inp.fr

Co-Chair: Sylvia Boyd, University of Ottawa, sylvia@site.uottawa.ca

1 - Improved Approximation Guarantees for Graph-TSP on Subquartic Graphs

Alantha Newman, CNRS, G-SCOP, 46 Avenue Félix Viallet, Grenoble, 38000, France, alantha.newman@grenoble-inp.fr

We discuss approximation algorithms for the graph-TSP problem on subquartic graphs (degree at most four). In particular, we consider the recent framework introduced by Mˆmke and Svensson in which the graph-TSP problem is reduced to computing a minimum-cost circulation in a certain network. Computing an approximation guarantee for graph-TSP is then equivalent to computing an upper bound on the minimum-cost circulation. Mucha's improved analysis of Mˆmke and Svensson's algorithm showed that, hypothetically, the worst-case approximation guarantee of 13/9 could be tight for subquartic graphs. We show that this is not the case, and we present an improved analysis for this class of graphs.

2 - Improved Integrality Gap Upper Bounds for TSP with Distances One and Two

Matthias Mnich, University of Bonn, Department of Computer Science, Friedrich Ebert Allee 144, Bonn, NW, 53113, Germany, mmnich@uni-bonn.de, Tobias Moemke

We study the structure of solutions to the subtour elimination linear programming relaxation for the traveling salesperson problem with one additional cutting plane inequality. For undirected instances we obtain an integrality gap upper bound of 5/4, and of 7/6 if the optimal LP solution is half-integral. For instances of order n with fractional LP value n, we obtain a tight integrality gap upper bound of 10/9 if there is an optimal solution with subcubic support.

3 - Toward a 6/5 Bound for the Minimum Cost 2-Edge Connected Subgraph Problem

Sylvia Boyd, University of Ottawa, sylvia@site.uottawa.ca, Philippe Legault

Given a complete graph G =(V,E) with non-negative edge costs c, the problem 2EC is that of finding a 2-edge connected spanning multi-subgraph of G of minimum cost. The linear programming relaxation 2EC_LP gives a lower bound for 2EC, and it has been conjectured that its integrality gap is 6/5. In this paper, we explore the idea of using the structure of solutions for 2EC_LP and the concept of convex combination to obtain improved approximation algorithms for 2EC. We focus our efforts on a family J of half-integer solutions that appear to give the largest integrality gap for 2EC_LP. We successfully show that for any x* in J, there exists a solution for 2EC of cost at most (6/5)cx*, proving that the conjecture holds true for this family.

■ TC09

09- Kings Garden 5

Semidefinite Hierarchies for Approximations in Combinatorial Optimization II

Cluster: Combinatorial Optimization

Invited Session

Chair: Monique Laurent, CWI & Tilburg University, Science Park 123, Amsterdam, Netherlands, M.Laurent@cwi.nl

Co-Chair: Nikhil Bansal, Dr., Technical University Eindhoven, Eindhoven, Netherlands, bansal@gmail.com

1 - On Unifying the Analyses of Strong Lift-and-Project Methods

Yu Hin Au, Dr., Milwaukee School of Engineering, 1025 N Broadway, Milwaukee, WI 53209, United States of America, au@msoe.edu, Levent Tuncel

Lift-and-project methods is a relatively modern approach for generating tight, tractable relaxations for integer programming problems that has received a lot of research attention in the last 25 years. In this talk, I will give a brief overview about the lift-and-project approach, and present some general tools that can help with analyzing the performances of these algorithms. In particular, we introduce many new variants of Sherali-Adams and Bienstock-Zuckerberg operators, and provide new techniques to analyze the worst-case performances as well as relative strengths of these operators in a unified way. We will also discuss some of their implications on polytopes related to matching and stable set problems.

2 - Approximation Resistance in LP and SDP Hierarchies

Madhur Tulsiani, Dr., Toyota Technological Institute at Chicago, 6045 S Kenwood Avenue, Chicago, IL 60637, United States of America, madhurt@ttic.edu, Subhash Khot, Pratik Worah

For a predicate f:{-1,1}^k \to {0,1} with \rho(f) = |f^{-1}(1)|/2^k, we call the predicate approximation resistant if given a near-satisfiable instance of CSP(f), it is computationally hard to find an assignment satisfying more than (\rho(f)+\eps)-fraction of constraints for every \eps>0. We will discuss a few variants of the notion of approximation resistance and discuss conditions characterizing (these variants of) approximation resistance in LP and SDP hierarchies. Based on joint work with Subhash Khot and Pratik Worah.

3 - Approximating Maximum Independent Set in Sparse Graphs

Nikhil Bansal, Dr., Technical University Eindhoven, Eindhoven, Netherlands, bansal@gmail.com

We consider the maximum independent set problem on graphs with maximum degree d. The best known result for the problem is an SDP based O(d log log d/ log d) approximation. It is also known that no o(d/ log^2 d) approximation exists assuming the Unique Games Conjecture. We will describe several new results for this problem. We show that the natural LP formulation for the problem strengthened by poly-logarithmic levels of the Shearli-Adams(+) hierarcy has an integrality gap of about O(d/log^2d), and discuss some algorithmic aspects.

■ TC10

10- Kings Terrace

Finance and Economics

Cluster: Finance and Economics

Invited Session

Chair: Bulat Gafarov, Pennsylvania State University, 4310 Crescent St., Apt. 2308, Long Island City, NY, 11101, United States of America, bzg134@psu.edu

1 - Computing Near-optimal Value-at-Risk portfolios using Integer Programming Techniques

Onur Babat, PhD Candidate, Lehigh University, 217 West Packer Avenue Apt 106, Bethlehem, PA, 18015, United States of America, onur.babat@lehigh.edu, Juan Vera, Luis Zuluaga

It is difficult to compute optimal VaR portfolios. This is due to VaR being non-convex and of combinatorial nature. It is also well-known that the VaR portfolio problem can be formulated as an integer program (IP) that is difficult to solve with current IP solvers for large-scale instances of the problem. To tackle this drawback, we present an algorithm to compute near-optimal VaR portfolios that takes advantage this IP formulation and provides a guarantee of the near-optimality of the solution. To illustrate the efficiency of the presented algorithm, numerical results are presented.

2 - On the Maximum and Minimum Response to an Impulse SVARs

Bulat Gafarov, Pennsylvania State University, 4310 Crescent St., Apt. 2308, Long Island City, NY, 11101, United States of America, bzg134@psu.edu, Jose Luis Montiel Olea

This paper proposes an intuitive, computationally simple, "adjusted" delta method confidence interval for set-identified coefficients of the impulse-response function in a Structural Vector Autoregression. We establish the uniform asymptotic validity of our inference procedure in models that impose zero and sign restrictions only on the contemporaneous responses to one structural shock. We treat the bounds of the identified set for the coefficients of impulse-responses as the maximum and minimum value of a mathematical program and we provide formulas for these values and their derivative. To illustrate our inference approach, we use a monetary Structural Vector Autoregression estimated with monthly U.S. data.

3 - DEA Indicators of Efficiency for the Companies Insurance Brokers in the Colombian Financial Means

Gloria Rodríguez, Universidad Nacional de Colombia, Ciudad Universitaria Edificio 311, Bogota, Colombia, girodriguezl@unal.edu.co

In the different countries worldwide financial traditional indicators are in use for evaluating the performance organizational of the companies, nevertheless these traditional indicators do not assure to approach a process of capture of decisions based on a minor risk; for everything previous it is necessary to approach other methodologies. The area of the companies' insurance brokers it shapes a good platform for the implementation and analysis of Date Envelopment Analysis DEA.

■ TC11

11- Brigade

Submodularity

Cluster: Combinatorial Optimization

Invited Session

Chair: Feng Li, PhD, Northeastern University, #135 The Logistics Institute, Shenyang, LN, 110819, China, fengli055@gmail.com

1 - A Generalized Polymatroid Approach to Stable Allocations with Lower Quotas

Yu Yokoi, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan, Yu_Yokoi@mist.i.u-tokyo.ac.jp

Classified Stable matching model, introduced by Huang (2010), is NP-hard in general, but solvable if its upper and lower quotas are defined only on a laminar family. Fleiner and Kamiyama (2012) have given a matroid theoretic interpretation to the latter result. In this talk, we generalize their results in terms of generalized polymatroids. We give an algorithm which finds a stable matching (or reports the nonexistence) in polynomial time and show the lattice structure of stable matchings.

2 - Finding a Stable Allocation in Polymatroid Intersection

Satoru Iwata, Professor, University of Tokyo, Deptartment of Mathematical Informatics, Tokyo, 113-8656, Japan, iwata@mist.i.u-tokyo.ac.jp, Yu Yokoi

As a generalization of stable matching of Gale and Shapley (1962), the concepts of matroid kernel and stable allocation were introduced respectively by Fleiner (2001) and by Baiou and Balinski (2002). This talk introduces a common generalization of these two, which we call a stable allocation in polymatroid intersection. We provide an algorithm for finding a stable allocation in strongly polynomial time, provided that oracles for computing exchange capacities are available.

3 - Integrated Scheduling of Production and Energy Consumption with Submodular Cost

Feng Li, PhD, Northeastern University, #135 The Logistics Institute, Shenyang, LN, 110819, China, fengli055@gmail.com, Lixin Tang

Motivated by practical applications in several industries, we study an integrated scheduling problem of production and energy consumption with submodular cost. In the problem, batch processing machine can process several jobs within its capacity limit simultaneously. In this paper, we propose an algorithm for solving the problem and carry out computational experiments to verify the performance of the algorithm.

■ TC13

13- Rivers

Alternate Direction Method in Non-Convex and Discrete Optimization

Cluster: Conic Programming

Invited Session

Chair: Jiming Peng, University of Houston, Industrial Engineering, Houston, TX, United States of America, jopeng@uh.edu

1 - An Integrated Approach to Non-convex QP: From Lagrangian Method to Modern Convex Relaxation

Jiming Peng, University of Houston, Industrial Engineering, Houston, TX, United States of America, jopeng@uh.edu

In this talk, we propose a new algorithm design framework for non-convex QP based on Lagrangian method and modern convex relaxation, which leads to novel alternate direction method (ADM). We characterize the convergence of the new ADMs in terms of a new notion the so-called approximate local optimal solution in optimization, and present several new optimization techniques that can help to locate the global optimal solutions to classes of non-convex QPs. Complexity of the new approach and its numerical performance will be discussed as well.

2 - Exact Augmented Lagrangian Dual for Mixed Integer Programming

Mohammad Javad Feizollahi, PhD Candidate, Georgia Institue of Technology, 755 Ferst Dr. NW, Atlanta, GA, 30332, United States of America, feizollahi@gatech.edu, Shabbir Ahmed, Andy Sun

We investigate augmented Lagrangian dual (ALD) for mixed integer programming (MIP) problems. We show that under mild assumptions, using any norm as a penalty function in ALD with a sufficiently large penalty coefficient closes the duality gap of MIPs. This approach is also able to recover a primal feasible solution. We also present an example where ALD with squared Euclidean norm penalty fails to close the duality gap for any finite penalty coefficient.

■ TC14

14- Traders

Eliciting the Wisdom of Crowds

Cluster: Game Theory

Invited Session

Chair: Shipra AgrawalResearcher, Microsoft Research, #9 Lavelle Road, Bangalore, 560025, India, shipra@microsoft.com

1 - Minimax Solutions, Random Playouts, and Perturbatons

Jacob Abernethy, Assistant Professor, Univ of Michigan, Ann Arbor, MI, 48109, United States of America, jabernet@umich.edu

In this talk we will explore the use of perturbation and randomization techniques for learning and decision-making. In particular, we will explore some nice connections between regularization methods commonly used in statistical learning and perturbation methods recently developed in online learning. The talk will also review some applications to problems in repeated games.

2 - Prediction Market Trading Strategies: Manipulation and Four Additional Price Misalignments

David Rothschild, Microsoft Research, 641 6th Ave., 7th FL, New York, NY, 10009, United States of America, davidmr@microsoft.com

Order books of real-money, election related prediction markets show persistent arbitrage opportunities. First, examining a randomized field trial of actual trades we demonstrate that arbitrage opportunities are significantly larger than the order book indicates. Second, examining transaction-level data for all trades (nearly 300,000 over 6,300 users) in one of the exchanges we present evidence suggestive of market manipulation by a single large trader. Third, we demonstrate four additional price misalignments resulting from biased trading and implicitly asymmetric trading costs. Finally, we explain how markets are still accurate, but also detail how to improve the information flow in prediction markets.

3 - Integrating Market Makers, Limit Orders, and Continuous Trade in Prediction Markets

Jennifer Wortman Vaughan, Researcher, Microsoft Research, 641 Avenue of the Americas, 7th Floor, New York, NY, 10011, United States of America, jenn@microsoft.com, David Pennock, Hoda Heidari, Sebastien Lahaie

We provide the first concrete algorithm for combining market makers and limit orders in a prediction market with continuous trade. Our mechanism handles bundle orders and arbitrary securities defined over combinatorial outcome spaces. We define the notion of an epsilon-fair trading path, a path in security space along which no order executes at a price more than epsilon above its limit, and every order executes when its market price falls more than epsilon below its limit. We show that under a supermodularity condition, a fair trading path exists for which the endpoint is efficient. We develop an algorithm for operating a continuous market maker with limit orders that respects the epsilon-fairness conditions even without supermodularity.

■ TC15

15- Chartiers

Bilevel Optimal Control

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

Invited Session

Chair: Stephan Dempe, Department of Mathematics and, Computer Science, Freiberg, 09596, Germany, dempe@math.tu-freiberg.de

1 - Necessary Optimality Conditions for Optimal Control Problems with Equilibrium Constraints

Jane Ye, University of Victoria, Victoria, Canada, janeye@uvic.ca

We introduce and study the optimal control problem with equilibrium constraints (OCPEC). The OCPEC is an optimal control problem with mixed state and control constraints formulated as time dependent complementarity constraints. It provides a powerful modeling paradigm for many practical problems such as bilevel optimal control problems and dynamic principal-agent problems. In this paper, we propose Clarke (C-), Mordukhovich (M-), and strong (S-) stationary conditions and give some sufficient conditions under which a local minimizer is C-, M-, S- stationary. This is a joint work with Lei Guo.

2 - On a Special Bilevel Optimal Control Problem with Fully Convex Lower Level

Patrick Mehlitz, TU Bergakademie Freiberg, Prueferstrasse 1, Freiberg, 09596, Germany, mehlitz@math.tu-freiberg.de

In this talk a bilevel optimal control problem is considered whose upper and lower level problem are convex with respect to all variables while the dynamics are linear. Firstly, a formula is presented which allows the computation of the subdifferential of the lower level optimal value function by evaluating Pontryagin-type optimality conditions. The bilevel optimal control problem is transformed into a single-level optimal control problem possessing a DC-type objective functional (i.e. it equals the difference of two convex functionals) and linear dynamics. Finally, necessary optimality conditions are derived from the obtained surrogate problem using the aforementioned subdifferential formula and some results from DC-programming.

3 - The Natural Gas Cash-Out Problem: A Bilevel Optimal Control Approach

Francisco Benita, Tecnológico de Monterrey, Avenida Eugenio Garza Sada 2501 Sur, Monterrey, Mexico, francisco_benita@hotmail.com, Vyacheslav Kalashnikov, Patrick Mehlitz

The aim of this study is threefold: first it formulates the well-known natural gas cash-out problem as a bilevel optimal control problem; second it provides interesting theoretical results about Pontryagin-type optimality conditions for a general bilevle optimal control problem where the upper level posses a Mayer-type cost function, pure state constraints and the lower level is a binary-fine-dimnensional programming problem; and third, it applies these theoretical results in order to find local minimizers of the gas cash-out problem.

■ TC16

16- Sterlings 1

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Dieter Weninger, University Erlangen-Nürnberg, Department of Mathematics, Cauerstr. 11, Erlangen, 91058, Germany, dieter.weninger@math.uni-erlangen.de

1 - Dantzig-Wolfe Reformulations for the Maximum Weighted Independent Set Problem

Jonas Witt, RWTH Aachen, Operations Research, Kackertstr. 7, Aachen, D-52072, Germany, jonas.witt@rwth-aachen.de, Marco Lübbecke

Dantzig-Wolfe reformulation of an integer program partially convexifies a subset of the constraints, which yields an extended formulation with a potentially stronger linear programming (LP) relaxation than the original formulation. This presentation is part of an endeavor to understand the strength of such reformulations in general. We investigate Dantzig-Wolfe reformulations of the edge formulation for the maximum weighted independent set problem. In particular we characterize reformulations not yielding a stronger LP relaxation than the edge formulation and present necessary as well as sufficient conditions such that the reformulation is best possible.

2 - Decomposing MIPs by using Discontinuous Functions

Dieter Weninger, University Erlangen-Nürnberg, Department of Mathematics, Cauerstr. 11, Erlangen, 91058, Germany, dieter.weninger@math.uni-erlangen.de, Alexander Martin

We describe a variable decomposition algorithm which partitions the original problem into a number of subproblems, where the cut variables will be replaced by discontinuous functions. The corresponding polyhedra are determined by projection and sensitivity analysis. The polyhedra are refined until a global feasible solution can be obtained from the subproblems. This process can be further iterated to find a proven optimal solution. Computational results show the potential of this approach.

3 - Design and Measurement Issues for Magnetic Scales

Armin Fügenschuh, Helmut Schmidt University / University of the Federal Armed Forces Hamburg, Holstenhofweg 85, Hamburg, 22043, Germany, fuegenschuh@hsu-hh.de, Marina Ludszuweit, Marzena Fügenschuh, Alexandar Mojsic, Joanna Sokol

We deal with the design of a magnetic scale as an absolute positioning system. Trapezoid-shaped magnetic areas are placed side by side, so that the resulting pattern enables a unique encoding of each position up to a micrometer level. The problem of finding a longest-possible scale from a set of elementary magnetic areas is formulated as a linear mixed-integer problem. We solve it with a mixture of a heuristic and an exact approach. We approximate the magnetic signal using measured data from an array of Hall sensor cells, which mathematically leads to matrix factorization problems. From there, we discuss how the absolute position is recovered. Practical problems, such as measuring in an unknown altitude, are addressed.

■ TC17

17- Sterlings 2

Nonconvex, Non-Lipschitz, and Sparse Optimization I

Cluster: Nonlinear Programming

Invited Session

Chair: Zhaosong Lu, Associate Professor, Simon Fraser University, Department of Mathematics, Burnaby, Canada, zhaosong@sfu.ca

1 - Sparse Solutions of Linear Complementarity Problems

Xiaojun Chen, Professor, The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, xiaojun.chen@polyu.edu.hk, Shuhuang Xiang

This paper considers the characterization and computation of sparse solutions and least p-norm ($0 < p < 1$) solutions of the linear complementarity problems. We show that the number of non-zero entries of any least-p-norm solution of the LCP is less than or equal to the rank of the matrix M, and all least-p-norm solutions for sufficiently small p are sparse solutions. Moreover, we provide conditions on M such that a sparse solution can be found by solving convex minimization. Applications to the problem of portfolio selection within the Markowitz mean-variance framework are discussed.

2 - Convergence Analysis of L1 Greedy Method for Sparse Solution

Ming-Jun Lai, Professor, University of Georgia, Boyd Graduate Studies Building, Athens, GA, 30602, United States of America, mingjun.lai@gmail.com

I shall present an analysis of L1 greedy method for sparse solution of underdetermined linear systems. The L1greedy method was proposed by Petukhov and his collaborator in 2012. Although it is not the most efficient method, it is an very accurate method. Numerical results will be demonstrated to show the accuracy by comparing it with many algorithms including the re-weighted L1 algorithm, hard thresholding pursuit algorithms (HTP), approximate message passing (AMS) algorithms, generalized AMS (GAMP) algorithm and etc.. A few attempts for speeding up the L1 greedy algorithm will be discussed.

3 - A Second-Order Method for Convex L1-Regularized Optimization with Active Set Prediction

Nitish Shirish Keskar, Northwestern University, 2145 Sheridan Road, Room C210, Evanston, IL, 60208, United States of America, nitishkeskar2012@u.northwestern.edu, Figen Oztoprak, Andreas Waechter, Jorge Nocedal

We describe an active-set method for minimizing an L1-regularized smooth convex function. At every iteration, the algorithm selects a candidate set of free and fixed variables and computes a trial step using an (inexact) subspace phase. If its quality is not acceptable, the set of free variables is restricted and the trial point is recomputed. We establish global convergence for our approach and compare the method against the state-of-the-art code LIBLINEAR.

■ TC18

18- Sterlings 3

Recent Advances in Simulation Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Enlu Zhou, School of Industrial & Systems Engineering, Georgia Institute of Technology, Atlanta, GA, United States of America, enlu.zhou@isye.gatech.edu

1 - Stratified Bayesian Optimization

Saul Toscano, Cornell University, 283 Rhodes Hall, Ithaca, NY, 14850, United States of America, st684@cornell.edu, Peter Frazier

We consider simulation optimization, and noisy derivative-free optimization of expensive functions, when most of the randomness in the objective is produced by a few influential scalar random inputs. We present a new Bayesian global optimization algorithm, called Stratified Bayesian Optimization (SBO), which uses this strong dependence to improve performance. Our algorithm is similar in spirit to stratification, a classical technique from simulation, which uses strong dependence on a categorical representation of the random input to reduce variance.

2 - Reconstructing Input Models via Simulation Optimization

Henry Lam, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, United States of America, khlam@bu.edu, Alexandrina Goeva, Bo Zhang

We consider the problem of calibrating a stochastic input model from data that is only available indirectly as the "output" of some system. This arises in service operations when data is observable only at an aggregate level. Taking a nonparametric perspective, we post a maximum entropy formulation that matches the simulation to empirical outputs, in order to recover the most natural input model that respects the data. We investigate approximate solutions to these optimizations, which typically possess non-convex stochastic constraints, by reducing them into sequences of non-convex optimizations with stochastic objectives but convex deterministic constraints, which are subsequently locally solvable by stochastic feasible direction methods.

3 - Simulation Optimization under Input Uncertainty

Enlu Zhou, School of Industrial & Systems Engineering, Georgia Institute of technology, Atlanta, GA, United States of America, enlu.zhou@isye.gatech.edu

Stochastic simulation is driven by input model, which is a collection of distributions that model the randomness in the system. Input model is often constructed from data, and hence input uncertainty arises due to the finiteness of data. Simulation optimization has been mostly studied under the assumption of a fixed input model, without accounting for the uncertainty of input model. We propose a new framework to study simulation optimization under input uncertainty. This framework can be viewed as a generalization of distributional robust optimization (DRO). We will then outline numerical methods and challenges in solving this framework.

■ TC19

19- Ft. Pitt

Hybrid Optimization II

Cluster: Constraint Programming

Invited Session

Chair: Michele Lombardi, DISI, University of Bologna, Viale del Risorgimento 2, Bologna, 40136, Italy, michele.lombardi2@unibo.it

1 - A Polyhedral Approach to the Chordal Completion Problem

David Bergman, University of Connecticut, United States of America, david.bergman@business.uconn.edu

The minimum chordal completion problem is the classical optimization problem of finding, on a simple undirected graph, the fewest number of edges necessary to add to the graph so that the largest induced cycle has length 3. Although the problem is simple to pose and has been considered for decades, few computational approaches have been attempted and research has focused primarily on heuristics. In this talk a integer programming approach to the problem is presented based on a polyhedral analysis of the convex hull of feasible solutions. Computational testing shows that the approach outperforms existing techniques.

2 - Lagrangian Relaxation Based on Decision Diagrams

Andre Augusto Cire, Assistant Professor, University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, M1C1A4, Canada, acire@utsc.utoronto.ca, David Bergman, Willem-Jan van Hoeve

A new research stream in optimization considers the use of multivalued decision diagrams (MDDs) to encode discrete relaxations of combinatorial optimization problems. In this talk we discuss how to strengthen an MDD relaxation by incorporating dual information in the form of Lagrangian multipliers into its cost structure. Computational experiments on scheduling problems indicate that this technique can improve solving times substantially when compared to other generic-purpose methods.

3 - Master/Slave Scheme for the Multi-Item, Multi-Plant and Multi-Capacity Lot-Sizing Problem

Samuel Deleplanque, ULB, Campus de la Plaine, NO, Bruxelles, Belgium, deleplanque.samuel@gmail.com, Enrico Gorgone, Safia Kedad Sidhoum, Alain Quilliot

We present a multi-item, multi-plant, multi-period Lot-Sizing Problem with Setup production times and multi-capacities. The problem consists of satisfying all the demand according to the production, the transfer and the storage capacities. The optimal solution will minimize the total cost (fixed and variable production costs, transfer cost and storage cost). The problem with capacities is NP-HARD. We established a Master/Slave resolution scheme based on a Lagrangian-based heuristic with a relaxation of all the capacities.

■ TC20

20- Smithfield

Algorithms in Nonsmooth and Nonconvex Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Milagros Loreto, Assistant Professor, University of Washington Bothell, 2575 NE Northstar, Issaquah, Wa, 98029, United States of America, Mloreto@uwb.edu

1 - On the Directional Derivative of Optimal Value Functions of Nonsmooth Convex Problems

Robert Mohr, Karlsruhe Institute of Technology, Degenfeldstrafle 5-9, Apartment 04.03.11, Karlsruhe, 76131, Germany, robert.mohr@kit.edu, Oliver Stein

We present a formula for the directional derivative of the optimal value function of a nonsmooth and completely convex parametric problem. The formula is valid at boundary points of the domain of the optimal value function if the direction belongs to a certain conic set. We derive a functional description for this conic set and apply the formula to selected convex problems such as convex semi-infinite problems or problems involving sums and maxima of norms.

2 - Convergence of a Nonconvex Bundle Method for Constrained Optimization

Minh Ngoc Dao, Dr, Hanoi National University of Education and University of British Columbia Okanagan, 3333 University Way, Kelowna, BC, V1V 1V7, Canada, minhdn@hnue.edu.vn

This work considers inequality constrained optimization problems on a closed convex subset of a finite dimensional real space, where the objective and constraints are described by real-valued locally Lipschitz but not necessarily smooth or convex functions. We use a progress function to handle the presence of constraints and propose a nonconvex bundle method based on downshifted tangents and a suitable backtracking strategy, which assures a global convergence for important classes of nonsmooth functions in applications.

3 - Modified Spectral Projected Subgradient Method (MSPS)

Milagros Loreto, Assistant Professor, University of Washington Bothell, 2575 NE Northstar, Issaquah, Wa, 98029, United States of America, Mloreto@uwb.edu, Alejandro Crema

A Modified version of the Spectral Projected Subgradient (MSPS) is presented. The MSPS is the result of applying to SPS the direction approach used by Spectral Projected Gradient version one (SPG1) proposed by Raydan et al. MSPS presents stronger convergence properties than SPS. We give a comprehensive theoretical analysis of the MSPS and its convergence is shown under some mild assumptions. To illustrate its behavior, we present and discuss numerical results for set covering problems.

■ TC21

21-Birmingham

Algorithms for Optimization with Structural Ambiguity

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

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

1 - Extending the Scope of Uniformly Optimal Methods for General Nonlinear Programming

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

We develop a generic framework to extend uniformly optimal convex programming algorithms to general nonlinear programming. Without requiring any problem parameters, these algorithms achieve the best known complexity for nonconvex problems, and the optimal complexity for convex ones. In particular, for the first time in the literature, we show that the level-type algorithms can be used for solving nonconvex problems uniformly.

2 - Adaptive Sampling for Simulation Optimization and Stochastic Root Finding

Raghu Pasupathy, Purdue University, pasupath@purdue.edu, Sara Shashaani

For roughly six decades since Robbins and Monro (1951), Stochastic Approximation has dominated the landscape of algorithms for root finding and optimization problems with Monte Carlo observable functions. Recently, however, there has been increasing interest in sampling-based frameworks where an existing recursive method, e.g., quasi-Newton or trust-region recursion, is embedded with Monte Carlo estimators of objects within the recursion. We consider the question of how to adaptively sample within such stochastic recursions. We demonstrate that a simple adaptive scheme that has connections to proportional-width sequential confidence intervals endows stochastic recursions with near-optimal convergence rates.

3 - Parallel Bayesian Global Optimization, with Application to Metrics Optimization at Yelp

Jialei Wang, Cornell University, Rhodes Hall, 292, Ithaca, NY, 14853, United States of America, jw865@cornell.edu, Scott Clark, Eric Liu, Peter Frazier

We consider parallel global optimization of expensive-to-evaluate functions, and propose an efficient method based on stochastic approximation for implementing a conceptual Bayesian optimization algorithm proposed by Ginsbourger et al. (2010). We also introduce an open-source software implementation of this algorithm, called Metrics Optimization Engine, developed in collaboration with engineers at Yelp, Inc. and used internally at Yelp to optimize prediction models and performance metrics.

■ TC22

22- Heinz

Novel Cuts for MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: James Luedtke, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53706, United States of America, jrluedt1@wisc.edu

1 - Intersection Cuts for Convex Integer Programs from Translated Cones

Umakanta Pattanayak, Research Scholar, IIT Bombay, IIT Bombay, Powai, Mumbai, MH, 400076, India, umakanta@iitb.ac.in, Vishnu Narayanan

We develop a general framework for intersection cuts for convex integer programs by studying integer points of the associated translated tangent cones. For proper translated cones, under certain mild conditions all intersection cuts are valid for the integer hull, and conversely a large class of valid inequalities are indeed intersection cuts, computable via polyhedral approximations. Finally, valid inequalities for non-pointed translated cones can be derived as intersection cuts for associated proper translated cones.

2 - Convex Nonlinear Relaxations of the Pooling Problem

James Luedtke, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53706, United States of America, jrluedt1@wisc.edu, Jeff Linderoth, Claudia D'Ambrosio

We investigate relaxations for the non-convex pooling problem, which arises in production planning problems in which products with are mixed in intermediate "pools" in order to meet quality targets at their destinations. We derive valid nonlinear convex inequalities, which we conjecture define the convex hull of this continuous non-convex set for some special cases. Numerical illustrations of the results will be presented.

3 - Perspective Cuts Revolution

Hassan Hijazi, Dr., NICTA, 7 London Circuit, Canberra, Australia, hassan.hijazi@nicta.com.au

This talk will cover recent advances in the application of perspective cuts for convexifying bilinear functions and quadratic on/off constraints.

■ TC23

23- Allegheny

Primal-Dual and Proximal Methods in Sparse Optimization II

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 - A Hybrid Quasi-Newton Projected-Gradient Method with Application to Lasso and Basis-Pursuit Denoise

Ewout van den Berg, IBM Watson, 1101 Kitchawan Rd., Yorktown Heights, NY, 10598, United States of America, evandenberg@us.ibm.com

In this talk I present a new algorithm for the optimization of convex functions over a polyhedral set. The algorithm is a hybrid of the spectral projected-gradient and quasi-Newton methods in which the type of step is determined dynamically at each iteration. Practical applications of the framework include the Lasso problem, which also appears as a subproblem in the basis-pursuit denoise solver SPGL1, as well as bound-constrained least squares. Experimental results on these problems will be presented.

2 - Designing Statistical Estimators that Balance Sample Size, Risk, and Computational Cost

John Bruer, California Institute of Technology, 1200 E California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, jbruer@cms.caltech.edu, Joel Tropp, Volkan Cevher, Stephen Becker

In this talk, we propose a tradeoff between computational time, sample complexity, and statistical accuracy that applies to statistical estimators based on convex optimization. When we have a large amount of data, we can exploit excess samples to decrease statistical risk, to decrease computational cost, or to trade off between the two. We propose to achieve this tradeoff by varying the amount of smoothing applied to the optimization problem. To develop these ideas, we use regularized linear regression as a case study. We present theoretical and numerical results that show the existence of such a tradeoff. We illustrate its use in an image interpolation problem.

3 - A Conjugate Interior Point Approach for Large-Scale Problems

Alexandr Aravkin, IBM T.J. Watson Research Center, 1101 Kitchawan Rd., Yorktown Heights, NY, 10598, United States of America, sasha.aravkin@gmail.com

Many important applications can be formulated as large-scale optimization problems, including classification in machine learning, data assimilation in weather prediction, inverse problems, and medical and seismic imaging. While first-order methods have proven widely successful in recent years, recent developments suggest that matrix-free second-order methods, such as interior-point methods, can be competitive. We develop a modeling framework for a wide range of problems, and show how conjugate representations can be exploited to design a uniform interior point approach for this class. We then show several applications, with emphasis on modeling and problem structure.

■ TC24

24- Benedum

MINLP: Non-Standard Approaches and Applications I

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Victor Blanco, Universidad de Granada, Facultad de CC Economicas, Granada, Spain, vblanco@ugr.es

1 - Heuristics based on Test-Sets for Reliability-Allocation Problems

Isabel Hartillo, Universidad de Sevilla, Dpto. Matematica Aplicada I, Sevilla, Spain, hartillo@us.es, Jes´s Gago-Vargas, Justo Puerto, Jose M Ucha

The reliability allocation problem for series-parallel homogeneous multi-state systems uses redundancy of components with different levels of performance in order to achieve a fixed reliability minimizing its cost. This problem has been treated with different heuristic methods as Genetic Algorithm, Tabu Search or Ant Colony Optimization. In our approach we use the skeleton given by a test set obtained from a linear subproblem. This algebraic technique has been used as exact method for the one state case. We use an Ant Colony Optimization algorithm to solve several instances of the problem.

2 - New Algebraic Approach to Multi-Objective Linear Integer Programming

Jose M Ucha, Universidad de Sevilla, Dpto. Algebra, Sevilla, Spain, ucha@us.es, Jesus Gago-Vargas, Isabel Hartillo, Haydee Jiménez

We propose an algebraic alternative to the partial Gröbner bases to deal with multi-objective linear integer programming problems. Using a classical epsilon-constraint strategy, we provide an approach that uses the classical Grˆbner bases to compute a test-set for one objective problems. In the bi-objective case, the computation of the complete Pareto optima set can be done essentially in a single process of reduction/division.

3 - A MINLP Multi-Criteria Optimization for the Aircraft Conflict Resolution Problem

F. Javier Martìn-Campo, Universidad Complutense de Madrid, Campus de Somosaguas, Pozuelo de Alarcon (Madrid), Spain, javier.martin.campo@ccee.ucm.es, Antonio Alonso-Ayuso, Laureano F. Escudero

A mixed integer nonlinear optimization model for the aircraft conflict resolution problem is presented. The aim of the problem consists of providing a configuration for a set of aircraft sharing the same air sector, such that every aircraft does not violate the safety distances with respect to the others. Three different optimization objectives are considered into a multi-criteria framework. A broad computational experiment is presented to assess the validity of the proposal.

■ TC25

25- Board Room

Optimization Methods in Pricing and Supply Chains

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Georgia Perakis, MIT, 100 Main Street, Cambridge, MA, United States of America, georgiap@mit.edu

1 - Scheduling Promotion Vehicles to Boost Revenues: A Provably-Good Analytical Approach

Lennart Baardman, MIT, Operations Research Center, Cambridge, MA, 02139, United States of America, baardman@mit.edu, Maxime Cohen, Kiran Panchamgam, Georgia Perakis, Danny Segev

Retailers use promotion vehicles (e.g. flyers, commercials etc.) to increase revenues. We model how to assign promotion vehicles to maximize revenues as an NLIP. The problem is proven to be NP-hard, and even hard to approximate. However, we construct an epsilon-approximation in the form of an IP of polynomial size. Also, we propose a greedy algorithm with a provable guarantee and on average near-optimal performance. Finally, using supermarket data we show our models can lead to a significant increase in revenues.

2 - A Graph Theoretic Way of Dynamic Pricing

Swati Gupta, Graduate Student, Operations Research Center, MIT, 77 Massachusetts Avenue, E40-149, Cambridge, United States of America, swatig@mit.edu, Georgia Perakis, Maxime Cohen, Jeremy J Kalas

We introduce a class of dynamic programs for multi-period multi-item pricing problems based on an equivalent graphical reformulation that can handle naturally various business rules that arise in practice while providing access to a wide range of ideas from combinatorial optimization. We consider demand models that capture the stockpiling behavior of consumers through dependence on past prices. For fixed memory, we propose a polynomial time algorithm but also illustrate that when the memory is large the problem is NP-hard. We then propose an FPTAS algorithm for the linear reference price demand model. Finally, we extend our results to capture cross-item effects using the notion of a single “virtual” competitor item.

3 - Robust Newsvendor Facing Mixed Demand

Daniel Chen, MIT, 77 Massachusetts Avenue, E40-112, Cambridge, MA, United States of America, dcchen@mit.edu, Retsef Levi, Georgia Perakis

In the newsvendor model, the goal is to determine an optimal inventory level facing uncertain demand and linear shortage and oversupply costs. Traditionally, full knowledge of the demand distribution is assumed, but this is unrealistic in practical scenarios. We model partial information by modeling demand as a mixture of known distributions with unknown weights and formulate the problem using robust optimization. Our proposed solution is tractable and uses this mixture structure in a robust manner. We use data to construct uncertainty sets and derive a bound on the probability of these sets containing the true distribution. This works well in computational experiments, even when the number of samples from the true distribution is small.

■ TC26

26- Forbes Room

Selected Topics in Stochastic Programming Applications

Cluster: Stochastic Optimization

Invited Session

Chair: Ruediger Schultz, University of Duisburg-Essen, Thea-Leymann-Strasse 9, Essen, Germany, ruediger.schultz@uni-due.de

1 - Worst Case Analysis of Noxious Substance Impact on Fish Metabolism

Judith Klein, M.Sc., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, judith.klein@uni-due.de, Ruediger Schultz, Christian Schlechtriem

Exposure of fish feed to noxious substances is a critical issue in fish farming. The talk deals with the two different aquaculture species Rainbow Trout (Oncorhynchus mykiss) and Common Carp (Cyprinus carpio). In particularly pesticide residues being uncertained, stochastic programming approaches, both risk neutral and risk averse, are investigated. Preliminary computational results is reported.

2 - Stochastic Semidefinite Programming for Unit Commitment Under Uncertainty

Tobias Wollenberg, Dipl.-Math., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, tobias.wollenberg@uni-due.de, Ruediger Schultz

This talk will address unit commitment under uncertainty of load in alternating current (AC) power systems. The presence of uncertain data leads us to (risk averse) two-stage stochastic programs. To solve these programs to global optimality a recent semidefinite programming approach to the optimal power flow problem is used. This results in specific mixed integer semidefinite stochastic programs for which a decomposition algorithm is presented.

■ TC27

27- Duquesne Room

Intermittent Resources and Demand Response II

Cluster: Optimization in Energy Systems

Invited Session

Chair: Alfredo Garcia, Professor, Department of Industrial and Systems Engineering, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611-6595, United States of America, alfredo.garcia@ufl.edu

1 - Robust Chance Constrained Optimization in Electricity Networks with Ramping Constraints

Luis Zuluaga, Lehigh University, Mohler Lab Room 387, 200 West Packer Avenue, Bethlehem, PA, 18015, United States of America, luis.zuluaga@lehigh.edu, Alberto Lamadrid, Mohsen Moarefdoost

We study the ramping costs and generation constraints in power networks in which renewable energy is the main source of uncertainty. A robust chance constrained optimization model is developed to design dispatch policies that manage the risk and maintain system reliability. Such model can be written using SOCP constraints for typical renewable power probability distributions. This model is compared in terms of efficiency with the stochastic programming formulation of the chance constraints using sampling techniques.

2 - A Polyheral Study of Multistage Stochastic Unit Commitment Polytope

Kai Pan, PhD Student, University of Florida, 411 Weil Hall, Gainesville, FL, 32611, United States of America, kpan@ufl.edu, Yongpei Guan

In this paper, we investigate a multistage stochastic integer programming formulation for the unit commitment problem under uncertainty. A scenario tree based deterministic equivalent formulation is provided, which leads to a large-scale mixed integer linear program (MILP). By exploring its polyhedral structure, several families of strong valid inequalities are generated. In particular, we obtain convex hull presentations for certain special cases and facets for the general polytope. Finally, the computational results verify the effectiveness of the proposed cutting planes.

■ TC28

28- Liberty Room

Advances in Global Optimisation

Cluster: Global Optimization

Invited Session

Chair: Ruth Misener, Lecturer and RA Eng. Research Fellow, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom, r.misener@imperial.ac.uk

1 - Global Optimization of Genenal Constrained Grey Box Models

Christodoulos Floudas, Professor and Director, Texas A&M Energy Institute, Texas A&M University, 302D Williams Administration Bldg., 3372 Texas A&M University, College Station, TX, 77843, United States of America, floudas@tamu.edu

A novel methodology for the global optimization of general constrained grey-box models is introduced. The key components of (a) sampling reduction, (b) identification of best surrogate functions for the objective function and constraints, (c) global optimization for the parameter estimation of each surrogate function, (d) global optimization of the resulting composite constrained grey-box approximation problem, and (e) updating of bounds via clustering, are discussed. Computational studies on challenging constrained grey-box models, and comparisons to existing approaches are presented.

2 - A Decomposition Algorithm for Two-Stage Stochastic Mixed-Integer Nonconvex Programs

Paul Barton, Professor, MIT, 66-470b, 77 Massachusetts Avenue, Cambridge, MA, United States of America, pib@mit.edu, Rohit Kannan

Two-stage stochastic mixed-integer nonconvex programs have found a wide range of applications in the design and operation of engineering systems. In this work, a decomposition-based branch-and-bound algorithm, which relies on Lagrangian duality and nonconvex generalized Benders decomposition (NGBD) for the lower bounding problem, and aggressive bounds tightening for obtaining tight variable bounds, is proposed. The computational advantages of the proposed algorithm over state-of-the-art global optimization software and the conventional Lagrangian relaxation algorithm are demonstrated through case studies using a recently-developed open-source utility for two-stage stochastic nonconvex programs.

■ TC29

29- Commonwealth 1

Tensor Recovery, Decomposition and Optimization

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 - Large Scale Eigenvalue Computation Using Tensor-train Format

Zaiwen Wen, Beijing International Center for Mathematical Research, Peking University, No. 5 Yiheyuan Road, Haidian District, Beijing, 100871, China, wenzw@math.pku.edu.cn

In this talk, we present an efficient approach for finding the p smallest eigenvalues and their associated eigenvectors represented in a prescribed tensor-train (TT) format by solving the trace-minimization problem for a given a huge symmetric matrix A.

2 - Higher-Order Singular Value Decomposition from Incomplete Data

Yangyang Xu, Postdoctoral Fellow, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, yangyang.xu@uwaterloo.ca

Higher-order singular value decomposition (HOSVD) is an efficient way for data reduction and also eliciting intrinsic structure of multi-dimensional array data. It has been used in many applications, and some of them involve incomplete data. I will talk about an incomplete HOSVD problem, which simultaneously achieves imputation of missing values and also tensor decomposition. With a rank-increasing strategy, the alternating minimization method is found very efficient to solve the problem. Numerical results on tensor face recognition and low-rank tensor recovery will be presented.

3 - Successive Rank-One Approximations of Nearly Orthogonally Decomposable Symmetric Tensors

Cun Mu, PhD Student, IEOR, Columbia University, 500 West 120th Street, New York, NY, 10027, United States of America, cm3052@columbia.edu

Many idealized problems in signal processing, machine learning and statistics can be reduced to the problem of finding the symmetric canonical decomposition of an underlying symmetric and orthogonally decomposable (SOD) tensor. Drawing inspiration from the matrix case, the successive rank-one approximations (SROA) scheme has been proposed and shown to yield this tensor decomposition exactly, and many numerical methods have thus been developed for the tensor rank-one approximation problem. In practice, however, the input tensor can only be assumed to be a nearly SOD tensor. This article shows that even in the presence of perturbation, SROA can still robustly recover the symmetric canonical decomposition of the underlying tensor.

■ TC30

30- Commonwealth 2

Approximation and Online Algorithms VI

Cluster: Approximation and Online Algorithms

Invited Session

Chair: David Shmoys, Cornell University, 231 Rhodes Hall, Ithaca, NY, United States of America, david.shmoys@cornell.edu

1 - An Experimental Evaluation of the Best-of-Many Christofides' Algorithm for the Traveling Salesman Problem

David Williamson, Professor, Cornell University, 236 Rhodes Hall, Ithaca, NY, 14850, United States of America, dpw@cs.cornell.edu, Kyle Genova

Recent papers on approximation algorithms for the traveling salesman problem (TSP) have given a new variant on the well-known Christofides' algorithm for the TSP, called the Best-of-Many Christofides' algorithm. The algorithm involves sampling a spanning tree from the solution the standard LP relaxation of the TSP; one then runs Christofides' algorithm on the resulting tree. We perform an experimental evaluation of several variants the Best-of-Many Christofides' algorithm. In our experiments, all of the implemented methods perform significantly better than the Christofides' algorithm; an algorithm that samples from a maximum entropy distribution over spanning trees seems to be particularly good.

2 - A Logarithmic Additive Integrality Gap for Bin Packing

Rebecca Hoberg, University of Washington, Seattle, WA, United States of America, rahoberg@math.washington.edu, Thomas Rothvoss

For bin packing, the input consists of n items with sizes s1,...,sn?[0,1] which have to be assigned to a minimum number of bins of size 1. Recently, the second author gave an LP-based polynomial time algorithm that employed techniques from discrepancy theory to find a solution using at most OPT+O(logOPT∑loglogOPT) bins. In this paper, we present an approximation algorithm that has an additive gap of only O(logOPT) bins, which matches certain combinatorial lower bounds. Any further improvement would have to use more algebraic structure. Our improvement is based on a combination of discrepancy theory techniques and a novel 2-stage packing: first we pack items into containers; then we pack containers into bins of size 1. Apart from being more effective, we believe our algorithm is much cleaner than the one of Rothvoss.

3 - Algorithms and Computational Results for the (Citi) Bike-Sharing System

David Shmoys, Cornell University, 231 Rhodes Hall, Ithaca, NY, United States of America, david.shmoys@cornell.edu, Eoin O'Mahony

New York launched the largest bike-sharing system in North America in May 2013. We have worked with Citibike, using analytics and optimization to change how they manage the system. Huge rush-hour usage imbalances the system; we answer the questions of where should bikes be before then and how to get them there? Pre-balancing the system in preparation for usage requires placement of the available bikes at stations to minimize the expected rush-hour outage minutes. We use continuous-time Markov chains combined with integer programming models to find the best placement. Achieving this requires trucking bikes around NYC overnight; to find the best routes we use integer programming models combined with observations about submodular structure.

Tuesday, 2:45pm - 4:15pm

■ TD01

01- Grand 1

Distributed Memory Algorithms/Exact Algorithms

Cluster: Implementations and Software

Invited Session

Chair: Deepak Rajan, Computer Scientist, Lawrence Livermore National Laboratory, P.O. Box 808, L-495, Livermore, CA, 94551, United States of America, rajan3@llnl.gov

1 - A Parallel Implementation of a Scenario Decomposition Algorithm for Stochastic 0-1 Programs

Kevin Ryan, Georgia Institute of Technology, 755 Ferst Drive, Atlanta, United States of America, kryan31@gatech.edu, Deepak Rajan, Shabbir Ahmed

A recently proposed scenario decomposition algorithm for stochastic 0-1 programs finds an optimal solution by evaluating and removing individual solutions discovered by solving scenario subproblems. In this work, we develop an asynchronous parallel implementation of the algorithm. We test the results on well known stochastic 0-1 programs and large scale stochastic optimization problems from the electric grid. New improvements to accelerate the original algorithm using local search and cutting planes are also presented.

2 - Distributed Memory B&B for Stochastic MIPs using Distributed Memory Simplex for Stochastic LPs

Geoffrey Oxberry, Postdoctoral Research Associate, Lawrence Livermore National Laboratory, P.O. Box 808, L-792, Livermore, CA, 94551, United States of America, oxberry1@llnl.gov, Cosmin Petra, Pedro Sotorrio, Deepak Rajan, Thomas Edmunds

Stochastic MIPs with large numbers of scenarios can easily result in deterministic equivalent formulations that exceed available memory on a single workstation. In such situations, one must distribute problem data over many computers; however, doing so requires reformulating existing serial algorithms to execute in parallel. Here, we describe a proof-of-concept distributed memory implementation of branch-and-bound with results for small stochastic MIPs, and discuss a path forward to solving much larger stochastic unit commitment problem instances.

3 - Efficient Update Algorithms for the Roundoff-Error-Free LU and Cholesky Factorizations

Adolfo Escobedo, PhD Candidate, Texas A&M University, 3131, TAMU, College Station, TX, 77843, United States of America, adolfoescobedo@tamu.edu, Erick Moreno-Centeno

We introduce efficient update algorithms for the Roundoff-error-free (REF) LU and Cholesky factorizations. The update operations are addition, deletion, and replacement of rows and columns of a basis. Combined with REF forward and backward substitution, the featured algorithms provide a complete framework for solving linear programs exactly and efficiently. A significant advantage of the REF linear programming framework is that the length of any coefficient calculated via its associated algorithms is bounded polynomially without having to use gcd operations.

■ TD02

02- Grand 2

Optimization in Energy Systems I

Cluster: Optimization in Energy Systems

Invited Session

Chair: Victor Zavala, Computational Mathematician, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, 60439, United States of America, vzavala@mcs.anl.gov

1 - Multiperiod MINLP Model for Long-Term Shale Gas Development

Markus Drouven, PhD Student, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA, United States of America, mdrouven@andrew.cmu.edu, Ignacio Grossmann

In this work we address the long-term shale gas development problem which involves determining the optimal development schedule for drilling and fracturing gas wells, and designing the pipelines and natural gas plants for the gathering infrastructure. This problem is formulated as a large-scale nonconvex MINLP involving concave investment cost expressions and bilinear terms for the flow balances for the components in the gas stream. We describe a solution strategy that relies on an MILP approximation that is coupled with a restricted MINLP, and which yields near optimal global solutions. We present results for some real world applications, which show the large economic savings that can be achieved.

2 - New Formulations and Valid Inequalities for the Optimal Power Flow Problem

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, Santanu Dey, Burak Kocuk

The optimal power flow (OPF) problem is a fundamental problem in electric power systems operations, and is a challenging nonconvex quadratic optimization problem. In this talk, we will present algorithmic techniques for finding globally optimal solutions of OPF. We begin by presenting a new formulation for the OPF problem and prove that the McCormick relaxation of the new formulation is stronger than that of the classic formulation. We study the qualities of several other relaxations based on SOCP and SDP. Then, we present a class of valid inequalities for the new formulation. Finally, we present extensive computational results to compare the new formulation and valid inequalities against the performance of the classical formulation.

3 - On the Role of Wind Correlation in Power Grid Economic Dispatch Operations

Cosmin Petra, Argonne National Laboratory, 9700 South Cass Avenue, Lemont, IL, 60439, United States of America, petra@mcs.anl.gov

We study the impact of capturing spatiotemporal correlations between multiple wind supply points on economic dispatch procedures. We show analytically that over/underestimation of correlation leads to positive and negative biases of dispatch cost, respectively. Then a large-scale computational study for the State of Illinois transmission grid with real topology and physical constraints is performed by using the interior-point solver PIPS-IPM on the BG/Q supercomputer at Argonne National Laboratory. We find that strong and persistent cost and price biases result from neglecting correlation information and indicate to the need of coordinating weather forecasts and uncertainty characterizations for wind power producers.

■ TD03

03- Grand 3

Network Design I

Cluster: Combinatorial Optimization

Invited Session

Chair: Laura Sanita, University of Waterloo, 200 University Ave W, Waterloo, Canada, laura.sanita@uwaterloo.ca

1 - Local Search Heuristics for Mobile Facility Location Problems

Zachary Friggstad, University of Alberta, 3-06 Athabasca Hall, University of Alberta, Edmonton, AB, T6G 2E8, Canada, zacharyf@cs.ualberta.ca, Chaitanya Swamy, Sara Ahmadian

In the Mobile Facility Location problem, a collection of facilities are already placed at locations throughout a metric space. They may be moved to new locations at a cost. The goal is to move these facilities in a way that minimizes their total movement cost plus the total cost of connecting each client to some new facility location. We present a 3+eps approximation for this problem based on local search, improving over the previous LP-based 8-approximation. The local search algorithm that tries to move a few facilities at a time can produce very expensive solutions. Our improvement comes by ensuring we always maintain an optimal matching between facilities and their destinations at each step of the local search procedure.

2 - A (1 + e)-Embedding of Low Highway Dimension Graphs into Bounded Treewidth Graphs

Andreas Feldmann, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada, andreas.feldmann@uwaterloo.ca, Jochen Koenemann, Wai Shing Fung, Ian Post

Graphs with bounded highway dimension were introduced by Abraham et al. as a model of transportation networks. We show that any such graph can be embedded into a bounded treewidth graphs with arbitrarily small distortion: if the highway dimension of G is constant we show how to compute a subgraph of the shortest path metric of a graph G with the following two properties. It distorts the distances of G by a factor of 1 + e in expectation and has a treewidth that is polylogarithmic in the aspect ratio of G. In particular, this result implies quasi-polynomial time approximation schemes for a number of optimization problems that naturally arise on transportation networks, including Travelling Salesman, Steiner Tree, and Facility Location.

3 - Finding Small Stabilizers for Unstable Graphs

Karthekeyan Chandrasekaran, University of Illinois, Urbana-Champaign, 104 S. Mathews Ave, 301, Transportation Building, Urbana, IL, 61801, United States of America, karthe@gatech.edu, Laura Sanita, Jochen Koenemann, Adrian Bock, Britta Peis

An undirected graph G is stable if its inessential vertices (those that are exposed by at least one maximum matching) form a stable set. Stable graphs play an important role in cooperative game theory. In this work, we focus on the following edge-deletion problem: given a graph G, can we find a minimum cardinality subset of edges whose removal yields a stable graph? We show that the removal of any such minimum cardinality subset of edges does not decrease the cardinality of the maximum matching in the graph. We further show that the problem is vertex-cover hard and also develop efficient approximation algorithms for sparse graphs and for regular graphs. Based on joint work with Adrian Bock, Jochen Koenemann, Britta Peis and Laura Sanita.

■ TD04

04- Grand 4

First-Order Methods for Structured and/or Conic Optimization – Part I

Cluster: Conic Programming

Invited Session

Chair: Robert Freund, Professor, MIT Sloan School of Mgmt., 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, rfreund@mit.edu

1 - Low-rank Matrix and Tensor Recovery: Theory and Algorithms

Donald Goldfarb, Professor, Columbia University, IEOR Department, 500 West 120th St., New York, NY, 10027, United States of America, goldfarb@columbia.edu, Zhiwei (Tony) Qin, Cun Mu, Bo Huang, John Wright

For problems in which the intrinsic structure of incomplete or corrupted data is more than 3-dimensional, low-rank completion and RPCA convex models for matrices have been extended to tensors. Here we establish recovery guarantees for both tensor completion and tensor RPCA, show that using the most popular convex relaxation for the tensor Tucker rank can be substantially sub-optimal in terms of the number of observations needed for exact recovery and introduce a very simple new convex relaxation that is theoretically and empirically much better. We also propose algorithms to solve these models that are based on ADAL, Frank-Wolfe and prox-gradient methods, and empirically study their performance on both simulated and real data.

2 - Optimal Randomized Gradient Methods

Cong Dang, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32603, United States of America, congdd@ufl.edu, Guanghui Lan

We present optimal primal dual randomized methods which only access part of dataset in each iteration.

3 - Perspectives and Extensions of Renegar's Efficient First-Order Methods for Conic Optimization

Robert Freund, Professor, MIT Sloan School of Mgmt., 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, rfreund@mit.edu

In 2014 Renegar presented a novel nonlinear transformation of a conic optimization problem into a non-smooth convex optimization problem over a simple set, which is ideally-suited for solution by first-order methods. He further improved the complexity of his method from a quadratic to a logarithmic dependence on the quality of the initial point through a novel "sub-scheme." In this talk we present a new perspective on Renegar's work that places it in the context of projective transformations and projective geometry, and that eliminates the need for any sub-scheme to achieve improved complexity. We also generalize these results to a particular structured class of convex optimization problems.

■ TD05

05- Kings Garden 1

Global Efficiency of Nonconvex Optimization Algorithms

Cluster: Nonlinear Programming

Invited Session

Chair: Coralia Cartis, Associate Professor, University of Oxford, Mathematical Institute, Oxford, United Kingdom, coralia.cartis@maths.ox.ac.uk

1 - A Trust Region Method with Worst-Case Iteration Complexity O(eps^(-3/2)) for Nonconvex Optimization

Frank E. Curtis, Lehigh University, 200 W Packer Ave, Bethlehem, PA, United States of America, frank.e.curtis@gmail.com

We present a trust region method for unconstrained nonconvex optimization that, in the worst-case, is able to drive the norm of the gradient of the objective below a prescribed threshold eps > 0 after at most O(eps^(-3/2)) iterations. Our work is inspired by the recently proposed Adaptive Regularisation framework using Cubics (i.e., the ARC algorithm), which attains the same worst-case complexity bound. Our algorithm is modeled after a traditional trust region algorithm, but employs modified step acceptance criteria and a novel trust region updating mechanism that allows it to achieve this desirable property. Importantly, our method also maintains standard global and fast local convergence guarantees. Numerical results are presented.

2 - Classical Unconstrained Optimization Based on "Occasionally Accurate" Random Models

Katya Scheinberg, Professor, Lehigh University, Department of Industrial Engineering, Bethlehem, PA, United States of America, katyas@lehigh.edu, Coralia Cartis

We will present a very general framework for unconstrained optimization which includes methods using random models for deterministic and stochastic optimization. We make assumptions on the stochasticity that are different from the typical assumptions of stochastic and simulation-based optimization. Several convergence and expected convergence rates results have been developed under this framework for standard optimization methods, such as line search, trust region method, direct search methods and adaptive regularization with cubics. We will present some of these results and outline the general analysis techniques based on theory of stochastic processes.

3 - Evaluation Complexity Bounds for Nonconvex Optimization under Milder Assumptions

Coralia Cartis, Associate Professor, University of Oxford, Mathematical Institute, Oxford, United Kingdom, coralia.cartis@maths.ox.ac.uk, Nick Gould, Philippe Toint

We consider first- and second-order regularisation methods, with varying powers of the regularization, applied to nonconvex unconstrained optimization problems that have Holder-continuous gradient and Hessian, respectively. We analyse the interplay between the exponent of the Holder properties and the power of the regularization term, recovering some known results and discovering some new ones.

■ TD06

06- Kings Garden 2

Optimization in Wireless Communication Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Di YuanVisiting, Professor, University of Maryland, College Park, MD, United States of America, diyuan@umd.edu

1 - Power Efficient Uplink Scheduling in SC-FDMA: Benchmarking by Column Generation

Hongmei Zhao, Linköping University, Mathematics Department, Linköping, Sweden, hongmei.zhao@liu.se, Di Yuan, Lei Lei

We study resource allocation in cellular systems and consider the problem of finding a power efficient scheduling in an uplink single carrier frequency division multiple access system (SC-FDMA). We first provide a basic integer linear programming formulation. Then we propose a much stronger column-oriented formulation and a corresponding column generation method, as well as an enhanced column generation scheme.The computational evaluation demonstrates that compared with a poor performance by the integer linear programming formulation,the column generation approach serves well for the purpose of benchmarking results for large-scale instances.

2 - Integer Programming Formulations for Packet Delay and Energy Minimization in WMSN

Michal Pioro, Professor, Lund University, EIT LTH Box 118, Lund, 221 00, Sweden, michal.pioro@eit.lth.se, Antonio Capone, Yuan Li

Cooperative forwarding of packets and interference cancellation are two recent techniques capable of improving traffic throughput in wireless mesh sensor networks (WMSN). The improvement is achieved thanks to (i) possible broadcasting of the same packet simultaneously from several nodes, and (ii) cancellation of signals carrying packets that are already present at the nodes. We develop integer programming (IP) formulations for packet delay and energy minimization for WMSN, showing how the standard signal to interference and noise ratio constraint used in IP approaches to WMSNs can be adjusted to take the two techniques into account. We also present numerical results illustrating the gain achieved with these two techniques.

■ TD07

07- Kings Garden 3

Advances in Integer Programming III

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Santanu Dey, Associate Professor, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, United States of America, santanu.dey@isye.gatech.edu

1 - Exploiting Submodularity in Nonlinear Integer Programming

Shabbir Ahmed, Professor, Georgia Institute of Technology, 765 Ferst Drive, Room 410 Groseclose Bld., Atlanta, GA, 30332, United States of America, shabbir.ahmed@isye.gatech.edu, Jiajin Yu

A variety of nonlinear integer programs involve nonlinear functions of binary variables exhibiting a diminishing marginals property known as submodularity. This talk will discuss approaches to exploit submodularity to develop effective mixed integer linear programming based methods for such problems.

2 - The Boolean Quadric Polytope for Graphs with Bounded Treewidth

Carla Michini, UW Madison, 330 North Orchard Street, Madison, WI, 53715, United States of America, michini@wisc.edu, James Luedtke

In this work we study the problem of minimizing a quadratic function over binary vectors. The boolean quadric polytope arises from a standard linearization of the objective function and has been extensively studied in the literature. We focus on problems where the quadratic form yields a graph with special structure, and we exploit such structure to find tight relaxations. While in general the boolean quadric polytope is known to admit no compact linear extended formulation, for graphs with bounded treewidth we derive an extended formulation of polynomial size.

3 - An Extended Formulation for K-partitioning

Arnaud Knippel, INSA Rouen, Avenue de l'Université, Saint-Etienne-du-Rouvray, 76801, France, arnaud.knippel@insa-rouen.fr, Zacharie Ales

To partition elements in K parts based on similarity or dissimilaritiy measures, we propose an extended formulation with edge variables, representative variables and artificial variables. It has no symmetry and gives good relaxations compared to some other classical formulations. We give polyedral results and present a numerical study.

■ TD08

08- Kings Garden 4

Optimization of Submodular Functions

Cluster: Combinatorial Optimization

Invited Session

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

1 - Constraint Satisfaction Problems and Generalisations of Submodularity

Stanislav Zivn, Associate Professor, Oxford University, Wolfson Building, Parks Road, Oxford, OX1 3QD, United Kingdom, standa.zivny@cs.ox.ac.uk

In this talk, we survey recent results on the computational complexity of optimisation problems that can be cast as Valued Constraint Satisfaction Problems (VCSPs). We will focus on problems that can or provably cannot, assuming standard complexity-theoretic assumptions, be solved optimally in polynomial time. Moreover, we will links these results to generalisations of submodularity.

2 - Fast Submodular Maximization

Roy Schwartz, Postdoctoral Researcher, Princeton University, 35 Olden St., Princeton, NJ, 08540, United States of America, roysch@cs.princeton.edu

Submodular maximization captures both classical problems in combinatorial optimization and recent more practical applications that arise in other disciplines, e.g., machine learning and data mining. Typically, the size of the inputs in these applications is very large. Hence, it is interesting to devise algorithms that in addition to providing a provable guarantee on the quality of the output are also very fast and simple. In this talk I will present several such examples from recent years, including unconstrained submodular maximization and maximization of a submodular function given a cardinality constraint.

3 - Distributed Submodular Maximization via Randomized Composable Core-sets

Vahab Mirrokni, Senior Staff Research Scientist, Google Research, 111 8th Ave, New York, United States of America, mirrokni@gmail.com, Morteza Zadimoghaddam

An effective technique for solving optimization problems over massive data sets is to partition the data into smaller pieces, solve the problem on each piece and compute a representative solution from it, and finally obtain a solution inside the union of the representative solutions. In this paper, we show how to apply this technique for monotone and non-monotone submodular maximization under a cardinality constraint, and prove the first constant-factor distributed approximation algorithms for these problems in two rounds of computation (e.g,. MapReduce). Our results provide a theoretical foundation to empirical effectiveness of similar algorithms.

■ TD09

09- Kings Garden 5

Topics in Robust Optimization I

Cluster: Robust Optimization

Invited Session

Chair: Dick den Hertog, Tilburg University, P.O. Box 90153, Tilburg, Netherlands, D.denHertog@uvt.nl

1 - Linearized Robust Counterparts of Two-Stage Robust Optimization Problem

Amir Ardestanijaafari, HEC Montreal, 3165 Edouard Montpetit Blvd, Apt 36, Montreal, QC, H3T 1K3, Canada, amir.ardestani-jaafari@hec.ca, Erick Delage

We study two-stage robust optimization problem wherein some decisions can be made when the actual data is revealed. Since this problem is computationally intractable we propose a conservative tractable approximation scheme for this problem based on linearizing the cross terms that appears due to the recourse problem. We relate this new scheme to methods that are based on exploiting affine decision rules. Furthermore, we show that our proposed method can be exploited to provide exact solutions in a family of robust multi-item newsvendor problem. Using a robust facility location problem, we also show how our proposed method can be used to derive conservative approximations that are tighter than existing tractable methods.

2 - Worst-Case Expectation Minimization with Given Means and Mean Absolute Deviations

Krzysztof Postek, Tilburg University, P.O. Box 90153, Tilburg, 5000LE, Netherlands, K.Postek@uvt.nl, Dick den Hertog, Bertrand Melenberg, Aharon Ben-Tal

We derive computationally tractable robust counterparts for constraints containing worst-case expected values of functions that are convex in the uncertain parameters. We assume knowledge of the supports, means and mean absolute deviations of the uncertain parameters. We show that the method provides solutions with good average-case performance. Moreover, we show this new method can be used to deal with convex constraints that contain implementation error or constraints that are convex in the linearly adjustable variables.

3 - Robust Solutions for Systems of Uncertain Linear Equations

Jianzhe Zhen, Tilburg University, P.O. Box 90153, Tilburg, 5000 LE, Netherlands, j.zhen@uvt.nl, Dick den Hertog

We propose two new ways for obtaining robust solutions of systems of linear equations that contain uncertain parameters. The first method calculates the center of the maximal inscribed ellipsoid of the set of possible solutions. The second method minimizes the expected violations. We compare these two new methods both theoretically and numerically with an existing method. Applications to the input-output model, Colley's Matrix Rankings and Google's PageRank demonstrate the advantages of the two new methods.

■ TD10

10- Kings Terrace

Quantitive Finance

Cluster: Finance and Economics

Invited Session

Chair: William Ziemba, University of British Columbia, Main Mall, Vancouver, Canada, wtzimi@me.com

1 - Optimal Capital Growth with Controls on the Rate and Size of Shortfalls

Leonard MacLean, Professor, Dalhousie University, 6100 University Avenue, Halifax, Canada, L.C.MacLean@dal.ca, Yonggan Zhao, William Ziemba

We consider the problem of the maximizing the growth rate of capital through investment in risky assets. The risk of capital shortfalls is controlled by: (i) a constraint on the shortfall rate requiring wealth to exceed an ex-ante discrete time wealth path with high probability; and (ii) a penalty on shortfall size in the objective using a convex function of the shortfall. The multi-period stochastic investment model is reformulated as a non-convex deterministic program, and the optimal constrained growth wagers at discrete points in time are calculated.

2 - Behaviouralizing Black-Litterman Part I: Behavioural Biases and Expert Opinions in a Diffusion Setting

Sebastien Lleo, Associate Professor, NEOMA Business Scholl, 59, rue Pierre Taittinger, Reims, 51100, France, seblleo@gmail.com, Mark Davis

This paper proposes a continuous time version of the Black-Litterman model that accounts for, and correct, some of the behavioural biases that analysts may exhibit. Our starting point is the Black-Litterman in Continuous Time model [QFL, 2013], with market data from eleven ETFs . We calibrate analyst views, show how to mitigate the impact of behavioural biases and compare the results of six dynamic investment models. We find that the views have a modest effect on the Kelly portfolio, but a large impact on the intertemporal hedging portfolio. Overall, the role of analyst views in the portfolio section process appears more about providing extra scenarios that are not reflected in historical data, rather than providing accurate forecasts.

3 - Reward-to-Variability Performance Measures

Mikhail Zhitlukhin, Research Fellow, Steklov Mathematical Institute, 8 Gubkina St., Mosow, 119991, Russia, mikhailzh@mi.ras.ru

We will consider minimal monotone functionals that dominate ratios of concave and convex functionals in a context of evaluation of performance of investments in financial markets. They have a natural interpretation in terms of the trade-off between profit and risk and generalize the Sharpe ratio (expected excess return divided by its standard deviation). The main result provides a dual representation of such functionals which allows to evaluate them in an efficient way.

■ TD11

11- Brigade

TSP and Relatives

Cluster: Combinatorial Optimization

Invited Session

Chair: Diego Pecin, Postdoctoral Researcher, Polytechnique Montreal, Université de Montréal - GERAD, Montreal, Canada, diegopecin@gmail.com

1 - 2-parity Inequalities for the Traveling Salesman Problem: Separation and Computational Experiments

Daniel Espinoza, Associate Professor, Universidad de Chile, Department of Industrial Engineering, Av. Republica 701, Santiago, RM, 837-0439, Chile, daespino@gmail.com, William Cook, Marcos Goycoolea

In this work we present a new separation algorithm for separating so-called 2-parity and domino parity inequalities for the TSP when the support graph is planar. The algorithm introduces new dominance rules for dominoes that greatly reduce the practical running time. We will present computational results on TSPLIB and other instances, including the 100,000 city problem known as Mona Lisa TSP.

2 - Variants of TSP Art

Robert Bosch, Professor, Oberlin College, Department of Mathematics, King 205 A, Oberlin, OH, 44074, United States of America, rbosch@oberlin.edu, Tom Wexler

TSP Art is produced by (1) applying a stippling algorithm to a grayscale image, (2) considering the resulting collection of dots to be the cities of a Euclidean TSP instance, (3) finding a high-quality tour of the cities, and finally, (4) drawing the tour. One well known example is the Mona Lisa TSP Challenge. Here we present several variants of TSP Art. In the process, we examine the roles played by the stippling and tour-finding algorithms.

3 - A New Branch-Cut-and-Price Algorithm for the Vehicle Routing Problem with Time Windows

Diego Pecin, Postdoctoral Researcher, Polytechnique Montreal, Université de Montréal - GERAD, Montreal, Canada, diegopecin@gmail.com, Claudio Contardo, Guy Desaulniers, Eduardo Uchoa

This talk introduces a new Branch-Cut-and-Price algorithm for the VRPTW that combines recent techniques for VRPs, such as: ng-routes, bidirectional pricing, strong branching, variable fixing, route enumeration, robust cuts, limited-memory Subset Row Cuts (lm-SRCs) —- a relaxation of the SRCs that is more friendly with the labeling algorithms used to solve the pricing. Our results show that all the 100-customer Solomon and several 200-customer Homberger instances can now be solved to optimality.

■ TD12

12- Black Diamond

Rail and Maritime Applications

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Mario Ruthmair, AIT Austrian Institute of Technology, Donau-City-Strasse 1, Vienna, 1220, Austria, mario.ruthmair@ait.ac.at

1 - Freight Train Routing in Congested Railway Networks

Torsten Klug, TU Berlin, Strafle des 17. Juni 135, Berlin, 10623, Germany, klug@zib.de, Thomas Schlechte, Ralf Borndörfer, Armin Fügenschuh

We investigate the strategic routing of freight trains in congested railway networks with mixed traffic. The problem has a strategic character since it asks only for a coarse routing through a marcroscopic network without the precise timings. We formulate the problem as mixed-integer non-linear program (MINLP) and adapt the congestion concept from road traffic to rail traffic. We linearize the non-linear terms of the objective and solve the resulting linear mixed-integer program with the commercial state of the art MIP solver CPLEX via a sequential approach. In this talk we propose the sequential MIP approach and present some results solving demand situations for the whole German railway network.

2 - Mixed Integer Linear Programming Models for the Interdependent Lock Scheduling Problem

Mario Ruthmair, AIT Austrian Institute of Technology, Donau-City-Strasse 1, Vienna, 1220, Austria, mario.ruthmair@ait.ac.at, Matthias Prandtstetter, Ulrike Ritzinger

We consider the Interdependent Lock Scheduling Problem which arises in ship traffic on rivers with multiple watergates. Each ship starts at a fixed time and follows a given path (upstream or downstream) along which it has to pass a series of watergates. The aim of the problem is to find a lock schedule resulting in minimal total ship travel times. In a weighted objective we also consider the minimization of the number of lockages. We present several mixed integer linear programming models and use CPLEX to solve them.

3 - Computing Equilibrium in the Stable Dynamic Transportation Model

Yuriy Dorn, PreMoLab MIPT, Institutsky per 1, Dolgoprudny, Russia, dornyv@yandex.ru, Alexander Gasnikov, Yurii Nesterov

Computing equilibrium in the Stable Dynamic transportation model (Nesterov and de Palma, 2003) can be reduced to huge-scale non-smooth convex optimization problem with constraints. We propose two new representations for this model: linear programming problem and non-smooth convex optimization problem without constraints. For the second representation we propose new method, which use structure of the problem. We also provide complexity analysis to this method and compare him with other methods for huge-scale optimization problems.

■ TD13

13- Rivers

Foundational Issues Motivated by Simplex Method and Pivoting Algorithms

Cluster: Conic Programming

Invited Session

Chair: Chris Ryan, University of Chicago, Chicago, IL United States of America, chris.ryan@chicagobooth.edu

1 - A Projection Based Relaxed Semismooth-Newton-Method for Conic Optimization-Problems

Felix Lieder, Heinrich-Heine-Universitaet Düsseldorf, Universitaetsstr. 1, Düsseldorf, Germany, Felix.lieder@hhu.de

In this talk we present a new projection based approach for solving conic optimization problems. In contrast to most other authors, we work with indefinite subroblems coming from our nonconvex formulation. These subproblems depend one or more relaxation parameters. In its most relaxed form, our method reduces to a simple fixpoint iteration, which has global convergence properties. Assuming that one is able to efficiently project on the involved cones, large problems can be handled. To obtain faster local convergence rates, we adjust our relaxation parameter(s) and use second order information. We present promising numerical results on semidefinite programs arising from relaxations of combinatorial problems.

2 - Strong Symmetric Duality and Simplex Type Algorithm for Continuous Linear Programs

Evgeny Shindin, PhD Student, The University of Haifa, Department of Statistics, Haifa, 31905, Israel, shindin@netvision.net.il, Gideon Weiss

We consider continuous linear programs over a continuous finite time horizon T, with a constant coefficient matrix, linear right hand side functions and linear cost functions, we search for optimal solutions in the space of functions of bounded variation. This generalizes separated continuous linear programms as formulated by Anderson, Pullan, and Weiss. We formulate a symmetric dual, show strong duality, give a detailed description of optimal solutions, and define a combinatorial analogue to basic solutions of standard LP. We present an algorithm that solves these problems in a finite bounded number of steps, using an analogue of the simplex method, in the space of measures.

3 - Projection: A Unified Approach to Semi-Infinite Linear Programs and Duality in Convex Programming

Chris Ryan, University of Chicago, Chicago, IL, United States of America, chris.ryan@chicagobooth.edu, Kipp Martin, Amitabh Basu

Fourier-Motzkin (FM) elimination is a projection algorithm for solving LPs. We extend FM elimination to semi-infinite LPs (SILPs) with finitely many variables and infinitely many constraints. Applying projection leads to new characterizations of properties for primal-dual pairs of SILPs. Our procedure yields a classification of variables — clean vs. dirty — to determine the existence of duality gaps. Our approach has applications in finite-dimensional convex optimization. For example, sufficient conditions for a zero duality gap, such as the Slater constraint qualification, are reduced to guaranteeing that there are no dirty variables. This leads to completely new proofs of sufficient conditions for zero duality gap.

■ TD14

14- Traders

Utility Tradeoffs in Mechanism Design

Cluster: Game Theory

Invited Session

Chair: Nima Haghpanah, MIT, 32 Vassar Street, Cambridge, MA, United States of America, nima.haghpanah@gmail.com

1 - Optimal Prior-Free Benchmarks

Sam Taggart, Northwestern University, 2145 Sheridan Rd, Evanston, IL, United States of America, samuelptaggart@gmail.com, Jason Hartline

For many optimization problems with limited information there is no pointwise optimal algorithm. Worst-case (a.k.a. prior-free) analysis can proceed by comparing the performance of the algorithm to a performance benchmark. One compelling standard for benchmark selection is Bayesian justification: any algorithm that approximates the benchmark should also be approximately optimal when there is a prior distribution over inputs. This work considers optimization over such benchmarks - i.e., finding the Bayesian justified benchmark that admits the tightest approximations. We exhibit the approach in designing a mechanism for selling a single item to optimize the cumulative utility of bidders.

2 - Mechanisms for Fair Attribution

Eric Balkanski, Harvard University, Maxwell Dworkin 219, 33 Oxford Street, Cambridge, MA, United States of America, ericbalkanski@g.harvard.edu, Yaron Singer

We consider a new genre of mechanism design, which to the best of our knowledge, has not been explored before. In particular we consider mechanisms for procurement which attribute the buyer's budget in a fair manner. We establish natural notions of fairness that are based on concepts from cooperative game theory. Our main result shows that for any monotone submodular function there exists a fair mechanism which is a 3-approximation and that this is tight. We discuss several special cases for which this approximation ratio can be improved and several natural extensions.

3 - Optimal Revenue-Utility Tradeoffs: Applications to Dynamic and Competing Mechanisms

Nima Haghpanah, MIT, 32 Vassar Street, Cambridge, MA, United States of America, nima.haghpanah@gmail.com, Itai Ashlagi, Constantinos Daskalakis

We propose the study of a single-dimensional mechanism design problem, termed optimal revenue-utility tradeoff, in which the objective is to maximize a linear combination of the seller's revenue and a function of the bidder's utility. Under general conditions, we provide simple mechanisms that solve or approximately solve this problem, and study three applications of our proposed problem and solution. First, we show how it can be directly used to solve instances of optimal taxation. Second, we use it to provide optimal dynamic mechanisms for selling two items to one buyer subject to strongly ex-post individual rationality conditions. Third, our problem captures single-dimensional revenue maximization in the presence of competing mechanisms.

■ TD15

15- Chartiers

Mixed-Integer Optimal Control for PDEs

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

Invited Session

Chair: Falk Hante, Dr., University of Erlangen-Nuremberg, Cauerstr. 11, Erlangen, 91058, Germany, falk.hante@fau.de

1 - Relaxation Methods for PDE Mixed-Integer Optimal Control

Falk Hante, Dr., University of Erlangen-Nuremberg, Cauerstr. 11, Erlangen, 91058, Germany, falk.hante@fau.de

The talk provides an introduction to the problem class including some benchmark problems from gas network operation, thermal manufacturing and traffic flow control. One way to assess the problem class is based on relaxation of the integer constraints. For this method, a-priori estimates for semilinear evolutions on Banach spaces are presented which allow an explicit construction of integer-controls from a relaxed control up to arbitrary precision. The method is demonstrated on numerical examples.

2 - Questions of Algorithm and Software Design for Optimal Control in Gas Networks

Marc C. Steinbach, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, mcs@ifam.uni-hannover.de

Transient optimization in gas networks poses major mathematical challenges by combining nonsmooth discrete-continuous optimization with ill-conditioned PDE constraints and complicated technical devices on large graphs. Based on earlier experience with small gas network models, the talk presents structural considerations for addressing some of these challenges in a potential solution framework. We also discuss fundamental design issues arising in the development of numerical software for the above problem and other highly complex applications.

3 - A Convex Analysis Approach for Computing Switching Controls for PDEs

Armin Rund, Karl-Franzens-University Graz, Heinrichstrasse 36, Graz, 8010, Austria, armin.rund@uni-graz.at, Karl Kunisch, Christian Clason

This talk is concerned with optimal control problems for parabolic partial differential equations subject to a switching penalty. Replacing this penalty with its convex relaxation leads to a primal-dual optimality system that allows an explicit pointwise characterization and whose Moreau-Yosida regularization is amenable to a semismooth Newton method in function space. Numerical results are presented and the extension to optimal switching between an arbitrary number of controls is discussed.

■ TD16

16- Sterlings 1

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Rosiane de Freitas, Professor/Sys Comp. Eng. PhD, IComp/UFAM, Av. Rodrigo Octàvio, 3000, Aleixo, Campu, Manaus, AM, Brazil, rosiane@icomp.ufam.edu.br

1 - A MILP Model for Order-Based Continuous Casting Planning at SSAB

Nils-Hassan Quttineh, Senior Lecturer, Linköping University, Linköping University, Department of Mathematics, Linköping, 58183, Sweden, nils-hassan.quttineh@liu.se

We present the challenges of planning the order-driven continuous casting production at the Swedish steel producer SSAB. Customers place orders for end products, which is translated into a demand of slabs of a certain steel grade and with given order-specific restrictions on weight, length and breadth. The overall planning problem is to minimize production waste while fulfilling the order-based demand, and we decomposed the problem by firstly schedule and group orders by steel grade, and secondly decide in which sequence the scheduled orders for each day should be cast. A MILP model is available which produces efficient production plans and simultaneously facilitates the daily work situation for the planners at SSAB.

2 - An Extended Formulation for Minsum Scheduling Problems on Unrelated Parallel Machines

Kerem Bulbul, Assoc. Prof., Sabanci University, Sabanci University, Orhanli, Tuzla, Istanbul, 34956, Turkey, bulbul@sabanciuniv.edu, Halil Sen

We present a novel extended mixed integer linear programming formulation – attacked by Benders decomposition with strengthened cuts – for solving minsum scheduling problems on unrelated parallel machines. Our formulation yields tight lower bounds and allows for the construction of near-optimal feasible solutions for instances with up to 5 machines and 200 jobs under the total weighted tardiness and total weighted earliness/tardiness objectives. Furthermore, the formulation turns out to be exact for the total weighted completion time objective, and instances with up to 1000 jobs and 8 machines are solved to optimality within a few seconds.

3 - MIP Formulations for Parallel Machine Scheduling Problems Based on Due Date Penalties

Rosiane de Freitas, Professor/Sys Comp. Eng. PhD, IComp/UFAM, Av. Rodrigo Octavio, 3000, Aleixo, Campu, Manaus, AM, Brazil, rosiane@icomp.ufam.edu.br, Bruno Dias, Rainer Amorim

This work addresses mixed integer programming formulations for parallel scheduling problems, with independent and non-preemptive jobs containing arbitrary processing times, to regular and non-regular objective functions based on due dates penalties, as lateness, unity penalty, tardiness and earliness-tardiness objective functions. A comparative analysis is presented, considering both theoretical aspects as well as more appropriate algorithmic strategies, where a battery of tests is performed with instances of literature.

■ TD17

17- Sterlings 2

Constraint Qualification and Convergence of Algorithms

Cluster: Nonlinear Programming

Invited Session

Chair: Roberto Andreani, Dr, State University Campinas- Brazil, Rua Sergio Buarque de Holanda, 651, Campinas, 13083-859, Brazil, andreani@ime.unicamp.br

1 - A Cone-Continuity Constraint Qualification and Algorithmic Consequences

Roberto Andreani, Dr, State University Campinas- Brazil, Rua Sérgio Buarque de Holanda, 651, Campinas, 13083-859, Brazil, andreani@ime.unicamp.br, Paulo J. S. Silva, Alberto Ramos, Josè Mario Martìnez

Every local minimizer of a smooth constrained optimization problem satisfies the sequential Ap- proximate Karush-Kuhn-Tucker (AKKT) condition. This optimality condition is used to define stop- ping criteria of many practical nonlinear programming algorithms. It is natural to ask for conditions on the constraints under which AKKT implies KKT. These conditions will be called Strict Constraint Qualifications (SCQ). In this paper we define a Cone-Continuity Property (CCP) that will be showed to be the weakest possible SCQ. Its relation with other constraint qualifications will also be clarified. In particular, it will be proved that CCP is strictly weaker than the Constant Positive Generator (CPG) constraint qualification.

2 - On Second Order Optimality Conditions for Nonlinear Optimization

Gabriel Haeser, Dr, University of São Paulo, Rua do Matao, 1010, São Paulo, Brazil, ghaeser@gmail.com, Paulo J. S. Silva, Roger Behling, Roberto Andreani

In this work we present new weak conditions that ensure the validity of necessary second order optimality conditions (SOC) for nonlinear optimization. We are able to prove that weak and strong SOCs hold for all Lagrange multipliers using Abadie-type assumptions. We also prove weak and strong SOCs for at least one Lagrange multiplier imposing the Mangasarian-Fromovitz constraint qualification and a weak constant rank assumption.

3 - On Second-Order Sequential Optimality Conditions for Nonlinear Optimization and Applications

Alberto Ramos, PhD Student, University of São Paulo, Rua do Matão, 1010, São Paulo, SP, 13278-138, Brazil, aramos27@gmail.com, Gabriel Haeser, Paulo J. S. Silva, Roberto Andreani

Sequential optimality conditions provide adequate theoretical tools to justify stopping criteria formany nonlinear programming solvers. Most of them use only first-order information. In this paper. we introduce new sequential optimality conditions that take into account first and second-order information. We prove that well established algorithms with convergence to second-order stationary points produce sequences whose limit points satisfy these new condition. In particular, we show global convergence of augmented Lagrangian and Regularized SQP to second-order stationary points under a weak constraint qualification.

■ TD18

18- Sterlings 3

Convex Conic Optimization: Models, Properties, and Algorithms I

Cluster: Conic Programming

Invited Session

Chair: Farid Alizadeh, Professor, Rutgers University, MSIS department, 100 Rockefallar, room 5142, Piscataway, NJ, 08854, United States of America, alizadeh@rci.rutgers.edu

1 - Cone-Free Infeasible-Start Primal-Dual Methods

Mehdi Karimi, PhD Student, Department of Combinatorics and Optimization, University of Waterloo, 200 University Avenue West,, Waterloo, ON, N2L 3G1, Canada, m7karimi@uwaterloo.ca, Levent Tuncel

We develop an infeasible-start primal-dual algorithm for convex optimization problems equipped with a self-concordant barrier for the convex domain of interest and its easy-to-calculate Legendre-Fenchel conjugate. Our approach is cone-free in the sense that we directly apply our techniques to the given good formulation without reformulating it in a conic form. After defining our central path, we present a long-step path following algorithm and prove that it solves the problem in polynomial time; returns an optimal solution if it exists, otherwise detects infeasibility or unboundedness. We introduce our Matlab-based code that solves a large class of problems including LP, SOCP, SDP, QCQP, Geometric programming, and Entropy programming.

2 - Pseudomonotonicity and Related Properties in Euclidean Jordan Algebras

Jiyuan Tao, Professor, Loyola University Maryland, 4501 North Charles Street, Baltimore, MD, 21210, United States of America, JTao@loyola.edu

In this talk, we introduce the concept of pseudomonotonicity on symmetric cones and present interconnections between pseudomonotonicity, monotonicity, the Z-property, the P_0-property, the column sufficiency property, the P-property, and the globally uniquely solvable property in the setting of Euclidean Jordan algebras.

3 - Optimization with Multivariate Risk Constraints Based on a General Class of Scalarization Functions

Gabor Rudolf, Koc University, Rumeli Feneri Yolu, Sariyer, Istanbul, 34450, Turkey, grudolf79@gmail.com, Nilay Noyan

We consider decision making problems where the decision results in multiple uncertain outcomes represented by a vector-valued random variable, and decision makers' preferences are incorporated via coherent risk measures. In a multivariate context scalarization functions are often used to combine the multiple outcomes. While the current literature on stochastic multi-criteria optimization relies almost exclusively on linear scalarization functions, a variety of other functions (such as Chebysev scalarizations) are commonly used in the deterministic multi-objective literature. In this work we aim to incorporate a general class of scalarization functions into risk-constrained stochastic multivariate decision problems.

■ TD19

19- Ft. Pitt

Hybrid Optimization III

Cluster: Constraint Programming

Invited Session

Chair: Willem-Jan van Hoeve, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, United States of America, vanhoeve@andrew.cmu.edu

1 - Practical Solution of Rich Routing Problems with CP and Metaheuristics

Luca Di Gaspero, Dr., University of Udine, DIEGM, via delle Scienze 208, Udine, UD, I-33100, Italy, luca.digaspero@uniud.it

A promising research line in the optimization community regards the hybridization of exact and heuristics methods. Among other alternatives we consider the specific integration of two complementary optimization paradigms, namely Constraint Programming (CP), for the exact part, and metaheuristics. We present the integration of Large Neighborhood Search and Ant Colony Optimization methods within the Gecode CP system and we show how it can be used to solve two practical optimization problems in the Vehicle Routing domain: the Balancing Bike-Sharing System problem, which aims at increasing the efficiency of public bike-sharing systems, and the HomeCare scheduling problem, which concerns the efficient planning of caregivers for home assistance.

2 - Accelerating the Development of Efficient CP Optimizer Models

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

The IBM Constraint Programming optimization system CP Optimizer was designed to provide automatic search and a simple modeling of discrete optimization problems, with a particular focus on scheduling applications. It is used in industry for solving operational planning and scheduling problems. We will give an overview of CP Optimizer and then describe in further detail a set of features such as input/output file format, warm-start or conflict refinement that help accelerate the development of efficient models.

■ TD20

20- Smithfield

Accelerated and Optimal First Order Methods

Cluster: Nonsmooth Optimization

Invited Session

Chair: Clovis Gonzaga, Professor, Federal University of Santa Catarina, R. Jorge Cherem, 57, Florianopolis, SC, 88053-620, Brazil, ccgonzaga1@gmail.com

1 - Accelerated Steepest Descent Algorithms for Convex Quadratic Functions

Clovis Gonzaga, Professor, Federal University of Santa Catarina, R. Jorge Cherem, 57, Florianopolis, SC, 88053-620, Brazil, ccgonzaga1@gmail.com, Ruana Schneider

The steepest descent algorithm with exact line searches (Cauchy algorithm) is inefficient, generating oscillating step lengths and a sequence of points converging to the span of the eigenvectors associated with the extreme eigenvalues. The performance becomes very good if a short step is taken at every (say) 10 iterations. We show a new method for estimating short steps, and also how to add a short step at each iteration with low computational cost. Finally, we use the roots of a certain Chebyshev polynomial to further accelerate the method.

2 - Optimized Gradient Methods for Smooth Convex Minimization

Donghwan Kim, Postdoctoral Research Fellow, University of Michigan, 1301 Beal Avenue, Ann Arbor, MI, 48109, United States of America, kimdongh@umich.edu, Jeffrey A. Fessler

We introduce new optimized first-order algorithms for smooth unconstrained convex minimization. Drori and Teboulle recently described a numerical method for computing the N-iteration optimal step coefficients in a class of first-order algorithms. However, the numerical method and the corresponding first-order algorithm are computationally expensive. By extending Drori and Teboulle's numerical analysis, we propose optimized gradient methods (OGM) that achieve a convergence bound that is two times faster than Nesterov's fast gradient methods (FGM); our bound is found analytically and refines the numerical bound. Furthermore, we show that the proposed OGM methods have efficient recursive forms that are remarkably similar to Nesterov's FGM.

3 - A General Framework for Accelerating First-Order Algorithms for Smooth Convex Optimization

Haihao Lu, MIT, Mathematics Department, 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, haihao@mit.edu

We present a general framework for constructing accelerated gradient methods for the class of smooth convex optimization problems. This unifying framework provides novel interpretations of the accelerating nature of the methods, and enables the development of a new family of accelerated methods. The framework can be applied to Nesterov's classical accelerated method, the dual-averaging method, and Tseng's accelerated proximal methods.

■ TD21

21-Birmingham

Computation and Applications of Conic Optimization

Cluster: Conic Programming

Invited Session

Chair: Hayato Waki, Institute of Mathematics for Industry, Kyushu University, Motooka 744,, NIshi-ku,, Fukuoka, 819-0395, Japan, waki@imi.kyushu-u.ac.jp

1 - Application of Facial Reduction to H-infinity State Feedback Control Problem

Hayato Waki, Institute of Mathematics for Industry, Kyushu University, Motooka 744,, NIshi-ku,, Fukuoka, 819-0395, Japan, waki@imi.kyushu-u.ac.jp, Noboru Sebe

When one encounters numerical difficulties in solving an SDP relaxation problem, one of the reasons may be no interior feasible solutions in the SDP relaxation problem. Facial reduction proposed by Borwein and Wolkowicz is useful for such SDP problems from viewpoint of computation. In this talk, we deal with H-infinity state feedback control problem and provide necessary and sufficient condition for SDP relaxation problems to have interior feasible solutions in terms of the control. Furthermore, we propose a way to remove the numerical difficulty which is available to control systems. Numerical results show that the numerical stability is improved by applying the way.

2 - Facial Reduction for Euclidean Distance Matrix Problems

Nathan Krislock, Assistant Professor, Northern Illinois University, 1425 W. Lincoln Hwy., DeKalb, IL, 60115, United States of America, krislock@math.niu.edu, Yuen-Lam Voronin, Henry Wolkowicz, Dmitriy Drusvyatskiy

A powerful approach to solving problems involving Euclidean distance matrices (EDMs) is to represent the EDM using a semidefinite matrix. Due to the nature of these problems, the resulting semidefinite programming problem is typically not strictly feasible. In this talk we discuss how to take advantage of this lack of strict feasibility by using facial reduction to obtain smaller equivalent problems. This approach has proven very successful for solving large-scale Euclidean distance matrix problems having little to no noise in the given incomplete distance measurements. We will present recent results on the use of facial reduction for solving noisy Euclidean distance matrix problems.

3 - Finding Sparse, Equivalent Sdps using Linear Programming and Combinatorial Techniques

Frank Permenter, Graduate Student, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-380, Cambridge, MA, 02139, United States of America, fperment@mit.edu, Pablo Parrilo

We present a new method for simplifying SDPs that blends aspects of symmetry reduction with sparsity exploitation. By identifying a subspace of sparse matrices that provably intersects (but doesn't necessarily contain) the set of optimal solutions, we both block-diagonalize semidefinite constraints and enhance problem sparsity for many SDPs arising in sums-of-squares optimization. The identified subspace is in analogy with the fixed-point subspace that appears in symmetry reduction, and, as we illustrate, can be found using efficient combinatorial and linear-programming-based techniques. Effectiveness of the method is illustrated on several examples.

■ TD22

22- Heinz

Variational Analysis in Nonsmooth Optimization I

Cluster: Variational Analysis

Invited Session

Chair: Martin Knossalla, University of Erlangen-Nuremberg, Cauerstr. 11, Erlangen, 91058, Germany, martin.knossalla@fau.de

1 - Bundle Methods with Linear Programming

Shuai Liu, RMIT University, Mathematical and Geospatial Sciences, Melbourne, 3000, Australia, liushuai04235@gmail.com, Andrew Eberhard, Yousong Luo

Traditional bundle methods solve a quadratic programming (QP) subproblem in each iteration. In this presentation, we exploit the feasibility of developing a bundle algorithm that only solves linear subproblems. We minimize the cutting-plane model over a trust region with infinity norm. Starting from convex optimization, we show that the method can be generalized to solve nonconvex problems through convexification. We consider functions that are locally Lipschitz continuous and prox-regular on a bounded level set. Under some conditions and assumptions, we study the convergence of the proposed algorithm through the outer semicontinuity of the proximal mapping.

2 - New Results on Subgradient Methods for Weakly Smooth and Strongly Convex Problems

Masaru Ito, Doctoral Student, Tokyo Institute of Technology, 2-12-1-W8-41, Oh-okayama, Meguro-ku, Tokyo, 152-8552, Japan, ito1@is.titech.ac.jp

We consider subgradient- and gradient-based methods for minimizing weakly smooth and strongly convex functions under a generalized notion of the standard Euclidean strong convexity. We propose a unifying framework for subgradient methods which yields two kinds of particularizations, namely, the Proximal Gradient Method (PGM) and the Conditional Gradient Method (CGM), unifying several existing methods. The unifying framework is developed for convex problems equipped with an oracle inexactness, which includes weakly smooth and strongly convex problems. We use the unifying framework to show optimal convergence of the PGMs for weakly smooth and strongly convex problems, and (nearly) optimal convergence of the CGMs for weakly smooth problems.

3 - Nonsmooth Optimization with Semi-Algebraic Data: Convergence Beyond the Proximal Setting

Edouard Pauwels, Postdoctoral Fellow, Technion, Factulty of Industrial, Engineering and Management, Haifa, 32000, Israel, epauwels@tx.technion.ac.il, JèrÙme Bolte

We focus on convergence of iterative schemes for non-smooth non-convex optimization in finite dimension. Most of current results are given for "prox-friendly" data: the nonsmooth part can be handled through efficiently computable operators. Many methods and applications do not fit this setting. We focus on Sequential Quadratic Programming ideas for general Nonlinear Programs. Despite their large usage, these methods lack satisfactory convergence analysis. This work constitutes a step toward the obtention of such theoretical guaranties. We combine properties of local tangent majorizing models with results from algebraic geometry to analyse the asymptotic properties of two recent methods for solving general Nonlinear Programming problems.

■ TD23

23- Allegheny

Sparse and Low-Rank Optimization in Imaging

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Justin Romberg, Georgia Tech, 777 Atlantic Dr. NW, Atlanta, GA, 30332, United States of America, jrom@ece.gatech.edu

1 - A Moment Approach for Tensor Decomposition

Gongguo Tang, Colorado School of Mines, CO, United States of America, gtang@mines.edu, Parikshit Shah

We develop a new approach for tensor decomposition that comes with theoretical and algorithmic guarantees. Tensor decomposition is formulated as estimating an atomic measure from its moments. By constructing a dual polynomial, we demonstrate that the measure optimization returns the correct decomposition under an incoherent condition on the rank-one factors. We present a hierarchy of semidefinite programs to approximate the measure optimization. By showing that the constructed dual polynomial is a sum-of-squares modulo the sphere, we show that the smallest SDP in the relaxation hierarchy is exact and the decomposition can be extracted from the semidefinite program solutions.

2 - Image Segmentation via Convex Cardinal Shape Composition

Alireza Aghasi, Georgia Institute of Technology, 75 5th St. NW, Atlanta, GA, 30308, United States of America, aghasi@gatech.edu, Justin Romberg

We propose a new shape-based modeling technique for applications in imaging problems. Given a collection of shape priors (a shape dictionary), we define our problem as choosing the right dictionary elements and geometrically composing them through basic set operations to characterize desired regions in an image. This is a combinatorial problem with a large number of possibilities. We propose a convex relaxation to the problem to make it computationally tractable. We take some major steps towards the analysis of the problem and characterizing its minimizers. Applications vary from shape-based characterization, optical character recognition, and shape recovery in occlusion, to other disciplines such as the geometric packing problem.

3 - Non-Convex Regularizers for Non-Gaussian Image Denoising

Albert Oh, University of Wisconsin-Madison, 1415 Engineering Drive, Dept. of Electrical and Computer Eng., Madison, WI, 53706, United States of America, akoh2@wisc.edu, Rebecca Willett

In this talk, we describe several classes of image denoising problems where the noise is non-Gaussian and where non-convex, sparsity-promoting regularization functions (which would be undesirable in Gaussian noise settings) not only admit efficient convex optimization algorithms, but also yield substantial empirical performance gains. The shape of the log-likelihood function helps determine viable and effective classes of regularizers.

■ TD24

24- Benedum

MINLP in Gas Transportation

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Ruediger Schultz, University of Duisburg-Essen, Thea-Leymann-Strasse 9, Essen, Germany, ruediger.schultz@uni-due.de

1 - Checking Feasibility in Stationary Models of Gas Transportation Networks-Structural Characteristics

Claudia Stangl, Dr., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, claudia.stangl@uni-due.de

Checking the feasibility of transportation requests belongs to the key tasks in gas pipeline operation. In its most basic form, the problem is to decide whether a certain quantity of gas can be sent through the network from prescribed entries to prescribed exit points. In the stationary case, the physics of gas flow together with technological and commercial side conditions lead to a pretty big (nonlinear, mixed-integer, finite dimensional) inequality system. The approach presented in this talk relies on transforming nonlinearities into a more accessible form, reducing the problem dimension of the underlying nlp.

2 - Checking Feasibility in Stationary Models of Gas Transportation Networks – Solving the MINLP

Ralf Gollmer, Dr., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, ralf.gollmer@uni-due.de, Ruediger Schultz, Claudia Stangl

The nomination validation for gas networks amounts to feasibility checking for a large mixed-integer non-convex problem. In this talk we present the problem-specific heuristics for choosing most of the binary variables a priori by heuristics, the remaining ones are modeled via the max- and abs-functions. A non-convex nonsmooth nlp results for which properties and reformulation are presented in the talk by Claudia Stangl. Though using heuristics, the approach works quite well for a real-world gas network.

3 - An Approach to Feasibility of Entry and Exit Flows in Gas Networks Using Groebner Bases Methods

Sabrina Nitsche, M.Sc., University of Duisburg-Essen, Faculty of Mathematics, Thea-Leymann-Str. 9, Essen, 45127, Germany, sabrina.nitsche@uni-due.de, Ruediger Schultz

In gas networks, feasibility of balanced entry and exit flows has to be checked very often as the loads at the entry and exit nodes vary. Our objective is to obtain an algebraic solution that is computed only once for a given network and then used to obtain any particular solution. In the talk some numerical results will be presented.

■ TD25

25- Board Room

Energy System Planning

Cluster: Optimization in Energy Systems

Invited Session

Chair: 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

1 - Expansion Planning in Colombia using Mixed-Integer Programming MILP Approach

Juan Sebastian Londoño Martìnez, Universidad de Antioquia, calle 67 No. 53 - 108, Medellìn, Colombia, juans.londono@udea.edu.co, Oscar Carreño, Richar Alexi Otalvaro Lopez

The expansion transmission planning, is a complex and huge problem. It is due to the different aspects that need to be dealt with for the solution. In Colombia this problem have different approach: XM (Colombian ISO), Transmission firm and UPME (The organization in charge of energy planning in Colombia. In this paper we compare those approach with the state-of-the-art and another worldwide firm. We propose a mathematical model based on MILP whose objective is enhance some critical aspects. This model have been implemented on GAMS and it was tested with the last expansion planning released by UPME.

2 - Construction Planning of a North Sea Offshore Energy Grid

Philipp Hahn, University of Kassel, Heinrich-Plett-Str. 40, Kassel, 34132, Germany, hahn@mathematik.uni-kassel.de, Frank Fischer, Andreas Bley

We consider the problem of extending offshore windparks and connecting them to the shore. The goal is to find a long term (time horizon till 2050) construction plan for building up an energy grid within the northsea that satisfies certain demands of produced power under budget constraints. The power grid is to be build with operable intermediate stages and should also enable the neigbouhring countries to trade energy more flexibly via this network. We present a first model for this problem and some preliminary computational results.

3 - Parallel Computing of Stochastic Programs with Application to Energy System Capacity Expansion

Andrew Liu, Assistant Professor, Purdue University, 315 N Grant St., West Lafayette, IN, 47906, United States of America, andrewliu@purdue.edu, Run Chen

Power grids' planning and operations exhibit extreme multiscale in the time dimension, ranging from hourly unit commitment\dispatch to decades of investment decisions. The linkage between decisions of different time scales usually is simple. Once the linkage is relaxed, the problem can be separated into multiple problems with each representing a single time scale. This presents a natural idea of using an augmented Lagrangian multiplier (ALM) method to design parallel algorithms, which can be embedded into the well-known progressive hedging (PH) algorithm, which itself is amenable for parallel computing. We will show convergence of the embedded algorithm for convex problems and present preliminary numerical results.

■ TD26

26- Forbes Room

Randomized Methods for Minimizing Finite Sums

Cluster: Stochastic Optimization

Invited Session

Chair: Alekh Agarwal, Microsoft Research, 641 Avenue of the Americas, New York, NY, 10011, United States of America, alekha@microsoft.com

1 - Advances in the Minimization of Finite Sums

Mark Schmidt, University of British Columbia, 201 2366 Main Mall, Vancouver, Canada, schmidtmarkw@gmail.com

We consider the problem of minimizing the sum of a finite set of smooth functions. Recently, several authors have proposed algorithms that achieve a linear convergence rate for this problem yet only examine a single randomly-chosen function on each iteration. We examine three recent advances in this vein. First, we show that an improved convergence rate can be achieved through the use of non-uniform selection of the function to update. Second, we show that far fewer gradient evaluations are required to obtain the convergence rate of current memory-free variants of these algorithms. Third, we discuss different strategies for accelerating the methods in order to improve the dependence on the condition number of the problem.

2 - A Lower Bound for the Optimization of Finite Sums

Leon Bottou, Research Scientist, T.B.D., T.B.D., New York, NY, 10003, United States of America, leon@bottou.org, Alekh Agarwal

This paper presents a lower bound for optimizing a finite sum of n functions, where each function is L-smooth and the sum is μ-strongly convex. We show that no algorithm can reach an error ϵ in minimizing all functions from this class in fewer than $\Omega(n + \sqrt{n(\kappa-1)}\log(1/\epsilon))$ iterations, where $\kappa=L/\mu$ is a surrogate condition number. We compare this lower bound to upper bounds for recently developed methods. We further compare all these bounds in a machine learning setup and conclude that a lot of caution is necessary for an accurate interpretation.

3 - Tradeoffs in Large Scale Learning: Statistical Accuracy vs. Numerical Precision

Sham Kakade, Principal Researcher, Microsoft Research, 1 Memorial Drive, Cambridge, MA, 02142, United States of America, skakade@microsoft.com

In many estimation problems, \eg linear and logistic regression, we wish to minimize an unknown objective given only unbiased samples. Disregarding computational constraints, the minimizer of a sample average — the empirical risk minimizer (ERM) or the M-estimator — is widely regarded as the estimation strategy of choice due to its desirable statistical convergence properties. Our goal is to perform as well as the ERM, on every problem, while minimizing the use of computational resources.

■ TD27

27- Duquesne Room

Markets and Congestion in Power Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Jeffrey Linderoth, 1513 University Ave, Madison, WI, 53706, United States of America, linderot@cae.wisc.edu

1 - Quantitative Analysis of Flexibility Services Regulation Frameworks for Distribution Systems

Sebastien Mathieu, Université de Liège, sebastien.mathieu@ulg.ac.be, Damien Ernst, Quentin Louveaux, Bertrand Cornélusse

We study the question of assessing the economic impact of interaction models governing the exchange of flexibility service within electrical distribution systems. We propose several interaction models that we evaluate using an agent-based method where each agent is assumed to maximize their profit through an optimization program. The agents we consider are distribution and transmission system operators, producers and retailers. A comparison over one year highlights the advantages and weaknesses of each interaction model.

2 - Nonatomic Congestion Games in Electricity Markets with Flexible Consumption

Quentin Louveaux, Professor, Université de Liège, 10 Grande Traverse, Liège, 4000, Belgium, q.louveaux@ulg.ac.be, Sebastien Mathieu

The load flexibility allows retailers to game to decrease their energy procurement cost on spot markets like the day-ahead energy market. The talk shows how this demand allocation game can be mapped to a nonatomic congestion game and the implications on the Nash equilibrium. We discuss the price of anarchy as well as the ratio between the prices at different periods in the case of linear offer curves. The bounds are dependent on the number of retailers. Finally we provide a method to compute the price at which the flexibility of the demand side should be remunerated if a retailer is requested to deviate from its Nash equilibrium. This method depends only on data of the spot market that could be made publicly available.

3 - Power Flow Models with Computationally Tractable Joint Chance Constraints

Eric Anderson, University of Wisconsin-Madison, 4430 Rolla Ln., Madison, WI, 53711, United States of America, eanderson4@wisc.edu, James Luedtke, Jeff Linderoth

The current line threshold model for transmission elements places the economics and reliability of single lines above that of system. A system risk measure needs to be developed and constrained so there is a proper trade off between the cost and risk of a given dispatch point. We develop a line risk measure and then constrain system risk. We solve this exactly via nonlinear programming in a static demand scenario and approximately in a demand scenario with a multivariate gaussian distribution. A computational example will be used to discuss the cost-risk frontier.

■ TD28

28- Liberty Room

Global Optimization with Complementarity Constraints

Cluster: Global Optimization

Invited Session

Chair: Joaquim JudiceRetired, Professor, Instituto Telecomunicacoes, Polo 2, Universidade de Coimbra, Coimbra, Portugal, judice@co.it.pt

1 - A Convex Reformulation of Rank-Constrained Optimization Problems

John Mitchell, Professor, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY, 12180, United States of America, mitchj@rpi.edu, Jong Shi Pang, Lijie Bai

Low rank approximations are desirable in many settings. We show that the problem of minimizing a linear or convex quadratic objective function of a matrix subject to linear constraints and an upper bound on the rank is equivalent to a convex conic optimization problem. The reformulation first represents the problem as a semidefinite program with conic complementarity constraints and then lifts the problem to give an equivalent convex conic optimization problem.

2 - A Reformulation of Cardinality Constraints Using a Complementarity-Type Condition

Alexandra Schwartz, TU Darmstadt, Dolivostrafle 15, Darmstadt, Germany, schwartz@gsc.tu-darmstadt.de, Michal Cervinka, Christian Kanzow, Oleg Burdakov

Programs with cardinality constraints are constrained optimization problems, where only a given number of the variables is allowed to be nonzero. We consider a reformulation of the cardinality constraint using binary variables, whose relaxation leads to a mathematical program in continuous variables with a complementarity-type constraint. We discuss the relation between the local and global solutions of the original and the relaxed problem. Additionally, we analyze the theoretical properties of the relaxed problem, which differ from those known for general mathematical programs with complementarity constraints. Finally, we suggest a regularization method for the solution of the relaxed problem and present some numerical results.

3 - Second-Order Cone Quadratic Eigenvalue Complementarity Problem

Joaquim Judice, Retired Professor, Instituto Telecomunicacoes, Polo 2, Universidade de Coimbra, Coimbra, Portugal, judice@co.it.pt, Alfredo Iusem, Hanif Sherali, Valentina Sessa

The Quadratic Eigenvalue Complementarity Problem on the Second-Order Cone (SOCQEiCP) has a solution under reasonable assumptions on the matrices included in its definition. A Nonlinear Programming Problem (NLP) formulation of SOCQEiCP is introduced such that a solution of SOCQEiCP is a global optimal minimum of NLP with a zero optimal value. An enumerative method based on RLT is proposed for solving NLP and its performance is enhanced by combining it with a semi-smooth Newton method.

■ TD29

29- Commonwealth 1

Recent Advances in ADMM I

Cluster: Nonsmooth Optimization

Invited Session

Chair: Xiaoming Yuan, Hong Kong Baptist University, Kowloon Tong, HongKong, China, xmyuan@hkbu.edu.hk

1 - A Majorized ADMM with Indefinite Proximal Terms for Linearly Constrained Convex Optimization

Min Li, Prof., Southeast University, School of Economics and Management, Sipailou 2#, Nanjing, 210096, China, limin@seu.edu.cn, Defeng Sun, Kim-Chuan Toh

This talk presents a majorized alternating direction method of multipliers (ADMM) with indefinite proximal terms for solving linearly constrained 2-block convex composite optimization problems with each block in the objective being the sum of a non-smooth convex function and a smooth convex function. By choosing the indefinite proximal terms properly, we establish the global convergence and O(1/k) ergodic iteration-complexity of the proposed method. The computational benefit of using indefinite proximal terms within the ADMM framework instead of the current requirement of positive semidefinite ones is also demonstrated numerically. This opens up a new way to improve the practical performance of the ADMM and related methods.

2 - Rate of Convergence of some Alternating Direction Methods

Deren Han, Prof., Nanjing Normal University, Nanjing, China, Nanjing, 210023, China, handeren@njnu.edu.cn

In this talk, we consider the convergence rate of ADMM when applying to the convex optimization problems that the subdifferentials of the underlying functions are piecewise linear multifunctions, including LASSO, a well known regression model in statistics as a special case. We prove that due to its inherent polyhedral structure, a recent global error bound holds for this class of problems. Based on this error bound, we derive the linear rate of convergence for ADMM. We also consider the proximal based ADMM, and derive its linear convergence rate.

3 - Block-Wise Alternating Direction Method of Multipliers for Multiple-Block Convex Programming

Xiaoming Yuan, Hong Kong Baptist University, Kowloon Tong, HongKong, China, xmyuan@hkbu.edu.hk, Bingsheng He

It has been shown that the direct extension of the alternating direction method of multipliers (ADMM) to a multiple-block case where the objective function is the sum of more than two functions is not necessarily convergent. For the multiple-block case, a natural idea is to artificially group the objective functions and the corresponding variables as two groups and then apply the original ADMM directly – the block-wise ADMM is accordingly named because each of the resulting ADMM subproblems may involve more than one function in its objective. We discuss how to further decompose the block-wise ADMM's subproblems and obtain easier subproblems, while the convergence can still be ensured.

■ TD30

30- Commonwealth 2

Approximation and Online Algorithms VII

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Howard Karloff, 310 West 85th St., New York, NY, 10024, United States of America, howard@cc.gatech.edu

1 - Simple Approximation Algorithms for MAX SAT

Matthias Poloczek, Cornell University, 272 Rhodes Hall, 136 Hoy Road, Ithaca, NY, 14853, United States of America, poloczek@cornell.edu, David Williamson, Anke van Zuylen, Georg Schnitger

We present simple linear-time algorithms that obtain 3/4-approximations for the maximum satisfiability problem (MAX SAT). In particular, their performance guarantees are comparable to Yannakakis' algorithm based on flows and LP (1994) or the LP-rounding algorithm of Goemans and Williamson (1994). Our first algorithm considers the variables in an arbitrary ordering and makes a random decision for each variable instantly and irrevocably. Secondly, we present a deterministic algorithm that performs two passes over the input. An interesting aspect is that this additional run over the input allows us to bypass an inapproximability result for deterministic greedy algorithms of Poloczek (2011).

2 - Entropy, Optimization and Counting

Nisheeth Vishnoi, EPFL IC IIF THL3, INJ 130 - Station 14, Lausanne, 1025, Switzerland, nisheeth.vishnoi@epfl.ch, Mohit Singh

We study the problem of computing max-entropy distributions over a discrete set of objects subject to observed marginals. While there has been a tremendous interest in such distributions in numerous areas, a rigorous study of how to compute such distributions has been lacking. We start by giving a structural result which shows that such succinct descriptions exist under very general conditions despite the fact the underlying set can be exponential. Subsequently, we give a meta-algorithm that can efficiently (approx.) compute max-entropy distributions provided one can efficiently (approx.) count the underlying discrete set. Conversely, we show how algorithms that compute max-entropy distributions can be converted into counting algorithms.

3 - Variable Selection is Hard

Howard Karloff, 310 West 85th St., New York, NY, 10024, United States of America, howard@cc.gatech.edu, Dean Foster, Justin Thaler

Consider the task of a machine-learning system faced with voluminous data on m individuals. How can the algorithm find a small set of features that best describes the individuals? We study the simple case of linear regression, in which a user has a matrix B and a vector y, and seeks a vector x, with as few nonzeroes as possible, such that Bx is approximately equal to y, and we call it SPARSE REGRESSION. We give a general hardness proof that (subject to a complexity assumption) no polynomial-time algorithm can give good performance (in the worst case) for SPARSE REGRESSION, even if it is allowed to include more variables than necessary, and even if it need only find an x such that Bx is relatively far from y.

Tuesday, 4:35pm - 5:25pm

■ TE01

01- Grand 1

A Gentle, Geometric Introduction to Copositive Optimization

Cluster: Plenary

Invited Session

Chair: Fatma Kilinc-Karzan, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, fkilinc@andrew.cmu.edu

1 - A Gentle, Geometric Introduction to Copositive Optimization

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

This talk illustrates the fundamental connection between nonconvex quadratic optimization and copositive optimization—-a connection that allows the reformulation of nonconvex quadratic problems as convex ones in a unified way. We focus on examples having just a few variables or a few constraints for which the quadratic problem can be formulated as a copositive-style problem, which itself can be recast in terms of linear, second-order-cone, and semidefinite optimization. A particular highlight is the role played by the geometry of the feasible set.