■ TE02

02- Grand 2

Fast Distributed Algorithms for Multi-Agent Optimization

Cluster: Plenary
Invited Session

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

1 - Fast Distributed Algorithms for Multi-Agent Optimization

Asu Özdaglar, Professor, Massachusetts Institute of Technology, 77 Massachusetts Avenue, 32-D630, Cambridge, MA, 02139, United States of America, asuman@mit.edu

Motivated by todayís data processing needs over large networks with local collection and processing of information, we consider a multi agent optimization problem where a network of agents collectively solves a global optimization problem with the objective function given by the sum of locally known convex functions. We present new distributed algorithms drawing on two different approaches: The first is based on Alternating Direction Method of Multipliers (ADMM), which is a classical method for sequentially decomposing optimization problems with coupled constraints. We show that convergence rate of distributed ADMM-based algorithms is O(1/k) (where k is the iteration number), which is faster than the O(1/sqrt(k)) rate of subgradient-based methods, and highlight the dependence on the network structure. The second approach develops an incremental Newton (IN) method, which accesses problem data sequentially. Under strong convexity of local objective functions, a gradient growth condition, and with proper stepsize rules, we show that convergence rate of the IN method is linear.

Wednesday, 9:00am - 9:50am

■ WA01

01- Grand 1

Coordinate Descent Algorithms

Cluster: Plenary
Invited Session

Chair: Jorge Nocedal, Northwestern University, Room M326, Technological Institute, 2145 Sheridan Road, Evanston, IL, United States of America, j-nocedal@northwestern.edu

1 - Coordinate Descent Algorithms

Stephen Wright, University of Wisconsin-Madison, University of Wisconsin-Madison, Madison, WI, United States of America, swright@cs.wisc.edu

Coordinate descent algorithms solve optimization problems by successively searching along coordinate directions or coordinate hyperplanes. They have been used in applications for many years, and their popularity continues to grow because of their usefulness in data analysis, machine learning, and other areas of current interest. This talk will describe the fundamentals of the coordinate descent approach, together with its variants and extensions. Convergence properties will be described, mostly with reference to convex objectives. We pay particular attention to a certain problem structure that arises commonly in machine learning applications, showing that efficient implementations of accelerated coordinate descent algorithms are possible for such structures. We also describe parallel variants and discuss their convergence properties under several models of parallel execution.

Wednesday, 10:20am - 11:50am

■ WB01

01- Grand 1

Recent Advances in Optimization Software

Cluster: Implementations and Software
Invited Session

Chair: Hans Mittelmann, Professor, Arizona State University, Box 871804, Tempe, Az, 85287-1804, United States of America, mittelma@asu.edu

1 - The State-of-the-Art in Optimization Software

Hans Mittelmann, Professor, Arizona State University, Box 871804, Tempe, Az, 85287-1804, United States of America, mittelma@asu.edu

Based on our ongoing benchmarking effort the current capabilities of selected open source and commercial optimization software will be highlighted.

2 - Reoptimization Techniques in MIP Solvers

Jakob Witzig, Zuse-Institute-Berlin, Takustr. 7, Berlin, 14195, Germany, witzig@zib.de

Recently, there have been many successful applications of optimization algorithms that solve a sequence of quite similar mixed-integer programs (MIPs) as subproblems. Traditionally, each problem in the sequence is solved from scratch. In this talk we consider reoptimization techniques that try to benefit from information obtained by solving previous problems of the sequence. We focus on the case that subsequent MIPs differ only in the objective function or that the feasible region is reduced. We propose extensions of the very complex branch-and-bound algorithms employed by general MIP solvers based on the idea to ``warmstart" using the final search frontier of the preceding solver run.

3 - On Recent Improvements in the Interior-Point Optimizer in MOSEK

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

In this talk we will discuss the recent advances in the interior-point optimizer in the upcoming version 8 release of MOSEK. The advances include: (1) an improved pre-solver; (2) a more stable semi-definite optimization solve; (3) an automatic dualizer for conic quadratic optimization problems; (4) the possibility to reformulate automatically QPs and QCQPs in conic form. We will present computational tests to benchmark the new implementation against the previous one.

■ WB02

02- Grand 2

Nonlinear Optimization for Power Systems

Cluster: Optimization in Energy Systems
Invited Session

Chair: Javad Lavaei, Assistant Professor, Columbia University, New York, New York, United States of America, lavaei@ee.columbia.edu

1 - Convexification of Optimal Power Flow Problem

Ramtin Madani, PhD Candidate, Columbia University, 3333 Broadway, Apt D12J, New York, 10031, United States of America, madani@ee.columbia.edu, Morteza Ashraphijuo, Abdulrahman Kalbat, Javad Lavaei

The flows in an electrical grid are described by nonlinear AC power flow equations. This talk is concerned with finding a convex formulation of the power flow equations using semidefinite programming (SDP). Addressing this problem facilitates performing several fundamental, yet challenging tasks such as economical dispatch and state estimation for power networks. Based on the sparsity of the network structure, a parallel algorithm for large-scale SDP problems will also be proposed.

2 - Alternating Direction Method of Multipliers for Sparse Semidefinite Programs

Abdulrahman Kalbat, Columbia University, 808 Schapiro CEPSR, 530 west 120th st, New York, NY, 10027, United States of America, ak3369@columbia.edu, Javad Lavaei

A parallel algorithm for solving an arbitrary sparse semidefinite program (SDP) is developed based on the alternating direction method of multipliers. The proposed algorithm has a guaranteed convergence under very mild assumptions. Each iteration of this algorithm has a simple closed-form solution, and consists of matrix multiplication and eigenvalue decomposition over matrices whose sizes are not greater than the treewdith of the sparsity graph of the SDP problem. The cheap iterations of the proposed algorithm enable solving real-world large-scale conic optimization problems.

3 - A Spatial Branch-and-Bound Method for ACOPF

Chen Chen, Graduate Student, UC Berkeley, 450 Sutardja Dai Hall #61, Berkeley, CA, 94730-1764, United States of America, chenchen@berkeley.edu, Alper Atamturk, Shmuel Oren

We study the Alternating Optimal Power Flow (ACOPF) problem, which is an electric generation dispatch problem. ACOPF can be formulated as a nonconvex Quadratically Constrained Quadratic Program with bounded complex variables. We propose a spatial branch-and-bound approach to solving the formulation. We introduce valid inequalities to strengthen the standard semidefinite programming relaxation, enabling branching on complex entries of the decision matrix. We also propose new branching rules and develop closed-form bound tightening procedures specific to ACOPF. Various algorithmic configurations are tested computationally on instances from the literature with small root gaps as well as more difficult new instances based on IEEE test cases.

2 - Alternating Direction Method of Multipliers for Sparse Semidefinite Programs

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■ WB03

03- Grand 3

Handling Infeasibility, Sparsity, and Symmetry in Combinatorial Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Marc Pfetsch, Prof., TU Darmstadt, Department of Mathematics, Dolivostr. 15, Darmstadt, 64293, Germany, pfetsch@mathematik.tu-darmstadt.de

1 - Analyzing Infeasibility in Flow Networks

Imke Joormann, TU Darmstadt, Department of Mathematic, Dolivostrasse 15, Darmstadt, D-64293, Germany, joormann@mathematik.tu-darmstadt.de, Marc Pfetsch

We study means to repair infeasibility in network flow problems with supplies and demands. After examining some characteristics, the boundary of the hardness is analyzed: We show non-approximability and hardness of different approaches, give polynomially solvable special cases and derive approximation and Fixed Parameter algorithms.

2 - Branch & Cut Methods for Exact Sparse Recovery

Andreas Tillmann, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, tillmann@mathematik.tu-darmstadt.de, Marc Pfetsch

While there are many heuristics for sparse recovery (the NP-hard task of finding the sparsest exact or approximate solution to an underdetermined linear equation system), guaranteeing or verifying their success is often NP-hard itself. This motivates tackling the sparse recovery problem directly, e.g., with methods from combinatorial optimization. We discuss Branch & Cut schemes for this purpose, based on set-cover-based binary program reformulations, and report new findings, connections to other interesting problems, and numerical results.

3 - Polyhedral Symmetry Handling via Fundamental Domains

Christopher Hojny, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, hojny@mathematik.tu-darmstadt.de, Marc Pfetsch

Symmetry in discrete optimization problems is known to have a negative influence on the performance of branch-and-bound procedures. In this talk, we extend a polyhedral approach to reduce the impact of symmetry. This work is based on Friedman's investigations on fundamental domains for integer programs. We develop a generalization to symmetry breaking polytopes and study the symmetry group's impact on the structure of symmetry breaking polytopes.

■ WB04

04- Grand 4

Advances and Applications in Conic Optimization Part II

Cluster: Conic Programming

Invited Session

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

1 - Nonlinear Doubly Nonnegative Cone Problems: Strict Complementarity and Optimality Conditions

Bolor Jargalsaikhan, University of Groningen, Hiddemaheerd 127, Groningen, 9737JZ, Netherlands, b.jargalsaikhan@rug.nl, Jan Rückmann

Doubly nonnegative cone (DNN) is intersection of positive semidefinite cone and nonnegative cone. Optimality conditions for nonlinear positive semidefinite programs has been studied. Unlike positive semidefinite case, DNN is not self-dual and its dual cone is not facially exposed. We study optimality conditions for nonlinear DNN problems. In particular, we investigate strict complementarity condition specialized to DNN cone and its application on second order necessary optimality conditions for nonlinear DNN problems.

2 - Improved LP-based Algorithms for Testing Copositivity and Other Properties

Akihiro Tanaka, University of Tsukuba, tanaka.akihiro@sk.tsukuba.ac.jp, Akiko Yoshise

Tanaka and Yoshise (2015) introduced some subcones of the copositive cone and showed that one can detect whether a given matrix belongs to one of those cones by solving linear optimization problems. They also provided an LP-based algorithm for testing copositivity using the subcones. In this talk, we investigate the properties of the subcones more precisely and propose improved algorithms for testing these properties and copositivity.

3 - Application of Inner-Iteration Krylov Subspace Methods to Interior-Point Methods for Linear Programs

Yiran Cui, Department of Computer Science, University College London, Gower Street, London, WC1E 6BT, United Kingdom, y.cui.12@ucl.ac.uk, Keiichi Morikuni, Takashi Tsuchiya, Ken Hayami

We present an implementation of the interior-point algorithm for linear programming based on the Krylov subspace methods for least squares problems. We employ an inner-iteration preconditioner recently developed by the authors to deal with severe ill-conditioning of linear equations in the final stage of iterations. The advantage of our method is that it does not break down even when previous direct methods do. Also, we save computation time and storage compared to previous explicit preconditioners.

■ WB05

05- Kings Garden 1

Recent Advances in Computational Optimization I

Cluster: Nonlinear Programming

Invited Session

Chair: William Hager, Professor, University of Florida, Department of Mathematics, Gainesville, FL, 32611, United States of America, hager@ufl.edu

Co-Chair: Gerardo Toraldo, Professor, University of Naples Federico II, Department of Mathematics and Applications, Via Cintia, Monte S. Angelo, Naples, I-80126, Italy, toraldo@unina.it

1 - On Steplength Rules in Gradient Methods

Gerardo Toraldo, Professor, University of Naples Federico II, Department of Mathematics and Applications, Via Cintia, Monte S. Angelo, Naples, I-80126, Italy, toraldo@unina.it, Salvatore Amaradio, Daniela di Serafino, Valeria Ruggiero, Luca Zanni

In the last 25 years the interest in gradient methods has been renewed after the publication of the work by Barzilai and Borwein. Since then, several strategies have been proposed for choosing the steplength, opening the way to novel first-order methods for continuous nonlinear optimization. These methods have become a valid and useful tool for large-scale problems, e.g. in machine learning and data mining. In this talk we consider some steplength rules and present their spectral properties, which provide insight into the computational effectiveness and regularization properties of the resulting gradient methods. Computational experiments supporting the theoretical analysis are provided.

2 - An Inexact Alternating Direction Algorithm for Separable Convex Optimization

Hongchao Zhang, Professor, Louisiana State University, Baton Rouge, LA, United States of America, hozhang@math.lsu.edu, William Hager, Maryam Yashtini

We will introduce an inexact alternating direction algorithm with variable stepsize for solving separable convex optimization. This algorithm generalizes the Bregman operator splitting algorithm with variable stepsiz (BOSVS) and allows to solve the convex subproblems to an adaptive accuracy. Global convergence and some preliminary numerical results will be discussed in this talk.

3 - On Acceleration Schemes and the Choice of Subproblem's Constraints in Augmented Lagrangian Methods

Ernesto G. Birgin, Professor, University of São Paulo, Department of Computer Science, São Paulo, SP, 05508-090, Brazil, egbirgin@ime.usp.br, Luis Felipe Bueno, José Mario Marttínez

Algencan is an Augmented Lagrangian (AL) method that solves a sequence of bound-constrained subproblems. With the aim of improving the practical performance of Algencan, an acceleration scheme, that tries to solve a KKT system by Newton's method in-between the AL iterations, was developed. For problems with only equality constraints, the acceleration scheme by itself presented an outstanding performance when compared against state-of-the-art NLP solvers and considering all equality-constrained problems from the CUTEst collection. This state of facts suggests that an AL method with equality-constrained subproblems may be developed.

■ WB06

06- Kings Garden 2

Combinatorial Optimization in Social Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Baski Balasundaram, Associate Professor, Oklahoma State University, 322 Engineering North, Stillwater, OK, 74078, United States of America, baski@okstate.edu

1 - Weighted Target Set Selection

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

The Target Set Selection (TSS) problem is a fundamental problem about the diffusion of influence in social networks. In our work, we consider the weighted version of it (the WTSS problem). The weights model the fact the cost to activate different nodes can vary. The TSS problem is known to be NP-hard, and earlier work has focused on approximation. Motivated by the desire to develop mathematical programming approaches to solve the WTSS problem, we focus on developing a strong formulation for the WTSS problem. We present a tight and compact extended formulation for the WTSS problem on trees. Furthermore, based on this strong formulation, a branch and cut approach is proposed for general networks. Computational results will be presented.

2 - On Imposing Connectivity Constraints in Integer Programs

Austin Buchanan, Texas A&M University, TAMU-3131, College Station, United States of America, buchanan@tamu.edu, Yiming Wang, Sergiy Butenko

In many clustering and network analysis applications, one searches for a connected subset of vertices that exhibits other desirable properties. To this end, this paper studies the connected subgraph polytope of a graph, which is the convex hull of subsets of vertices that induce a connected subgraph. We determine precisely when vertex separator inequalities induce facets and when they induce all nontrivial facets. These vertex separator inequalities are of particular interest because they have been successfully used to enforce connectivity in application. We also study the complexity of lifting, and provide closed-form descriptions of the connected subgraph polytopes of stars and paths.

3 - On the 2-club Polytope of Graphs

Baski Balasundaram, Associate Professor, Oklahoma State University, 322 Engineering North, Stillwater, OK, 74078, United States of America, baski@okstate.edu, Illya Hicks, Foad Mahdavi Pajouh

A k-club is a subset of vertices in a graph that induce a subgraph of diameter at most k, where k is a positive integer. The k-club model for k>=2 is interesting to study from a polyhedral perspective as the property is not hereditary on induced subgraphs. This article introduces a new family of facet defining inequalities for the 2-club polytope. The complexity of separation over this new family of inequalities is shown to be NP-hard. An exact formulation of this separation problem and a greedy separation heuristic are also proposed. The effectiveness of these new facets as cutting planes, and the difficulty of solving the separation problem are then investigated via computational experiments on a test-bed of benchmark instances.

■ WB07

07- Kings Garden 3

Advances in Integer Programming IV

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Alper Atamturk, UC Berkeley, Sutardja Dai Hall, Berkeley, CA, United States of America, atamturk@berkeley.edu

1 - k-Dimensional Lattice Closure

Oktay Gunluk, IBM Research, 1101 Kitchawan Road, Yorktown Heights, NY, United States of America, gunluk@us.ibm.com, Diego Moran, Sanjeeb Dash

We define the k-dimensional lattice closure of a polyhedral set to be the intersection of the convex hulls of all possible relaxations of the set with k integer variables. More precisely, given a mixed integer set with integer variables x, a relaxation of this form is obtained by (i) choosing up to k integer vectors c_1, ...,c_k, (ii) requiring dot products < c_1,x >,...,< c_k,x > to be integral, and (iii) dropping the integrality requirement on x. The k-dimensional lattice closure is equal to the split closure when k=1 and equals the crooked cross cut closure when k=2. The k-dimensional lattice closure of a (rational) polyhedral mixed integer set is known to be polyhedral when k=1, and we extend this result to larger values of k.

2 - Second-order Cone Presolving Techniques in Mixed-integer Optimization

Henrik Alsing Friberg, Industrial PhD Student, MOSEK ApS, Fruebjergvej 3, Copenhagen O, 2100, Denmark, henrik.alsing.friberg@mosek.com, Alper Atamturk

Inspired by Savelsbergh (1994), we extend basic analysis and probing techniques to mixed-integer second-order cone optimization. We show how the coefficients of a second-order cone constraint can be tightened, and how simple forms of facial reduction can be detected efficiently.

3 - Two Classes of Valid Inequalities for the DC Optimal Transmission Switching Problem

Burak Kocuk, Georgia Tech, 765 Ferst Drive, NW, Atlanta, GA, 30318, United States of America, burak.kocuk@gatech.edu, Santanu Dey, Andy Sun

As the modern transmission control and relay technologies evolve, transmission line switching has become an important option in power system operators' toolkits. Much research has focused on developing heuristic algorithms while the mathematical theory of the underlying optimization problem has not been well studied. In this work, we propose two classes of valid inequalities. The first class is based on a cycle-induced relaxation where we characterize the convex hull and use it to generate valid inequalities. The second class is based on Wheatstone Bridges, the key elements in congestion analysis. We show that separation can be done in polynomial time for both classes. Extensive computational experiments show promising results.

■ WB08

08- Kings Garden 4

Scheduling

Cluster: Combinatorial Optimization

Invited Session

Chair: Andreas Wiese, MPI for Informatics, Campus E 1.4, Saarbruecken, 66123, Germany, awiese@mpi-inf.mpg.de

1 - A Fully Polynomial-Time Approximation Scheme for Speed Scaling with Sleep State

Antonios Antoniadis, MPI for Informatics, Germany, aantonia@mpi-inf.mpg.de, Chien-Chung Huang, Sebastian Ott

In this talk, we consider classical deadline-based preemptive scheduling of jobs in a computing environment equipped with both dynamic speed scaling and sleep state capabilities: Each job is specified by a release time, a deadline and a processing volume, and has to be scheduled on a single, speed-scalable processor that is supplied with a sleep state. The goal is to output a feasible schedule that minimizes the energy consumption. The currently best known upper and lower bounds are a 4/3-approximation algorithm and NP-hardness. We describe how to close the aforementioned gap between the upper and lower bound on the computational complexity of the problem by presenting a fully polynomial-time approximation scheme for it.

2 - Deadline Scheduling of Conditional DAG Tasks

Vincenzo Bonifaci, Researcher, Consiglio Nazionale delle Ricerche, Via dei Taurini 19, Rome, RM, 00185, Italy, vincenzo.bonifaci@iasi.cnr.it, Sanjoy Baruah, Alberto Marchetti-Spaccamela

Directed acyclic graphs (DAGs) are a standard model for representing concurrent tasks. The nodes of the DAG correspond to sequential portions of the task, and the arcs of the DAG encode precedence constraints. We propose and evaluate an extension of this model to allow conditional execution of task portions, as well as intra-task concurrency. The Global Earliest Deadline First (GEDF) scheduling of systems represented in this generalized model is studied, and a polynomial time GEDF-schedulability test with constant speedup bound is derived. With regards to GEDF scheduling it is shown that there is no penalty, in terms of worse speedup factor, in generalizing the non-conditional DAG task model in this manner.

3 - An O(m2og m)-Competitive Algorithm for Online Machine Minimization

Kevin Schewior, TU Berlin, Sekretariat MA 5-1, Strafle des 17. Juni 136, Berlin, 10623, Germany, schewior@math.tu-berlin.de, Nicole Megow, Lin Chen

We consider preemptively scheduling jobs with deadlines that arrive online over time. The task is to determine a feasible schedule on a minimum number of machines. We present a general O(m≤log m)-competitive algorithm, where m is the optimal number of machines in an offline solution. This is the first algorithm whose guarantee depends solely on m. The existence of such an algorithm was open since the seminal work by Phillips et al. (STOC 1997). To develop the algorithm, we investigate two complementary special cases of the problem depending on the nesting structure of the processing intervals, namely, laminar and agreeable instances. For them, we provide an O(log m)-competitive and an O(1)-competitive algorithm, respectively.

■ WB09

09- Kings Garden 5

Robust Optimization Methodology

Cluster: Robust Optimization

Invited Session

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

1 - A Study of Risk-Averse Two-Stage Stochastic Program with Distribution Ambiguity

Yongpei Guan, Associate Professor, University of Florida, Weil Hall 303, Gainesville, FL, 32611, United States of America, guan@ise.ufl.edu, Chaoyue Zhao

In this research, we investigate the data-driven risk-averse two-stage stochastic program with a new class of probability metrics. We reformulate the problem as a traditional two-stage robust optimization problem for the discrete distribution case and develop a sampling approach for the continuous distribution case. For both cases, we prove that the risk-averse two-stage stochastic problem converges to its risk-neutral counterpart at an exponential rate.

2 - Multistage Robust Mixed Integer Optimization with Adaptive Partitions

Iain Dunning, PhD Candidate, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-149, Cambridge, MA, 02139, United States of America, idunning@mit.edu, Dimitris Bertsimas

We present a new method for multistage adaptive mixed integer optimization (AMIO) problems that extends previous work on finite adaptability. The approach analyzes the optimal solution to a non-adaptive version of an AMIO problem and uses this information to construct partitions in the uncertainty set. We repeat this process iteratively to further improve the objective. We provide theoretical motivation for this method, and detail how to apply it to multistage AMIO problems to respect the natural non-anticipativity constraints. We provide lower and upper bounds on the solution quality, and demonstrate in computational experiments that the method can provide substantial improvements over a non-adaptive solution and existing methods.

3 - Distributionally Robust Counterpart over Ambiguity Sets with Semi-infinite Expectation Constraints

Zhi Chen, Department of Decision Sciences, PhD B1-02 Biz2 Building, NUS Business School, Singapore, 117592, Singapore, chenzhi@u.nus.edu, Melvyn Sim, Huan Xu

We investigate semi-infinite ambiguity sets that involve expectation constraints besides generalized moments and support information. We study the associated intractable distributionally robust counterpart by considering approximate ambiguity sets with finite expectation constraints. Based on worst-case distribution, we demonstrate an algorithm that improves the approximation gradually. We present expressive examples of this class of ambiguity sets, and show examples where authenticity of the worst-case distribution is relatively easy to verify so that the algorithm is efficient.

■ WB10

10- Kings Terrace

New Twists in Risk Minimization Modeling

Cluster: Finance and Economics

Invited Session

Chair: Jun-ya Gotoh, Professor, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, jgoto@indsys.chuo-u.ac.jp

1 - Buffered Probability of Exceedance: Properties and Applications in Finance

Stan Uryasev, University of Florida, Gainesville, FL, 32611, United States of America, uryasev@ufl.edu, Alexander Mafusalov, Matthew Norton

This paper investigates a new probabilistic characteristic called buffered probability of exceedance (bPOE). bPOE counts tail outcomes averaging to some specific threshold value. Minimization of bPOE can be reduced to convex and Linear Programming. We will discuss two applications of bPOE concept. The first application considers the Cash Matching of a Bond Portfolio. We minimize bPOE that assets exceed liabilities. The second application uses bPOE in data mining. AUC characteristic standardly used to evaluate classification models. We explored so called Buffered AUC (bAUC) as a counterpart of the standard AUC.

2 - Two Perspectives on Robust Empirical Optimization

Jun-ya Gotoh, Professor, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, jgoto@indsys.chuo-u.ac.jp, Michael Jong Kim, Andrew E. B. Lim

In this talk, we consider a robust formulation for empirical optimization. Our main finding is that robust empirical optimization is essentially equivalent to two different problems with seemingly different concerns - an empirical mean-variance problem and the problem of maximizing a (probabilistic) lower bound on out-of-sample performance. The connection to the empirical mean-variance problem is shown using a simple Taylor expansion, and the connection to optimizing a lower bound on the out-of-sample performance is shown using an empirical version of Bennett's inequality.

3 - Optimizing Over Coherent Risk Measures for Binary Classification

Akiko Takeda, Associate Professor, The University of Tokyo, Department of Mathematical Informatics, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan, takeda@mist.i.u-tokyo.ac.jp, Dimitris Bertsimas

Binary classification models are often formulated as minimization of loss functions (measures of misclassification) under a norm constraint. Recent several works relate loss functions to financial risk measures. We propose binary classification models minimizing coherent risk measures by robust optimization formulation. Setting a new uncertainty set leads to a new binary classification model. The numerical experiments imply that coherent risk measure minimization performs better than the non-coherent variant for classification.

■ WB11

11- Brigade

Assignment Type Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Joris Van de Klundert, Professor, Erasmus University Rotterdam, Burg Oudlaan 50, M5-29, Rotterdam, 3000 DR, Netherlands, vandeklundert@bmg.eur.nl

1 - Revisiting the Branch & Cut Method for the Axial and Planar Assignment Problem

Stathis Plitsos, PhD Candidate, Athens University of Economics and Business, 47A Evelpidon Str. & 33 Lefkados Str., Athens, 113 62, Greece, stathisp@aueb.gr, Dimitrios Magos, Ioannis Mourtos

We revisit the Branch & Cut approach for the axial and planar assignment problems, after adopting a unifying approach and deploying problem-specific cuts, branching rules and tabu-search, plus a generic feasibility-pump variant that integrates constraint propagation and cuts during the pumping cycles (i.e., cuts facilitate both lower and upper bound improvement). Experimentation on large-scale instances shows that our approach reduces the time to optimality and solves memory-wise intractable instances compared to a commercial solver.

2 - Hypergraph Assignments

Ralf Borndoerfer, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, borndoerfer@zib.de, Olga Heismann

The hypergraph assignment problem generalizes the assignment problem from bipartite graphs to what we call bipartite hypergraphs; it is motivated by applications in railway vehicle rotation planning. The problem is NP-hard even for hyperedge size two, but can be solved in polynomial time for certain cost functions. Its polyhedral structure includes a class of generalized odd set inequalities that are also valid for the set packing problem. The expected cost of a random hyperassignment that uses half of the possible hyperedges in a complete partitioned hypergraph with hyperedge size two and i.i.d. exponential random variables with mean 1 as hyperedge costs lies between 0.3718 and 1.8310.

3 - The Adaptive Operating Room Schedule with Overtime Cost: An Application of Knapsack Problem

Joris Van de Klundert, Professor, Erasmus University Rotterdam, burg oudlaan 50, M5-29, rotterdam, 3000 DR, Netherlands, vandeklundert@bmg.eur.nl, Guanlian Xiao, Willem Van Jaarsveld

In practice, the complexity of operating room scheduling importantly stems from its stochastic nature, which often leads to dynamic adjustments. Scientific literature on such adaptive scheduling approaches is scarce. We formally define practically relevant adaptive scheduling problems and corresponding adaptive policies, introducing the concept of committing. The core of the adaptive policies is formed by a pseudopolynomial algorithm to solve a general class of static stochastic operating room scheduling problems. We present extensive computational analysis, based on data from the largest academic medical center in The Netherlands, and show that the benefits over static ones are significant.

■ WB12

12- Black Diamond

Integer Programming Applications in Transportation and Logistics

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Martine Labbé, Professor, Université Libre de Bruxelles, Bd. du Triomphe, CP 212, Brussels, 1050, Belgium, mlabbe@ulb.ac.be

1 - A Computationally-Tractable Stochastic Integer Program for the Single Airport Ground Holding Problem

Alex Estes, University of Maryland-College Park, 4423 Math Building, University of Maryland, College Park, MD, 20740, United States of America, asestes1@gmail.com, Michael Ball

We present a multistage stochastic integer programming model to address the problem of assigning delays to flights when demand at an airport exceeds capacity. Our model extends an integer program which solves the static single airport ground holding problem, so that our model considers some dynamic aspects of the problem which are not included in the static model. We provide conditions which guarantee that the SIP has an integral extreme point and we provide computational results which demonstrate the value of our model over the static model, as well as the computational tractability of our model.

2 - Efficient use of Airspace through Monetary Incentives

Étienne Marcotte, Postdoctoral Researcher, Université Libre de Bruxelles, Boulevard du Triomphe, CP 212, Brussels, 1050, Belgium, emarcott@ulb.ac.be, Martine Labbè

We consider the problem of alleviating congestion in the European airspace through the modulation of the service charges imposed by the Air Navigation Service Providers [ANSP] on the airspace users. This is a bilevel optimization problem which can be formulated using a mixed integer programming representation, which we present. A heuristic based on Variable Neighborhood Descent [VND] is introduced to obtain approximate solutions of this model on real-life instances, which are often too large to be solved using linear programming techniques.

■ WB13

13- Rivers

Formulations, Representations, and Applications in Conic Programming

Cluster: Conic Programming

Invited Session

Chair: Tomohiko Mizutani, Tokyo Institute of Technology, 2-12-1-W9-69, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan, mizutani.t.ab@m.titech.ac.jp

1 - Regularized Multidimensional Scaling with Radial Basis Functions

Sohana Jahan, University of Southampton, School of Mathematics, Southampton, United Kingdom, sj1g12@soton.ac.uk, Hou-Duo Qi

Multi-Dimensional Scaling(MDS) with Radial Basis Function(RBF) is very important method for dimension reduction. A key issue that has not been well addressed in MDS-RBF is effective selection of centers of RBF. We treat this selection problem as multi-task learning problem and employ (2,1)-norm to regularize the original MDS-RBF objective function. We propose its two reformulations: Diagonal and Spectral, which can be solved through iterative block-majorization method. Numerical experiments show improved performance of our models over the original.

2 - Convex Cone with Semidefinite Representable Sections

Anusuya Ghosh, Research Scholar, Indian Institute of Technology Bombay, D 170, Hostel 11, IIT Bombay, IE&OR Lab, Old CSE Building, IIT Bombay, Mumbai, MH, 400 076, India, ghosh.anusuya007@gmail.com, Vishnu Narayanan

We contribute sufficient conditions for semidefinite representability of convex cone considering its sections. The r-sections of convex cone are semidefinite representable (SDR) iff its intersection by (r+1)-flat are SDR. If a convex set K is SDR at a point p in it, then cone(p,K) is SDR. The intersection of convex sets X and Y is a neighbourhood of p relative to Y, if Y is SDR and Y is contained in cone(p,X).

3 - Spectral Clustering by Ellipsoid and its Connection to Separable Nonnegative Matrix Factorization

Tomohiko Mizutani, Tokyo Institute of Technology, 2-12-1-W9-69, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan, mizutani.t.ab@m.titech.ac.jp

We propose a variant of the normalized cut algorithm for spectral clustering. The algorithm shares similarity with the ellipsoidal rounding algorithm for separable nonnegative matrix factorization. The normalized cut algorithm has the issue that the choice of initial points affects the construction of clusters since K-means is incorporated in it, whereas the algorithm proposed here does not. We report experimental results to show the performance of the algorithm.

■ WB14

14- Traders

Privacy in Games

Cluster: Game Theory

Invited Session

Chair: Balasubramanian Sivan, Microsoft Research, One Microsoft Way, Redmond, WA, 98052-6399, United States of America, balu2901@gmail.com

1 - Privacy and Truthful Equilibrium Selection in Aggregative Games

Rachel Cummings, PhD Student, California Institute of Technology, 1200 E California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, rachelc@caltech.edu, Michael Kearns, Aaron Roth, Zhiwei Steven Wu

We study large multi-dimensional aggregative games, which generalize anonymous games and weighted congestion games, and we solve the equilibrium selection problem in a strong sense. We give an efficient weak mediator: a mechanism which has only the power to listen to reported types and provide non-binding suggested actions, such that (a) it is an asymptotic Nash equilibrium for every player to truthfully report their type to the mediator and follow its suggested action; and (b) when players do so, they end up coordinating on a particular asymptotic pure strategy Nash equilibrium of the induced complete information game. We achieve this by giving an efficient differentially private algorithm for computing a Nash equilibrium in such games.

2 - Private Convex Programming Yields Truthful Auctions

Aaron Roth, Assistant Professor, University of Pennsylvania, aaroth@cis.upenn.edu, Justin Hsu, Zhiyi Huang, Zhiwei Steven Wu

An electricity provider faces demand that might rise above its ability to generate power. Rather than resorting to brown-outs, the utility will shut off the air-conditioners of individual buildings remotely. Using this ability, they might be able to coordinate shut-offs so that nobody is ever uncomfortable, but so that peak electricity usage never rises above power production. This optimization introduces a privacy concern: the utility now makes decisions as a function of customers reported behavior. Is there a way to protect the privacy of consumers? Can we also elicit costs truthfully? We show that the answer is “yes” to this problem, and to a broad class of welfare maximization problems that can be posed as convex programs.

3 - Equilibrium Selection in Large Games via Private Mediators

Jonathan Ullman, Junior Fellow, Simons Society of Fellows, Columbia University, 450 Computer Science Bldg, 1214 Amsterdam Ave, New York, NY, 10027, United States of America, jullman@gmail.com

We study the problem of implementing equilibria of complete information games as ex-post Nash equilibria of incomplete information games, and address this problem using “mediators.” A mediator is a mechanism that does not have the power to enforce outcomes or to force participation; rather it only has the power to suggest outcomes on the basis of voluntary participation. We show that despite these restrictions mediators can implement equilibria of complete information games in settings of incomplete information assuming only that the game is large – there are a large number of players, and any player’s action affects any other player’s payoff by at most a small amount. Our result follows from a novel application of differential privacy.

■ WB15

15- Chartiers

Stationarity Conditions, Algorithms and Applications for PDE Constrained Optimization with Time Dependent Processes

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

Invited Session

Chair: Nikolai Strogies, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Berlin, Germany, strogies@math.hu-berlin.de

Co-Chair: Michael HintermüllerProf., Humboldt-Universitaet zu Berlin, Room 2.426 (House 2, 4th floor), Rudower Chaussee 25, Berlin, 12489, Germany, hint@math.hu-berlin.de

1 - Second-order Analysis for Optimal Control of the Schrödinger Equation

Axel Kroener, INRIA Saclay and CMAP, Ecole Polytechnique, Route de Saclay, 91128 Palaiseau Cedex, Palaiseau Cedex, France, axel.kroener@inria.fr, Maria Soledad Aronna, Frédéric Bonnans

In this talk we present second order necessary and sufficient optimality conditions for a bilinear optimal control problem governed by the Schrˆdinger equation with pointwise constraints on the control. The problem describes a quantum particle in a given potential subject to an electric field which represents the control. Second order necessary and sufficient optimality conditions are derived following ideas developed originally in the context of ordinary differential equations using the Goh transformation.

2 - A Priori Error Estimates for Nonstationary Optimal Control Problems with Gradient State Constraints

Francesco Ludovici, Universitaet Hamburg, Bundestrasse 55, Hamburg, Germany, francesco.ludovici@uni-hamburg.de, Ira Neitzel, Winnifried Wollner

In this talk we consider semilinear parabolic optimal control problems subject to inequality constraints on the gradient of the state variable. Our main focus will be on pointwise in time and averaged in space gradient state constraints. Making use of the discontinuous Galerkin method for the time discretization and of standard finite elements for the space discretization, we derive convergence rates as temporal and spatial mesh size tends to zero.

3 - Fast Solvers for Time-dependent PDE-constrained Optimization

John Pearson, EPSRC Fellow, University of Kent, Kent, United Kingdom, J.W.Pearson@kent.ac.uk

PDE-constrained optimization problems, especially those of time-dependent form, have numerous applications across mathematics and science more widely. In this talk we discuss the fast iterative solution of the huge-scale matrix systems that arise from finite element discretizations of these problems. Using the saddle point structure of the matrices involved, we are able to construct powerful preconditioners using effective approximations of the (1,1)-block and Schur complement. We consider a number of application areas, including the optimal control of fluid flow, pattern formation processes within mathematical biology, and models involving fractional differential equations.

■ WB16

16- Sterlings 1

Advances in Integer Programming V

Cluster: Integer and Mixed-Integer Programming

Invited Session

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

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

1 - The Impact of Linear Programming on the Performance of Branch-and-Cut based MIP Solvers

Matthias Miltenberger, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, miltenberger@zib.de, Thorsten Koch

A major part of the total running time of a branch-and-cut based MIP solver is spent solving LP relaxations. Therefore, one would expect the performance of the underlying LP solver to greatly influence the performance of the MIP solver. Surprisingly, this is often not the case. The solver framework SCIP allows to plug in various LP solvers, including SoPlex, XPRESS, CPLEX, and Gurobi. Using this setup we analyze the behavior and try to answer the question why the performance difference between the LP solvers does not necessarily translate to the MIP solver.

2 - Integer Programming by Projection

H. Paul Williams, Emeritus Professor of Operational Research, London School of Economics, Retired, Trencrom House, Cheriton Close, Winchester, Ha, SO22 5HN, United Kingdom, h.p.williams@lse.ac.uk, John Hooker

A method of solving (M)IPs by Projection is described. Projecting out variables from an IP results in a finite disjunction of polytopes.The resulting disjunction can be represented as the solution set of linear congruences in variables with bounded domains.Elimination of the integer variables can be accomplished by making use of the Generalised Chinese Remainder Theorem.The method leads to Branch-and-Bound and Cutting Plane procedures which are bounded by the number of variables in the model. The elimination procedure leads to a Value Function in which Shadow Prices are represented by Step Functions which are eventually Shift-Periodic. It also gives ‘average’ Shadow Prices.

3 - A New Algorithm for a Wide Class of Binary Bilevel Problems

Pierre-Louis Poirion, LIX, Ecole Polytechnique, Palaiseau, 91128, France, poirion@lix.polytechnique.fr, Sonia Toubaline, Claudia D’Ambrosio, Leo Liberti

We present a new algorithm to solve binary bilevel programs. At each step of the algorithm, we solve a binary linear slave program, check the feasibility for the master problem, and add a cut if the solution is not feasible. As an application, we show how this algorithm can be used to solve a binary bilevel model for real time control of medium voltage electrical networks.

■ WB17

17- Sterlings 2

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: Marina Andretta, University of São Paulo, Av. Trabalhador São-carlense, 400, São Carlos, SP, 13566590, Brazil, andretta@icmc.usp.br

1 - A Newton-Like Method for Distributed Optimization

Natasa Krejic, professor, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovica 4, Novi Sad, Serbia-Montenegro, natasak@uns.ac.rs, Dusan Jakovetic, Natasa Krklec Jerinkic, Dragana Bajovic

A connected network with n agents, each of which has access to† a local strongly convex function, is considered. The agents cooperate in minimizing the overall cost function. We propose a Newton-like method based on the particular structure of a penalty-like reformulation of the unconstrained problem. A second order information is incorporated into the distributive Newton step approximation. It is shown that the method converges linearly. Numerical results demonstrate a significant gain in terms of computational efficiency in comparison with the existing alternatives.

2 - Effective Methods for the Problem of Calculation of Matrix of Correspondences

Alexey Chernov, Moscow Institute of Physics and Technology, Institutskii pereulok, 9, Dolgoprudnyi, Russia, alexmipt@mail.ru, Alexander Gasnikov, Petro Stetsyuk

It is well known that the problem of calculation of the matrix of correspondences is reduced to the special type of entropy-linear programming (ELP) problem (A. Wilson). Recently there were obtained a few methods arXiv:1410.7719 for ELP with precise estimates of complexity. We compare these methods with Shor's r-algorithm, with well known Bregman's balancing method and with some others (Fang—Rajasekera—Tsão) on the example of the calculation of the matrix of correspondences. For the most of these methods there is no theoretical estimates of their global rate of convergence. Therefore, we present also encouraging results of numerical experiments.

3 - An Inner-Outer Nonlinear Programming Approach for Constrained Quadratic Matrix Model Updating

Marina Andretta, University of São Paulo, Av. Trabalhador São-carlense, 400, São Carlos, SP, 13566590, Brazil, andretta@icmc.usp.br, Ernesto G. Birgin, Marcos Raydan

Quadratic Finite Element Model Updating Problem (QFEMUP) concerns with updating a symmetric second-order finite element model so that it remains symmetric and the updated model reproduces a given set of desired eigenvalues and eigenvectors by replacing the corresponding ones from the original model. Taking advantage of the special structure of the constraint set, it is first shown that the QFEMUP can be formulated as a suitable constrained nonlinear programming problem. To avoid that spurious modes appear in the frequency range of interest in the updated model, additional constraints based on a quadratic Rayleigh quotient are dynamically included in the constraint set. Numerical experiments show that the algorithm works well in practice.

■ WB18

18- Sterlings 3

Topics in Optimization in Healthcare

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Andrew J. Schaefer, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, schaefer@ie.pitt.edu

1 - The Big Data Newsvendor: Practical Insights from Machine Learning

Gah-Yi Vahn, Assistant Professor, London Business School, Sussex Place, Regent's Park, London, United Kingdom, gvahn@london.edu, Cynthia Rudin

We investigate the newsvendor problem when one has n observations of p features related to the demand as well as historical demand data. We propose two approaches to finding the optimal order quantity in this new setting ó that of Machine Learning (ML) and Kernel Optimization (KO). We show that both solution approaches yield decisions that are algorithmically stable, and derive tight bounds on their performance. We apply the feature-based algorithms for nurse staffing problem in a hospital emergency room and find that the best KO and ML algorithms beat the best practice benchmark by 23% and 24% respectively in out-of-sample cost with statistical significance at the 5% level.

2 - Estimating Lipid Management Guidelines' Risk Value Of A Life Year On Treatment

Niraj Pandey, University at Buffalo, 342 Bell Hall, North Campus, Buffalo, NY, 14260, United States of America, npandey@buffalo.edu, Murat Kurt, Mark Karwan

Statins reduce the risk of heart attack and stroke with adverse side effects, but how to quantify these effects to help physicians make treatment decisions remains to be an open question. We gauge these adverse effects for patients with Type 2 diabetes from a central policy maker's point of view by formulating a dynamic decision model in which the objective is to minimize the risk of a first major cardiovascular event where time spent on treatment is penalized by a perceived risk increase. We seek penalty factors that make published lipid management guidelines as close as possible to optimal. We present computational results using clinical data and derive insights.

3 - Mitigating Information Asymmetry in Liver Allocation: A Stochastic Programming Approach

Andrew J. Schaefer, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, schaefer@ie.pitt.edu, Sepehr Nemati, Zeynep Icten, Lisa Maillart, Mark Roberts

Transplantation is the only treatment for end-stage liver disease, the twelfth-leading cause of death in the U.S. The U.S. liver allocation system induces information asymmetry, as patients are only required to update their health within certain prescribed time windows, which can lead to a misallocation of livers. Another concern is "update burden" – while requiring daily updates would eliminate the information asymmetry, it would be highly inconvenient for patients. We present a multi-objective stochastic program to simultaneously mitigate information asymmetry and update burden. We calibrate our model with clinical data and provide a set of Pareto-optimal health reporting requirements.

■ WB19

19- Ft. Pitt

Decision Diagrams in Optimization I

Cluster: Constraint Programming

Invited Session

Chair: John Hooker, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States of America, jh38@andrew.cmu.edu

1 - Scenario Bundling for Exact Multistage Stochastic Optimization

Utz-Uwe Haus, Cray Inc., Zufikon, 5621, Switzerland, uhaus@ethz.ch, Carla Michini, Marco Laumanns

We propose a generic method to reformulate multistage stochastic optimization problems as mixed-integer programs by bundling equivalent scenarios, avoiding scenario sampling. The approach makes use of binary decision diagrams to store a cover of the scenario space, and uses them to derive an inequality system for computing scenario probabilities conditioned on the lower-level decisions. As applications we discuss the pre-disaster network strengthening and network interdiction problems and showcase computational improvements over previous approaches.

2 - Solving the Pricing Problem in a Branch-and-Price Algorithm for Graph Coloring using ZDDs

David Morrison, Inverse Limit, 255 McDowell Lane Unit A, W Sacramento, CA, 95605, United States of America, drmorr@evokewonder.com, Edward Sewell, Sheldon Jacobson

Branch-and-price algorithms combine a branch-and-bound search with an exponentially-sized LP formulation that must be solved via column generation. Unfortunately, the standard branching rules used in branch-and-bound for integer programming interfere with the structure of the column generation routine; therefore, most such algorithms employ alternate branching rules to circumvent this difficulty. In this talk, we show how a zero-suppressed binary decision diagram (ZDD) can be used to solve the pricing problem in a branch-and-price algorithm for the graph coloring problem, even in the presence of constraints imposed by branching decisions. This approach can improve convergence of the column generation subroutine.

■ WB20

20- Smithfield

Fast Algorithms for Compressed Sensing and Matrix Completion

Cluster: Nonsmooth Optimization

Invited Session

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

1 - Parallel-l0: A Fully Parallel Algorithm for Combinatorial Compressed Sensing

Jared Tanner, Professor, Oxford University, Mathematical Institute, Oxford, United Kingdom, tanner@maths.ox.ac.uk, Rodrigo Mendoza-Smith

We consider the problem of solving for the sparsest solution of large underdetermined linear system of equations where the matrix is the adjacency matrix of an expander graph corresponding with at most d neighbours per node. We present a new combinatorial compressed sensing algorithm with provable recovery guarantees, fully parallel with computational runtime less than traditional compressed sensing algorithms, and able to recover sparse signals beyond l1-regularization.

2 - Model Expander Iterative Hard Thresholding

Bubacarr Bah, University of Texas, 2515 Speedway, Austin, TX, United States of America, bah@math.utexas.edu, Luca Baldassarre, Volkan Cevher

We present a linear time recovery algorithm with provable recovery guarantees for signals that belong to some general structured sparsity models, such as rooted connected trees and overlapping groups models, where the signals are encoded by sparse measurement matrices. The algorithm achieves relatively more accurate reconstruction from a much reduced sketch sizes, and it always returns a signal from the given sparsity model, which is useful to many applications since it allows to interpret the solution with respect to the chosen sparsity structure even in the presence of perturbations.

3 - Conjugate Gradient Iterative Hard Thresholding

Jeffrey D. Blanchard, Grinnell College, Grinnell College, Grinnell, IA, 50112-1690, United States of America, Blanchaj@Grinnell.edu

Conjugate Gradient Iterative Hard Thresholding (CGIHT) is a an effective algorithm for solving the L0 minimization problem in compressed and the low rank matrix completion problem. CGIHT combines low per iteration complexity (IHT, NIHT) with the accelerated asymptotic convergence rates of projection based algorithms (HTP, CoSaMP). In addition to competitive theoretical recovery guarantees, CGIHT is observed to recover sparse vectors and low rank matrices in less time than other algorithms.

■ WB21

21-Birmingham

Applications of Multiobjective Optimization

Cluster: Multi-Objective Optimization

Invited Session

Chair: Markus Hartikainen, Postdoctoral Researcher, University of Jyvaeskylae, P.O. Box 35, Jyvaeskylae, Finland, markus.hartikainen@jyu.fi

1 - Optimizing Marketing Activities in Banking System using Multi-Objective Optimization

Asaf Shupo, Manager, TD Bank Group, 77 King Street 10th fl, Toronto, Canada, asaf.shupo@td.com

In order to increase the volume of lending, retaining their customers, increasing long term profit, etc. banks organize promotion campaigns with different goals which in many cases conflicting each other. In marketing activities, marketers looking for customers that more likely generate high profit, high volume of lending, high respond rate, etc. Those objectives conflict each other, and the optimal solution should consider the tradeoff amongst the objectives. This current research presents an approach of using multi-objective optimization, finding optimal marketing strategy which optimizes at the same time the goals of a cash campaign: the average promotional rate, the total cash volume, and the total response rate of the campaign.

2 - Several Approaches for Solving the Multiobjective One-Dimensional Cutting Stock Problem

Angelo Aliano Filho, Master Degree, UNICAMP, Campinas, SP, Brazil, Campinas, SP, 13083-725, Brazil, angeloaliano@hotmail.com, Antonio Carlos Moretti, Margarida Vaz Pato

This work deals with the Multiobjective One-Dimensional Cutting Stock Problem (MODCSP). Due to its wide applicability in several fields, this problem is widely studied in Combinatorial Optimization. MODCSP has two objective functions that need to be minimized simultaneously, i.e., minimize the number of cutting patterns, and the number of setup machine. We developed several exact techniques of Multiobjective Optimization for obtain the optimal Pareto Front and we will present some ones in this conference.

3 - Forest Harvesting and Selling with Conflicting Objectives

Markus Hartikainen, Postdoctoral Researcher, University of Jyvaeskylae, P.O. Box 35, Jyvaeskylae, Finland, markus.hartikainen@jyu.fi

A decision problem concerning the harvesting of forest and selling the wood is considered based on conflicting objectives. Objectives considered include profit, sustainability and the amount of necessary renegotiation of previous deals with the wood buyers. Decision variables considered include the timings of the harvests and the amount of wood sold to various buyers. Pareto optimal solutions to the problem are found using multiobjective mixed-integer linear optimization and the SIMO program for forest management planning.

■ WB22

22- Heinz

Variational Analysis in Nonsmooth Optimization II

Cluster: Variational Analysis

Invited Session

Chair: Mau Nam Nguyen, Assistant Professor, Portland State University, 725 SW Harrison Street, Portland, OR, 97201, United States of America, mnn3@pdx.edu

1 - Second-Order Analysis of Piecewise Linear Functions and its Application to Lipschitzian Stability

Ebrahim Sarabi, Wayne State University, 695 Kirts Blvd, Apt 206, Troy, MI, 48084, United States of America, ebrahim.sarabi@wayne.edu, Boris Mordukhovich

We present second-order analysis of proper convex and piecewise linear functions. We first provide an efficient calculation of the prenormal cone to ∂f for a proper convex and piecewise linear f. Then we show how this allows us to find the second-order subdifferential for this class of functions entirely in terms of the initial data. Finally, if time permits, I will talk about the applications in sensitivity analysis.

2 - On the Convergence of the Proximal Forward-Backward Splitting Method with Linesearches

Yunier Bello Cruz, Universidade Federal de Goias, Campus Samambaia, UFG-IME Sala 219, Goiania, Brazil, yunier@impa.br, Nghia Tran

In this paper we focus on the convergence analysis of the proximal forward-backward splitting method for solving nonsmooth optimization problems in Hilbert spaces when the objective function is the sum of two convex functions. Assuming that one of the functions is Fr\'echet differentiable and using two new linesearches, the weak convergence is established without any Lipschitz continuity assumption on the gradient. Furthermore, we obtain many complexity results of cost values at the iterates when the stepsizes are bounded below by a positive constant. A fast version with linesearch is also provided.

3 - Generalized Differentiation and Characterizations for Differentiability of Infimal Convolutions

Mau Nam Nguyen, Assistant Professor, Portland State University, 725 SW Harrison Street, Portland, OR, 97201, United States of America, mnn3@pdx.edu

In this talk we present new results on generalized differentiation properties of the infimal convolution. This class of functions covers a large spectrum of nonsmooth functions well known in the literature. The subdifferential formulas obtained unify several known results and allow us to characterize the differentiability of the infimal convolution which plays an important role in variational analysis and optimization.

■ WB23

23- Allegheny

Complexity of Sparse Optimization in High Dimensions

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Alekh Agarwal, 641 Avenue of the Americas, 7th floor, New York, NY, 10023, United States of America, alekhagarwal@gmail.com

1 - Sparse Graph Estimation via Noncovex Optimization

Han Liu, Princeton University, Sherrerd Hall 224, ORFE, Princeton, NJ, 08544, United States of America, hanliu@princeton.edu

The graphical model has proven to be a useful abstraction in statistics and machine learning. The starting point is the graph of a distribution. While often the graph is assumed given, we are interested in estimating the graph from data. In this talk we present new statistical optimization methods for graph estimation. The performance of these methods is illustrated and compared on several real and simulated examples.

2 - On Iterative Hard Thresholding Methods for High-Dimensional M-Estimation

Prateek Jain, Microsoft Research India, #9 Lavelle Road, Bangalore, KA, 560001, India, prajain@microsoft.com, Ambuj Tewari, Purushottam Kar

The use of M-estimators in generalized linear regression models in high dimensional settings requires risk minimization with hard L0 constraints. Of the known methods, the class of projected gradient descent (also known as iterative hard thresholding (IHT)) methods is known to offer the fastest and most scalable solutions. However, the current state-of-the-art is only able to analyze these methods in extremely restrictive settings which do not hold in high dimensional statistical models. In this work we bridge this gap by providing the first analysis for IHT-style methods in the high dimensional statistical setting.

3 - Lower Bounds on the Performance of Polynomial-Time Algorithms for Sparse Linear Regression

Yuchen Zhang, University of California, Department of Computer Science, Berkeley, CA, 94720, United States of America, yuczhang@eecs.berkeley.edu, Michael I Jordan, Martin Wainwright

Under a standard assumption in complexity theory (NP not in P/poly), we demonstrate a gap between the minimax prediction risk for sparse linear regression that can be achieved by polynomial-time algorithms, and that achieved by optimal algorithms. In particular, when the design matrix is ill-conditioned, the minimax prediction loss achievable by polynomial-time algorithms can be substantially greater than that of an optimal algorithm. This result is the first known gap between polynomial and optimal algorithms for sparse linear regression, and does not depend on conjectures in average-case complexity.

■ WB24

24- Benedum

Decomposition Approaches in MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Giacomo Nannicini, Prof., SUTD, Singapore University of Technology and Design, 8 Somapah Road, Singapore, Singapore, nannicini@sutd.edu.sg

1 - A Decomposition-and-Reduce Approach for Stochastic Nonconvex Mixed-integer Nonlinear Programming

Xiang Li, Queen’s University, 19 Division Street, Dupuis 403, Kingston, ON, K7L3N6, Canada, xiang.li@queensu.ca, Dan Li

We discuss an updated nonconvex generalized Benders decomposition (NGBD) method for solving stochastic nonconvex mixed-integer nonlinear programming (MINLP) problems. In this method, domain reduction techniques, such as bound contraction strategies, are systematically integrated into the NGBD procedure, leading to progressively improved convex relaxations and tightened variable bounds. The inclusion of domain reduction techniques not only reduces the number of NGBD iterations, but also speeds up the solution of nonconvex subproblems. Case study results show that, for some difficult stochastic nonconvex MINLPs, the updated NGBD method is faster than the standard NGBD method by over an order of magnitude.

2 - A Multiplicative Weights Update Algorithm for Quadratic MINLP

Luca Mencarelli, CNRS LIX, Ecole Polytechnique, Palaiseau, 91128, France, mencarelli@lix.polytechnique.fr, Leo Liberti, Youcef Sahraoui

We describe an adaptation of the Multiplicative Weights Update algorithm for Mixed-Integer Nonlinear Programming. This algorithm iteratively updates a distribution based on a gains/costs vector at the preceding iteration, samples decisions from the distribution in order to updates the gains/costs vector. Our adaptation relies on the concept of “pointwise reformulation”, which depends from some parameters theta. The Multiplicative Weights Update algorithm is used to find good values for theta.

3 - Nonlinear Chance-Constrained Problems with Applications to Hydro Scheduling

Dimitri Thomopulos, University of Bologna, Viale Risorgimento 2, Bologna, Italy, dimitri.thomopulos@unibo.it, Andrea Lodi, Giacomo Nannicini, Enrico Malaguti

The midterm hydro scheduling problem is about optimizing the performance of a hydro network over a period of some months. This decision problem is affected by uncertainty on energy prices, demands and rainfalls, and we model it as a multi-stage nonlinear chance-constrained mathematical problem. At each stage we have to decide how much water to release from the reservoirs, and as a consequence, how much energy to produce. We present a Branch-and-Cut algorithm and a separation algorithm for the corresponding nonlinear scenario subproblems.

■ WB25

25- Board Room

Business Models for Integrating Demand Response in Electricity Markets

Cluster: Optimization in Energy Systems

Invited Session

Chair: Antony Papavasiliou, Assistant Professor, Catholic University of Louvain, Voie du Roman Pays 34, Office b.114, Louvain la Neuve, 1348, Belgium, anthony.papavasiliou@uclouvain.be

1 - A Business Model for Load Control Aggregation to Firm up Renewable Capacity

Shmuel Oren, Professor, University of California - Berkeley, IEOR Dept., Etcheverry Hall, Berkeley, CA, 94720, United States of America, oren@ieor.berkeley.edu, Clay Campaign, Kostas Margellos

We describe a business model for a retail electricity service aggregator that buys from its customers, options to limit total supply to their meters. The customers are responsible to meet the prescribed limits by managing the household energy use behind the meter. The aggregator can bundle the contracted curtailment options into wholesale DR offers or firm up wind resources offered into the wholesale energy markets. We formulate the overall aggregator problem optimizing the menu of contracts offered to retail customers along with the curtailment policy, the nameplate wind capacity matched up with the retail demand, and quantity of energy offered by the aggregator in the day ahead wholesale market as function of wholesale price.

2 - Models for Cooptimization of Demand and Reserve

Golbon Zakeri, University of Auckland, Private Bag 92019, Auckland, New Zealand, g.zakeri@auckland.ac.nz, Mahbubeh Habibian, Anthony Downward

We will provide a mixed integer program that co-optimizes the demand for a large consumer of electricity and the supply of reserve for this participant. We will discuss the properties of this model and present results.

3 - Priority Service Contracts for Residential Demand Response: Pricing, Aggregation and Dispatch

Antony Papavasiliou, Assistant Professor, Catholic University of Louvain, Voie du Roman Pays 34, Office b.114, Louvain la Neuve, 1348, Belgium, anthony.papavasiliou@uclouvain.be

We present an end-to-end priority service mechanism for mobilizing residential demand response. Consumers choose color designations for devices that correspond to reliability of service guarantees. Devices with specific colors are bundled into wholesale market energy and ancillary services bids. Accepted bids are translated to load control signals. An example illustrates the optimal design of the tariff and the dispatch of deferrable residential loads.

■ WB26

26- Forbes Room

Advances in Stochastic and Robust Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Sanjay Mehrotra, Professor, Northwestern University, IEMS Department, Evanston, IL, 60208, United States of America, mehrotra@northwestern.edu

1 - A Distributionally Robust Support Vector Machine Model and its Performance

Sanjay Mehrotra, Professor, Northwestern University, IEMS Department, Evanston, IL, 60208, United States of America, mehrotra@northwestern.edu

We propose a distributionally-robust framework for computing Support Vector Machines (DR-SVMs). We consider an ambiguity set for the population distribution based on the Kantorovich metric and present a distributionally-robust counterpart of the SVMs. Computational results on simulated and real data show that the DR-SVMs outperform the classical SVMs in terms of the Area Under Curve (AUC) measures when applied to small data.

2 - Experiences with First Order Methods in Some Stochastic Optimization Problems

Jorge Vera, Professor, Pontificia Universidad Catolica de Chile, Dept. Industrial and System Engineering, Vicuna Mackenna 4860, Santiago, 7820436, Chile, jvera@ing.puc.cl, Alfonso Lobos

First order methods have become increasingly important in recent years. Current literature shows promising applications in several areas, being stochastic optimization a very relevant one. In this work we show our experience with some first order methods, like the accelerated stochastic subgradient and Frank Wolfe methods, as well as a modified adaptive version of stochastic subgradient. We show results for some test instances as well as a two stage problem originating in a real industrial situation.

■ WB27

27- Duquesne Room

Quantum Communication Complexity and Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Joao Gouveia, University of Coimbra, Apartado 3008 EC Santa Cruz, Coimbra, 3001-501, Portugal, jgouveia@mat.uc.pt

1 - Sum of Squares Degree and Quantum Query Complexity

Troy Lee, Nanyang Technological University, 21 Nanyang Link, Singapore, Singapore, troyjlee@gmail.com, Ronald de Wolf, Jedrzej Kaniewski

The positive semidefinite rank is characterized by a one-way model of quantum communication complexity where the goal is to compute a function in expectation. We show this characterization holds for the two-way model of communication as well. Further, we study the analogous quantum query model of computing a function in expectation. We show that the complexity of a boolean function f in this model is characterized by the minimum d such f can be written as a sum of squares of degree d polynomials.

2 - Round Elimination in Exact Communication Complexity

Teresa Piovesan, PhD Candidate, CWI, Science Park 123, Amsterdam, Netherlands, piovesan@cwi.nl, Debbie Leung, Florian Speelman, Harry Buhrman, Jop Briet

We study two graph parameters, the chromatic number and the orthogonal rank, in the context of exact classical and quantum communication complexity. In particular, we consider a promise equality problem, where Alice and Bob must decide if their inputs are equal or not. For this, the chromatic number and the orthogonal rank (of a certain graph) characterise the one-round classical and one-round quantum communication complexity. While classically allowing multiple rounds does not give any advantage, we show an instance that exhibits an exponential gap between the one- and two-round quantum communication complexities.Thus the quantum communication complexity for every fixed number of rounds turns out to enjoy a much richer structure.

3 - Nonlocal Games and Conic Programming

Antonios Varvitsiotis, Research Fellow, Nanyang Technological University, Singapore and Centre for Quantum Technologies, National University of Singapore, Singapore, Singapore, avarvits@gmail.com, Jamie Sikora

A nonlocal game is a cooperative task between two players and a verifier: Each player is given a question by the verifier according to some joint probability distribution. The players respond to the verifier who consults a truth table dictating whether the players win or lose. The classical value of a game is the maximum winning probability using classical strategies and the quantum value is the maximum winning probability over all quantum strategies. We show that the classical and the quantum value of a nonlocal game can be formulated as linear conic programs over the completely positive and the completely positive semidefinite cone, respectively, and discuss the usefulness of these formulations.

■ WB28

28- Liberty Room

Advances in Solving QCQPs

Cluster: Global Optimization

Invited Session

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

1 - On Projected Cutting Surfaces for Mixed-Integer Quadratically Constrained Programs

Hongbo Dong, Assistant Professor, Washington State University, Neill 103, Pullman, WA, 99163, United States of America, hongbo.dong@wsu.edu

Convex relaxations with balanced strength and computational complexity are crucial for globally solving mixed-integer quadratically constrained programs. In this talk, we will focus on the idea of exploiting the strength of semidefinite relaxations (SDRs) by iteratively adding cutting surfaces to strengthen convex relaxations that are cheaper to solve than SDRs. We will extend our previous studies to more general instances of MIQCPs, and report our numerical results.

2 - A Generalized Trust Region Subproblem with Hollows and Non-Intersecting Linear Constraints

Boshi Yang, The University of Iowa, Department of Mathematics, Iowa City, IA, 52242, United States of America, boshi-yang@uiowa.edu, Kurt Anstreicher, Sam Burer

We study a generalized trust region subproblem in which a nonconvex quadratic function is minimized over unit ball and the intersection of n concave quadratic constraints and m non-intersecting linear constraints. Geometrically speaking, we first study the case when n small separate ellipsoids without intersecting boundaries are removed from the unit ball. We then take away m non-intersecting caps from the unit ball without touching the boundaries of the hollows inside. It is known that when n=0 or when n=1 and m=0, the problem has a tight Semidefinite Programming (SDP) relaxation. Our new result shows that the SDP relaxation is also tight for general n. and m .

3 - Convexity Analysis of Polynomials and Applications to Optimization

Krishnamurthy Dvijotham, Postdoctoral Fellow, California Institute of Technology, 68 N Michigan Ave, Apartment 2, Pasadena, CA, 91106, United States of America, dvij@cs.washington.edu, Venkat Chandrasekaran

We propose a general framework to analyze the domain of convexity of polynomials over the nonnegative orthant. Given a polytope P contained within the nonnegative orthant, we characterize a convex constraint on the coefficients of a polynomial so that the polynomial is provably convex over P, when reparameterized in terms of exponentials. For the special case of quadratic functions, we derive tighter characterizations of these conditions. We discuss the implications of these results to solving QCQPs and polynomial optimization problems over the non-negative orthant.

■ WB29

29- Commonwealth 1

Fast Algorithms for Convex Matrix Optimization Problems

Cluster: Nonsmooth Optimization

Invited Session

Chair: Defeng SunProf., National University of Singapore, Department of Mathematics, 10 Lower Kent Ridge Road, Singapore, Singapore, matsundf@nus.edu.sg

1 - Aug2QP: A Two-Phase Augmented Lagrangian Method for Large-Scale Convex Conic Quadratic Programming

Xudong Li, Research Assistant, National University of Singapore, Department of Mathematics, Block S17, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, matlixu@nus.edu.sg, Cui Ying, Defeng Sun, Kim-Chuan Toh

In this talk, we aim to solve high dimensional convex conic quadratic programming problems. To solve the targeted problems efficiently, we introduce a two-phase augmented Lagrangian method, with Phase I to generate a good initial point and Phase II to obtain an accurate solution fast. In Phase I, we first introduce a symmetric Gauss-Seidel (sGS) technique. This technique allows us to design a novel sGS based semi-proximal augmented Lagrangian method to find a solution of low to medium accuracy. Then, in Phase II, a proximal augmented Lagrangian algorithm, with the inner subproblems to be solved by combining an inexact accelerated proximal gradient (APG) method with the sGS technique, is proposed to obtain a more accurate solution.

2 - An Inexact Accelerated Block Coordinate Descent Method for Least Squares Semidefinite Programming

Defeng Sun, Prof., National University of Singapore, Department of Mathematics, 10 Lower Kent Ridge Road, Singapore, Singapore, matsundf@nus.edu.sg, Kim-Chuan Toh, Liuqin Yang

We consider least squares semidefinite programming (LSSDP) where the primal matrix variable must satisfy given linear equality and inequality constraints, and must also lie in the intersection of the cone of positive semidefinite matrices and a simple polyhedral set. We propose an inexact accelerated block coordinate descent (ABCD) method for solving the problem via its dual, which can be reformulated as a convex composite minimization problem whose objective is the sum of a coupled quadratic function involving four blocks of variables and two separable non-smooth functions involving only the first and second block, respectively.

3 - Low-rank Spectral Optimization

Michael Friedlander, University of California, Department of Mathematics, Davis, CA, 95616, United States of America, mpfriedlander@ucdavis.edu

Various applications in signal processing and machine learning give rise to highly structured spectral optimization problems characterized by low-rank solutions. Two examples include optimization problems from phase retrieval and matrix completion. I will describe how the particular structure of these problems allows for a special kind of duality framework that leads to computationally convenient formulations.

■ WB30

30- Commonwealth 2

Approximation and Online Algorithms VIII

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Yang Jiao, PhD Student, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, yangjiao@andrew.cmu.edu

1 - Designing Overlapping Publish-Subscribe Networks

Jennifer Iglesias, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, jiglesia@andrew.cmu.edu, R. Ravi, Ravi Sundarum, Rajmohan Rajaraman

The publish-subscribe network design problem is defined on a metric with given publisher and subscriber nodes and demands between them. The goal is to build a minimum total cost set of networks (one for each publisher, subscriber, each being a star or tree), where for each demand pair their networks overlap. I will present approximation algorithms for different types of demand sets and show the natural LP for this problem has an Omega(log log n) integerality gap.

2 - Approximation Schemes for the Container Selection Problem

Kanthi Sarpatwar, University of Maryland, College Park, 166 Westway, Apt T4, Greenbelt, MD, 20770, United States of America, kanthik@gmail.com, Viswanath Nagarajan, Baruch Schieber, Hadas Shachnai, Joel Wolf

The container selection problem is a special case of the non-metric k-median, naturally arising in cross platform scheduling. In the continuous variant, we are given a set C of input points in the d-dimensional real space, for some d>=2, and a budget k. An input point p can be assigned to a container point c only if c dominates p in every dimension. The assignment cost of p is equal to the L1-norm of point c. The goal is to find k container points in d-dimensional space such that the total assignment cost of all input points is minimized. The discrete variant of the problem has one key distinction ñ container points must be chosen from a given set F. We will discuss (bi) approximation schemes for both variants and some hardness results.

3 - Primal Dual Approximation Algorithm for Inventory Routing on the Line

Yang Jiao, PhD Student, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, yangjiao@andrew.cmu.edu

We consider the deterministic inventory routing problem over a discrete finite time horizon. Given clients on a metric, each with daily demands that must be delivered from a depot and holding costs over the planning horizon, an optimal solution selects a set of daily tours through a subset of clients to deliver all demands before they are due and minimizes the total holding and tour routing costs over the horizon. We give a constant factor primal dual approximation for inventory routing on the line metric.

Wednesday, 1:10pm - 2:40pm

■ WC01

01- Grand 1

Solvers for Mixed Integer Nonlinear Optimization Problems

Cluster: Implementations and Software

Invited Session

Chair: Pietro Belotti, Xpress Optimizer Team, FICO, Starley Way, Birmingham, United Kingdom, pietrobelotti@fico.com

1 - CCGO: A Fast Heuristic Global Optimizer

John Chinneck, Carleton University, Systems and Computer Engineering, 1125 Colonel By Drive, Ottawa, ON, K1S 5B6, Canada, chinneck@sce.carleton.ca, Mubashsharul Shafique

CCGO is a heuristic multi-start method for global optimization that is highly scalable and especially effective for nonconvex problems having multiple disconnected feasible regions. It finds good quality solutions quickly. The core components are: initial sampling, constraint consensus and clustering to identify feasible regions, direct search to improve clusters, and local solver launch. The algorithm is inherently concurrent. Empirical results show its effectiveness as compared to leading complete solvers and other multi-start codes.

2 - Non-Linear Modelling with Xpress Mosel and the New Variable Elimination Feature of Xpress-NLP

Livio Bertacco, FICO, Starley Way, Birmingham, B37 7GN, United Kingdom, liviobertacco@fico.com

This talk presents some recent enhancements to the FICO Xpress Mosel modelling language and non-linear solver. The new variable elimination feature of Xpress-NLP has led to large improvements in the modelling and solving of two pricing problems that use recursive formulae to predict demands. Another new feature of Mosel is the support for annotations which can be used to quickly define a user interface for FICO Optimization Modeler, or generate model documentation.

■ WC02

02- Grand 2

Progress in Energy Markets Optimization

Cluster: Optimization in Energy Systems

Invited Session

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

1 - Look-ahead Scheduling of Energy, Reserves and Ramping under Uncertainty in a Two-Settlement Framework

Alberto Lamadrid, Lehigh University, 621 Taylor Street, Bethlehem, United States of America, ajlamadrid@lehigh.edu

This paper quantifies the technical and economic tradeoffs of an advanced scheduling model over generally accepted deterministic methods in use for the operation of the system. Our main contribution lies in the determination of benefits and costs between a systematic new model we are proposing, and policy rules in use by system operators, identifying key differences in provision of energy and ancillary services, their pricing and the overall security of the system. This paper builds on our previous work in this area, formulating a look-ahead optimization of the total net benefits, calculated as the expected benefits of electricity consumption net of the cost of energy and ancillary services for several periods.

2 - Electricity Forward Price Discovery for Structural Price Models

Boris Defourny, Assistant Professor, Lehigh University, 200 W Packer Ave, Bethlehem, PA, 18015, United States of America, defourny@lehigh.edu, Somayeh Moazeni

We first discuss a stochastic model of electricity spot prices that relies on a model of the supply stack capturing heat rates and fuel prices. We then propose an approach to discover electricity risk premiums and to construct electricity forward prices for long maturities, by leveraging the information in fuel forward curves.

3 - Optimization of a Distributed Generation Portfolio through Bilateral Contracts

François Gilbert, Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL, United States of America, fgilbert@anl.gov, Miguel Anjos, Patrice Marcotte, Gilles Savard

We consider an energy aggregator linking distributed generators with the grid through a two-sided portfolio of bilateral contracts, positioned for the point-wise procurement of energy to the grid. The challenge raised by the coordination of disparate resources and the securing of obligations over long time periods is addressed through a two-time scale model, where robust short term operational decisions are based on long term resource usage incentives, obtained from a min-cost flow representation that embeds the full extent of all contract durations.

■ WC03

03- Grand 3

Advances in Combinatorial Optimization and Applications

Cluster: Combinatorial Optimization

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 - A Polyhedral Study of Multilinear Programs with Box Constraints

Alberto Del Pia, Assistant Professor, University of WisconsinñMadison, Madison, United States of America, delpia@wisc.edu, Aida Khajavirad

We study the polyhedral convex hull of a mixed-integer set S defined by a collection of multilinear equations over the 0-1-cube. Such sets appear frequently in the factorable reformulation of mixed-integer nonlinear optimization problems. In particular, the set S represents the feasible region of a linearized unconstrained zero-one polynomial optimization problem. Our theoretical developments extend several well-known results from the Boolean quadric polytope and the cut polytope literature, paving a way for devising novel optimization algorithms for nonconvex problems containing multilinear subexpressions.

2 - Semi-Infinite Relaxations for a Dynamic Knapsack Problem with Stochastic Item Sizes

Alejandro Toriello, Georgia Tech University, atoriello@isye.gatech.edu

We consider a knapsack problem in which item sizes are stochastic and realized after an attempted insertion, and the decision maker chooses an item to insert dynamically based on remaining capacity. We derive relaxations of polynomial and pseudo-polynomial size based on different approximations of the value function, relate them to previous work and compare them theoretically and computationally.

3 - Strengthened Sparse Approximations for Polytopes

Marco Molinaro, Georgia Tech ISyE, marco.molinaro@isye.gatech.edu, Andres Iroume, Santanu Dey

Sparse cutting-planes are often the ones used in mixed-integer programing (MIP) solvers, since they help in solving the linear programs encountered during branch-&-bound more efficiently. Together with Dey and Wang, we have started exploring the strength of sparse cuts, namely how well they can approximate the integer hull. In this talk I will present new analyzes of the strength of sparse cuts under more refined measures that attempt to better capture the situation encountered in integer programming.

■ WC04

04- Grand 4

Semidefinite Programming and Polynomial Optimization II

Cluster: Conic Programming

Invited Session

Chair: Cordian Riener, Aalto University, Aalto, Helsinki, Finland, Cordian.Riener@aalto.fi

1 - Polyhedral Approximation of the Completely Positive Semidefinite Cone

Sabine Burgdorf, Doktor, Centrum Wiskunde & Informatica (CWI), Science Park 123, Amsterdam, Netherlands, burgdorf@cwi.nl, Teresa Piovesan, Monique Laurent

The completely positive semidefinite cone is a generalization of the completely positive cone: it consists of nxn symmetric matrices that admit a Gram representation by positive semidefinite matrices of any size. This cone is used by Laurent and Piovesan to model quantum graph parameters as conic optimization problems, and by Mancinska and Roberson to characterize the set of bipartite quantum correlations as projection of an affine section of it. We present a hierarchy of polyhedral cones which covers its interior. This will be used for computing some variant of the quantum chromatic number by way of a linear program.

2 - A Semidefinite Algorithm for Decomposing Completely Positive Matrices

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

A real symmetric matrix C is completely positive if C = B * B^T for a nonnegative matrix B. The question of deciding whether a matrix is completely positive or not can be equivalently formulated as a truncated moment problem. We propose a semidefnite algorithm for solving the question. It is based on solving semidefinite programs with moment variables. If a matrix is completely positive, then we can get a decomposition for it; if it is not completely positive, then we can get a mathematical certificate for that.

■ WC05

05- Kings Garden 1

Numerical Methods for Nonlinear Optimization II

Cluster: Nonlinear Programming

Invited Session

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

1 - Quasi-Newton Multipoint and Interpolation Methods with Line Search for Solving Nonlinear Equations

Oleg Burdakov, Linköping University, Linköping, Sweden, oleg.burdakov@liu.se, Ahmad Kamandi

We consider multipoint and interpolation methods for solving systems of nonlinear equations. They approximate the Jacobian matrix using quasi-Newton updates. Due to their ability to more completely utilize the information gathered at the previous iterations about the Jacobian matrix, these methods are especially efficient in the case of expensive functions. Their local convergence is known to be superlinear. We apply a line search strategy to make them globally convergent and justify this theoretically. Results of numerical experiments are presented. They show that the considered methods are more efficient than Broyden's method globalized in the same way.

2 - An Adaptive Feasible Discretization Method for Semi-Infinite Programming

Shuxiong Wang, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No.55, ZhongGuanCun DongLu, Beijing, China, Beijing, 100190, China, wsx@lsec.cc.ac.cn, Ya-xiang Yuan

We present a novel method to solve semi-infinite programming which guarantees that each iteration point is feasible for the original problem. The basic idea is to construct some proper upper bound functions of the constraint function to obtain the consistent inner approximate region with finitely many constraints. The adaptive subdivision algorithm is proposed to obtain a Karush-Kuhn-Tucker point of the original problem for the given tolerance. A refinement procedure is designed to ensure that the approximate regions are monotone. We prove that our algorithm terminates in finite iterations. Numerical experiment shows the performance of our algorithm .

3 - A Modified Self-Scaling Memoryless BFGS Method for Unconstrained Optimization

Cai-Xia Kou, Beijing University of Posts and Telecommunications (BUPT), No. 10, XiTuChengLu, BUPT, Peking,China, Beijing, China, koucx@lsec.cc.ac.cn, Yu-Hong Dai

Recently, based on self scaling memoryless BFGS (SSMLBFGS) method by Perry and Shanno, new conjugate gradient algorithms, called CG_DESCENT and CGOPT, have been proposed by Hager and Zhang (2005) and Dai and Kou (2010), respectively. It is somewhat surprising that the two cg methods perform more efficient than the SSMLBFGS method.We propose an efficient implementation of the SSMLBFGS method with some suitable modifications. It is shown that the directions satisfy the sufficient descent conditions.Global convergence analysis is made for convex and nonconvex functions,respectively. The numerical experiments in CUTEr indicate that the modified SSM-BFGS method yields a desirable improvement over the original SSMLBFGS method and CGOPT.

■ WC06

06- Kings Garden 2

Scalable Algorithms for Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Ilya Safro, Assistant Professor, Clemson University, 228 McAdams Hall, Clemson, SC, 29634, United States of America, isafro@clemson.edu

1 - Scalable Dense Subgraph Discovery

Charalampos Tsourakakis, Postdoctoral Fellow, Harvard University, 33 Oxford Street, Cambridge, MA, 02138, United States of America, babis@seas.harvard.edu

In this talk we present the following contributions. (1) We develop an algorithm that achieves time- and space-efficiency {\em simultaneously} for the densest subgraph problem (DSP) in dynamic graphs. It is the first of its kind for graph problems to the best of our knowledge [STOC'15]. (2) We present the k-clique DSP, a generalization of the DSP. We show exact and approximation algorithms. Experimental evaluation indicates that as we increase the value of k we are able to find large near-cliques [WWW'15]. We believe that our work is a significant advance in routines with rigorous theoretical guarantees for scalable extraction of large near-cliques from networks. Joint work with: S.Bhattacharya, M.Henzinger, D.Nanongkai

2 - Parallel Algorithms for Geometric Graph Problems

Grigory Yaroslavtsev, Postdoctoral Fellow, University of Pennsylvania, 2400 Chestnut St., Apt. 2910, Philadelphia, PA, 19103, United States of America, grigory@grigory.us, Aleksandar Nikolov, Alexandr Andoni, Krzysztof Onak

I will describe algorithms for geometric graph problems in the modern parallel models inspired by MapReduce. The talk will be self-contained, including an introduction into models capturing "MapReduce"-like systems. I will also give describe a few major open problems in the area. As an example, I will present an algorithm for the Minimum Spanning Tree (MST) problem in 2D. The algorithm takes constant number of rounds of communication and total space and communication proportional to the size of the data. The ideas behind the MST algorithm can be expressed within a general "Solve-and-Sketch" algorithmic framework. Besides MST it also applies to the approximate Earth-Mover Distance (EMD) and the transportation cost problem.

3 - Multiscale Methods for Network Generation and Response to Epidemics

Ilya Safro, Assistant Professor, Clemson University, 228 McAdams Hall, Clemson, SC, 29634, United States of America, isafro@clemson.edu

In many real-world problems, a big scale gap can be observed between micro- and macroscopic scales of the problem because of the difference in mathematical (engineering, social, biological, physical, etc.) models and/or laws at different scales. The main objective of the multiscale algorithms is to create a hierarchy of problems, each representing the original problem at different coarse scales with fewer degrees of freedom. We present multiscale approaches for two problems: optimal response to epidemics, and network generation. Both approaches are inspired by algebraic multigrid scheme reinforced by the algebraic distance connectivity strength.

■ WC07

07- Kings Garden 3

Constraint Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Jordi Castro, Prof., Universitat Politecnica de Catalunya, Dept. of Stats. and Operations Research, Barcelona, Spain, jordi.castro@upc.edu

1 - Recent Branching Improvements for Mixed Integer Programming in SCIP

Gerald Gamrath, Zuse Institute Berlin, Takustr. 7, Berlin, Germany, gamrath@zib.de

One of the essential components of a branch-and-bound based mixed integer linear programming (MIP) solver is the branching rule. We report on recent branching improvements developed within the academic MIP solver SCIP. This includes strong branching with domain propagation to improve strong branching predictions and the first branching rule on general disjunctions implemented within SCIP which branches on multi-aggregated variables. Furthermore, we present how dual degeneracy can be exploited by cloud branching to get more exact pseudo costs and how the reliability of pseudo costs can be evaluated by statistical means.

2 - (Pre-)Solving Non-Linear Pseudo-Boolean Optimization Problems

Michael Winkler, Gurobi GmbH, Takustr. 7, Berlin, 14195, Germany, winkler@gurobi.com

Pseudo-Boolean Optimization is a generalization of Binary Programming that also allows terms involving products of binary variables. We describe an Constraint Integer Programming(CIP) approach that can be advantageous compared to a standard Mixed Integer Programming formulation. Furthermore, we introduce specialized presolving techniques for non-linear constraints that can be used to shrink the problem or even to transform non-linear to linear problems. These techniques have been implemented within the CIP framework SCIP, which is used for computational results.

3 - Branch-and-Cut for Linear Programs with Overlapping SOS1 Constraints

Tobias Fischer, TU Darmstadt, Graduate School of Computational Engineering, Dolivostr. 15, Darmstadt, 64293, Germany, fischer@gsc.tu-darmstadt.de, Marc Pfetsch

SOS1 constraints require that at most one of a given set of variables is nonzero. In this talk, we develop a branch-and-cut approach for SOS1 constraints, including branching rules, primal heuristics and cutting planes. We focus on the case in which the SOS1 constraints overlap and algorithmically exploit the corresponding conflict graph. In a computational study, we evaluate our implementation and compare it to the solution of a big-M formulation.

■ WC08

08- Kings Garden 4

Combinatorial Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Chenglong Zou, McGill University, 845 Rue Sherbrooke O, Montreal, Canada, chenglong.zou@mail.mcgill.ca

1 - Multiflow Colouring Results

Chenglong Zou, McGill University, 845 Rue Sherbrooke O, Montreal, Canada, chenglong.zou@mail.mcgill.ca

Given a graph G and a set of routing demands H, we wish to color H such that every color class can be simultaneously routed. A lower bound on the coloring number can be calculated by comparing cuts, but it is not clear what the upper bound is. In this talk, we cover results on Okamura-Seymour graphs; for non-crossing demands a tight gap can be obtained, but in the general case the gap can be as bad as a factor of 3/2.

2 - Adaptive Telecommunication Network Operation with a Limited Number of Reconfigurations

Frank Pfeuffer, Zuse Institute Berlin, Takustrafle 7, Berlin, 14195, Germany, pfeuffer@zib.de, Axel Werner

To reduce energy consumption, telecommunication providers consider to adapt their core network dynamically to follow the daily traffic curve by changing the configuration of the hardware, while imposing constraints ensuring network stability. We consider the problem of finding a limited number of time intervals partitioning a finite time horizon and network configurations able to route all traffic in its associated interval. We present an algorithm iteratively computing hop-constrained shortest cycles in a certain weighted graph and refining the arc weights obtained as lower and upper bounds of a network design problem. On practical instances only a fraction of all possibilities have to be explored.

■ WC09

09- Kings Garden 5

Topics in Robust Optimization II

Cluster: Robust Optimization

Invited Session

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

1 - A Composite Risk Measure Framework for Decision Making under Uncertainty

Zizhuo Wang, University of Minnesota, 111 Church St SE, Minneapolis, MN, 55455, United States of America, zwang@umn.edu, Pengyu Qian, Zaiwen Wen

We present a unified framework for decision making under uncertainty. Our framework is based on the composite of two risk measures, where the inner risk measure accounts for the risk of decision given the exact distribution of uncertain model parameters, and the outer risk measure quantifies the risk that occurs when estimating the parameters of distribution. The framework generalizes several existing models, including stochastic programming, robust optimization, distributionally robust optimization, etc. Using this framework, we study a few new models which imply probabilistic guarantees for solutions and yield less conservative results. Numerical test on portfolio selection problem are shown to demonstrate the strength of our model.

2 - Continuity of Robust Optimization Problems

Philip Mar, University of Toronto, 5 King's College Road, Toronto, On, M5S 3G8, Canada, philip.mar@mail.utoronto.ca, Timothy Chan

We discuss the stability properties of robust optimization satisfying the strong Slater condition, with closed and convex uncertainty sets. We show, by way of results in Linear Semi-Infinite Optimization, that the optimal values of two robust optimization problems satisfying certain conditions are Lipschitz continuous with respect to the Hausdorff distance between their respective uncertainty sets. We also present implications for measuring a price of robustness and approximating robust optimization with complex uncertainty sets.

3 - A Functional Robust Newsvendor Model for Coordinating Pricing and Inventory Strategies

Jian Hu, University of Michigan, jianhu@umich.edu, Sanjay Mehrotra, Junxuan Li

We propose a functional robust newsvendor model considering the coordination of pricing and inventory decisions in an uncertain and instability market. Respecting to the uncertainty and instability highly challenging the precise assessment of price-demand curves, this model specifies an uncertainty set of nonparametric price-demand curves in cooperation with the least-squares model fitting technique, and seeks the best decisions against the worst case. We discuss the impact of the functional robustness and the wholesale price on the maximum profit that a retailer can earn, and show that the performance of this model exhibits the principles of marketing.

■ WC10

10- Kings Terrace

Robust/Risk-Aware Stochastic Optimization and Game Theory

Cluster: Stochastic Optimization

Invited Session

Chair: William Haskell, Assistant Professor, National University of Singapore, 1 Engineering Drive, Singapore, 117576, Singapore, wbhaskell@gmail.com

1 - Dynamic Linear Programming Games with Risk-Averse Players

Nelson Uhan, Assistant Professor, United States Naval Academy, Chauvenet Hall, Annapolis, MD, 21402, United States of America, uhan@usna.edu, Alejandro Toriello

We study dynamic linear programming games, a class of cooperative games in which the costs of cooperation are uncertain and evolve over time, and the players are risk averse. These games generalize the classic linear production game, and as a result, model a variety of cooperative settings. We focus on the strong sequential core (SSC) of these games — the set of allocations that distribute costs as they are incurred and are stable against coalitional defections at any point in time — and establish sufficient conditions for its emptiness and non-emptiness. Qualitatively, whereas the SSC is always non-empty when players are risk-neutral, our results indicate that cooperation among risk-averse players is much more difficult.

2 - Learning with Stochastic Dominance

William Haskell, Assistant Professor, National University of Singapore, 1 Engineering Drive, Singapore, 117576, Singapore, wbhaskell@gmail.com, George Shanthikumar, Max Shen

We incorporate risk aversion into data-driven decision-making making in two settings. In the first setting, 'statistical learning', we design a loss function that incorporates a continuum of risk preferences via stochastic dominance. Then, we show how to construct a policy that maps data to decisions that minimizes this loss function. In the second setting, we solve online optimization problems with stochastic dominance constraints. In online optimization, we create a model for sequential decision making where the random reward is evaluated in terms of stochastic dominance. We solve a stochastic dominance-constrained multi-armed bandit as a special case.

3 - SHARP: A Novel Human Behavior Model in Repeated Stackelberg Security Games

Debarun Kar, University of Southern California, 941 Bloom Walk, SAL 300, Los Angeles CA 90089, United States of America, dkar@usc.edu, Francesco Delle Fave, Fei Fang, Nicole Sintov, Milind Tambe

Recently, researchers have focused on modeling human behavior to protect against boundedly rational adversaries in repeated Stackelberg security games (SSGs). However, the existing models rely on sufficient data in the initial rounds and fail to address the adversaries' skewed perception of probability and adaptation to past actions, which is extremely detrimental to defender performance. This paper presents a novel model, SHARP, to overcome these limitations. We compare the models when tested against human subjects, llustrating the strengths and weaknesses of different models and showing the advantages of SHARP.

■ WC11

11- Brigade

Special Input Types

Cluster: Combinatorial Optimization

Invited Session

Chair: Joachim Schauer, University of Graz, Universitaetsstrasse 15, Graz, 8010, Austria, joachim.schauer@uni-graz.at

1 - The Quadratic Assignment Problem is Easy for Robinsonian Matrices

Matteo Seminaroti, CWI, Science Park 123, Amsterdam, 1098 XG, Netherlands, m.seminaroti@cwi.nl, Monique Laurent

Robinsonian matrices arise in the classical seriation problem and in many applications where unsorted similarity (or dissimilarity) information must be reordered. We show that the quadratic assignment problem QAP(A,B) can be solved in polynomial time when A and B are, respectively, Robinson similarity and dissimilarity matrices and one of A or B is a Toeplitz matrix. Furthermore, we present a new polynomial-time algorithm to recognize Robinsonian matrices based on unit interval graphs and Lex-BFS.

2 - Asymptotic Aspects of the Quadratic Knapsack Problem

Joachim Schauer, University of Graz, Universitaetsstrasse 15, Graz, 8010, Austria, joachim.schauer@uni-graz.at

We study subclasses of the quadratic knapsack problem, where the profits are independent and identically distributed random variables defined on the interval [0,1] and the knapsack capacity is proportional to the number of items. We show asymptotically the the ratio of the optimal solution and the objective value of a very easy heuristic almost surely tends to 1 as the size of the knapsack instance tends to infinity. As a consequence using randomly generated instances falling into this scheme seems to be inappropriate for studying the performance of heuristics and (to some sense) exact methods. However such instances are frequently used in the literature for this purpose.

■ WC12

12- Black Diamond

Stochastic Optimization and Decomposition Methods

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Fabian Bastin, Associate Professor, University of Montreal, DIRO, CP 6128 Succ. Centre-Ville, Montreal, QC, H3C 3J7, Canada, bastin@iro.umontreal.ca

1 - Forced and Natural Nestedness

David Morton, Professor of Industrial Engineering and Management Sciences, Northwestern University, 2145 Sheridan Road, Tech, Evanston, IL, 60208-3109, United States of America, david.morton@northwestern.edu

We consider two classes of combinatorial optimization problems in which we seek a family of nested solutions. For the first class, we formulate two types of two-stage stochastic integer programs to force the nested structure, given a probability distribution on the uncertain model parameters, e.g., resource availability. For the second class, we maximize a supermodular gain function subject to a single resource-availability constraint, and give conditions which lead naturally to nestedness of solutions at certain budget increments. A facility location problem, a graph clustering problem, and a chance-constrained model illustrate ideas.

2 - Adaptive Sampling Trust Region Optimization (ASTRO)

Sara Shashaani, sara.shashaani@gmail.com, Raghu Pasupathy

We develop derivative free algorithms for optimization contexts where the objective function is observable only through a stochastic simulation. The algorithms we develop follow the trust-region framework where a local model is constructed, used, and updated as the iterates evolve through the search space. The salient feature of our algorithms is the incorporation of adaptive sampling to keep the variance (statistical error) and the squared bias (model error) of the local model in lock step, in a bid to ensure optimal convergence rates. Such balancing is accomplished dynamically, through careful estimation of errors using function estimates at visited points. We will discuss convergence and efficiency.

3 - Mixed Recursive Logit Models for Route Choice Analysis

Fabian Bastin, Associate Professor, University of Montreal, DIRO, CP 6128 Succ. Centre-Ville, Montreal, QC, H3C 3J7, Canada, bastin@iro.umontreal.ca, Emma Frejinger, Tien Mai

Route choice models are popular to describe individual path choices in a transportation, but are often considered as expensive to estimate and can present challenges for prediction. We propose a route choice model that takes advantages from the mixed logit models without requiring sampling of paths and is straightforward to use for prediction. We design a decomposition method in order to deal with the complexity of the model estimation. Correlations in the network are modeled using the subnetwork components approach proposed by Frejinger and Bierlaire (2007). Numerical experiments are performed base on a real network with more than 3000 nodes and 7000 links.

■ WC13

13- Rivers

Conic Linear Optimizaton

Cluster: Conic Programming

Invited Session

Chair: Tamás Terlaky, Department Chair, Lehigh University, Industrial Engineering Dept., 200 West Packer Ave., Bethlehem, PA, 18015, United States of America, terlaky@Lehigh.edu

Co-Chair: Julio Goez, Postdoctoral Student, GERAD, Universite de Montreal Campus, Montreal, Canada, jgoez1@gmail.com

1 - Using Disjunctive Conic and Cylindrical Cuts in Solving Quantitative Asset Allocation Problems

Sertalp B. Cay, PhD Student, Lehigh University, Dept. Industrial and Systems Engineering, 200 W. Packer Avenue, Bethlehem, PA, 18015, United States of America, sec312@lehigh.edu, Tamas Terlaky, Julio Gòez

The novel methodology of disjunctive conic and cylindrical cuts (DCC) was developed recently to solve mixed integer second order cone optimization (MISOCO) problems. First steps are made in implementing this powerful methodology in a Branch-and-Conic-Cut software package. In this talk we demonstrate the usefulness of this novel methodology in solving asset allocation problems that are modeled as MISOCO. Preliminary numerical results show that DCCs have significant positive impact when solving sets of realistic problem instances.

2 - On Disjunctive Conic Cuts: When They Exist, When They Cut?

Mohammad Shahabsafa, PhD Student, Lehigh University, Dept. Industrial and Systems Engineering, 200 W. Packer Avenue, Bethlehem, PA, 18015, United States of America, mos313@lehigh.edu

The development of Disjunctive Conic Cuts (DCCs) for MISOCO problems has recently gained significant interest in the optimization community. Identification of cases when DCCs are not existing, or not useful, saves computational time. In this study, we explore cases where either the DCC methodology does not derive a DCC which is cutting off the feasible region, or a DCC does not exist. Among others, we show that reformulating a p-order cone with a set of second order cones and then deriving DCC for the resulting MISOCO does not cut off the feasible region of the reformulated problem, while deriving DCCs directly for p-order cone optimization problems seems to be impossible.

3 - A Polynomial Primal-Dual Affine Scaling Algorithm for Symmetric Conic Optimization

Ali Mohammad Nezhad, PhD Student, Lehigh University, Dept. Industrial and Systems Engineering, 200 W. Packer Avenue, Bethlehem, PA, 18015, United States of America, alm413@Lehigh.EDU, Tamas Terlaky

The primal-dual Dikin-type affine scaling method was originally proposed for linear optimization and then extended to semidefinite optimization. Here, we generalize the method to symmetric conic optimization using the notion of Euclidean Jordan algebras. The method starts with a feasible but not necessarily centered primal-dual solution and features simultaneously centering and reducing the duality gap. The method's iteration complexity bound is analogous to the semidefinite optimization case.

■ WC14

14- Traders

Theory of Games involving Networks, Uncertainty and Computations in Static Games

Cluster: Game Theory

Invited Session

Chair: Vikas Vikram Singh, Post-Doc, Université Paris Sud, Laboratoire de Recherche en Informatique, Bat 650 Ada Lovelace, Orsay, 91405, France, vikas.singh@lri.fr

1 - A Polynomial Time Algorithm for Rank-1 Two Player Games (Despite Disconnected Solutions)

Ruta Mehta, Georgia Institute of Technology, 266 Ferst Drive, KACB, Room 2111, Atlanta, GA, 30332, United States of America, rmehta@gatech.edu, Bharat Adsul, Jugal Garg, Milind Sohoni

A finite two-player game is represented by two matrices (A,B), one for each player. The rank of such a game is defined as rank(A+B). Finding Nash equilibrium (NE) in zero-sum games, i.e., rank 0, reduces to linear programming (von Neumann'28). We solve the open question of Kannan and Theobald (2005) of designing an efficient algorithm for rank-1 games, where the main difficulty is disconnected solution set. We circumvent this by moving to a space of rank-1 games which contains our game (A, B), and defining a quadratic program whose optimal solutions are NE of all games in this space. We then isolate the Nash equilibrium of (A, B) as the fixed point of a single variable function which can be found in polynomial time via a binary search.

2 - Rationing Problems in Bipartite Networks

Jay Sethuraman, Columbia University, 500 West 120th Street, 314 S.W. Mudd Building, New York, NY, 10027, United States of America, jay@ieor.columbia.edu

In the bipartite rationing problem, a set of agents share a single resource available in different types, each agent has a claim over only a subset of the resource-types, and these claims overlap arbitrarily. The goal is to divide fairly the various types of resource between the claimants. We consider generalizations of standard rationing methods to the network context, and characterize the solutions using compelling axioms used in the economics literature on rationing. I will focus on two standard requirements—-truthfulness and consistency—-and discuss ways of extending standard rationing methods to the network setting while satisfying these properties (Joint work with Moulin, Ilkilic, Bochet, Chandramouli).

3 - Existence of Nash Equilibrium for n-Player Games with Random Payoffs

Vikas Vikram Singh, Post-Doc, Université Paris Sud, Laboratoire de Recherche en Informatique, Bat 650 Ada Lovelace, Orsay, 91405, France, vikas.singh@lri.fr, Oualid Jouini, Abdel Lisser

We consider n-player static games where each player has finite number of actions. Unlike the extensively studied case in the literature where the payoffs of all players are deterministic, we consider the situation where the payoffs of each player are random variables and follow a multi-normal distribution. We show that there always exists a mixed strategy Nash equilibrium. For two player games, where one row of row player's payoff matrix and one column of column player's payoff matrix are independent normal random variables, we develop an optimization problem and show the one-to-one correspondence between a Nash equilibrium of the game and a global minimum of the optimization problem.

■ WC15

15- Chartiers

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

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

Invited Session

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

1 - Strong Optimality Conditions for Optimization Problems with VI Constraints of the 2nd Kind

Juan Carlos De los Reyes, MODEMAT, Quito, Ecuador, juan.delosreyes@epn.edu.ec, Christian Meyer

We investigate optimality conditions for optimization problems constrained by a class of variational inequalities of the second kind. Based on a nonsmooth primal-dual reformulation of the governing inequality, the differentiability of the solution map is studied. Directional differentiability is proved both for finite-dimensional problems and problems in function spaces, under suitable assumptions on the active set. A characterization of Bouligand and strong stationary points is obtained thereafter. Finally, based on the obtained first-order information, trust-region algorithms are proposed for the solution of the optimization problems.

2 - Instantaneous Control of an EWOD Model with Complementarity-based Contact Line Pinning

Harbir Antil, Assistant Professor, George Mason University, 4400 University Drive, MS: 3F2, Exploratory Hall, room 4201, Fairfax, VA, 22030, United States of America, hantil@gmu.edu

A time-discrete spatially-continuous electrowetting on dielectric (EWOD) model with contact line pinning is considered as the state system in an optimal control framework. The pinning model is based on a complementarity condition. The associated optimal control problem thus becomes a mathematical optimization problem with equilibrium constraints in function space. In addition to the physical variables describing velocity, pressure, and voltage, the solid-liquid-air interface, i.e., the contact line, arises as a geometric variable that evolves in time. Primal first-order optimality and dual stationarity conditions are derived, respectively, using techniques from non-smooth optimization and set-valued analysis for each time step.

3 - A Vanishing Viscosity Based Relaxation-Regularization Method for MPCC's with Hyperbolic Operators

Nikolai Strogies, Humboldt-Universitaet zu Berlin, Unter den Linden 6, 10099 Berlin, Berlin, Germany, strogies@math.hu-berlin.de

The existence of solutions to a minimization problem subject to complementarity constraints involving a non-stationary linear hyperbolic first order differential operator will be discussed for a certain class of objective functionals. Stationarity conditions will be derived using a vanishing viscosity regularization of the operator and a penalization-relaxation technique for the complementarity constraint. Further a solution algorithm will be presented. The theoretical results will be illustrated by numerical experiments using conforming finite elements.

■ WC16

16- Sterlings 1

Advances in Integer Programming VI

Cluster: Integer and Mixed-Integer Programming

Invited Session

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

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

1 - Proximity Benders: A Decomposition Heuristic for Stochastic Programming

Matteo Fischetti, Prof., University of Padua, via Gradenigo 6/A, Padova, PD, 35126, Italy, matteo.fischetti@unipd.it, Natashia Boland, Michele Monaci, Martin Savelsbergh

Stochastic Programming models are typically solved through Benders decomposition, a dual solution method where a sequence of infeasible (super-optimal) solutions are generated until a first feasible solution is eventually found and the method terminates. As convergence may require a very large computing time, the method is quite unsatisfactory from a heuristic point of view. Proximity search is a recently-proposed heuristic paradigm, producing a sequence of feasible solutions of improved value. In this paper we investigate the use of proximity search as a tactical tool to drive Benders decomposition, and computationally evaluate its performance as a heuristic on different classes of stochastic programming problems.

2 - TU Representation of Matrices

Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zürich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch, Rico Zenklusen, Robert Hildebrand, Joerg Bader

Call a matrix A to have a TU representation V,W if [V,W] is TU and there exists an integral matrix U such that A = V + U W. We connect the TU representation of matrix A to the number of integer variables that are required to represent the integer programming problem Ax <= b, x integral. For instance, every binary knapsack master problem in n variables has a TU representation that allows us to reformulate the problem as mixed integer optimization problem in only sqrt(n) integral variables.

3 - Relationships between Simple Intersection Cuts, L&P Cuts, and Generalized Intersection Cuts

Tamas Kis, Institute for Computer Science and Control, Kende utca 13-17, Budapest, 1111, Hungary, kis.tamas@sztaki.mta.hu, Egon Balas

We examine the connections between the classes of cuts in the title. We show that lift-and-project (L&P) cuts are equivalent to generalized intersection cuts (GICs) obtained from positive combinations of the complements of the inequalities of each term of the disjunction. Moreover, we give necessary and sufficient conditions for an L&P cut to be equivanet to a SIC. We also show that L&P cuts from more general disjunctions than a split may not be equivalent to any SIC, which is in strong contrast with L&P cuts from a split which are known to be equivalent to SICs from the corresponding strip. We also give a numerical example for a MIP and a L&P cut which is not valid for any corner polyhedron obtained from any basis of the LP relaxation.

■ WC17

17- Sterlings 2

Nonlinear Optimization Algorithms

Cluster: Nonlinear Programming

Invited Session

Chair: Daniel P. Robinson, 3400 N. Charles Street, Baltimore, MD, 21218, United States of America, daniel.p.robinson@gmail.com

1 - Handling Negative Curvature in Gradient Methods for Unconstrained and Bound Constrained Optimization

Wei Guo, Lehigh University, 200 W Packer Ave, Bethlehem, United States of America, weg411@lehigh.edu, Frank E. Curtis

A gradient-descent method is proposed for unconstrained and bound constrained nonlinear optimization. Emphasis is placed on techniques for computing appropriate step sizes when negative curvature is present. The method extends the well-known Barzilai Borwein "two-point step size" method, its variants and gradient projection methods for unconstrained and bound constrained optimization, respectively. Global convergence is guaranteed under mild assumptions. Numerical results are presented to illustrate the benefits of the method in the presence of negative curvature.

2 - A QP Solver for Nonconvex Bound-Constrained Problems (NC-BCQP)

Hassan Mohy-ud-Din, Postdoctoral Associate (Yale, March 2015-), Johns Hopkins University (2009-15), Yale University (2015-), New Haven, New Haven, CT, United States of America, mohyuddin.engineer@gmail.com, Rachael E. H. Tappenden, Daniel P. Robinson

We present an active-set algorithm for finding a local minimizer to NC-BCQP. Our algorithm extends ideas developed by Dostal and Schoberl that is based on the linear CG algorithm for (approximately) solving a linear system with a positive-definite coefficient matrix. This is achieved by making two key changes. First, we perform a line search along negative curvature directions when they are encountered in the linear CG iteration. Second, we use Lanczos iterations to compute approximations to leftmost eigen-pairs, which is needed to promote convergence to points satisfying certain second-order optimality conditions. We prove convergence guarantees for the proposed algorithm, as well as demonstrate its robustness and efficiency on NC-BCQP.

3 - Approximate Inverse Preconditioning Strategies based on Krylov-Subspace Methods

Giovanni Fasano, Assistant Professor, University Ca'Foscari of Venice, Department of Management, S. Giobbe, Cannaregio 873, Venice, VE, 30121, Italy, fasano@unive.it, Massimo Roma

We propose a class of preconditioners for symmetric linear systems and sequences of linear systems. Our preconditioners are specifically suited for large indefinite linear systems and may be obtained as by-product of Krylov-subspace solvers. Each preconditioner in our class is identified by setting the values of some parameters and possibly scaling matrices. We provide theoretical properties of our preconditioners, including a discussion on the relation with LMP preconditioners by Gratton et al. Several new numerical results are also included, and a natural extension to a Preconditioned Nonlinear Conjugate Gradient method is proposed, showing the versatility of our approach.

■ WC18

18- Sterlings 3

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Joe Naoum-Sawaya, IBM Research, Damastown Industrial Estate, Dublin 15, Ireland, jnaoumsa@uwaterloo.ca

1 - A Benders and Cut Procedure for Supply Chain Design Problem

Defeng Sun, Northeastern University, China, 300 Gooding Way Apt 302, Albany, CA, 94706, United States of America, cdfsun@gmail.com, Lixin Tang

A Benders and Cut procedure is investigated for the supply chain design problem, based on the integration of algorithms such as Branch & cut, Lagrangian relaxation and Benders decomposition.

2 - Robust Critical Node Selection by Benders Decomposition

Joe Naoum-Sawaya, IBM Research, Damastown Industrial Estate, Dublin 15, Ireland, jnaoumsa@uwaterloo.ca, Christoph Buchheim

The critical node selection problem (CNP) seeks to determine the nodes to delete in a graph to minimize the number of connected pairs in the resulting residual network. In several applications, the weights on the connections are either uncertain or hard to estimate so recently robust optimization approaches have been considered for CNP. In this presentation, we address very general uncertainty sets, only requiring a linear optimization oracle for the set of potential scenarios. In particular, we can deal with discrete scenario based uncertainty, Gamma-uncertainty, and ellipsoidal uncertainty. For this general class of robust CNP, we propose an exact solution method based on Benders decomposition and provide extensive computational results.

3 - Heuristics for the Bin Packing Problem with Conflicts

Federico Pousa, Universidad de Buenos Aires, Ciudad Universitaria - Pabellon 1, Buenos Aires, Argentina, fedepousa@gmail.com, Isabel Mendez-Diaz, Paula Zabala

In the bin packing problem with conflicts, the aim is to assign items into the minimum number of bins subject to the fact that certain pairs of items cannot be assigned to the same bin. We propose an ILP formulation and several heuristics for the problem and we compare them to existing ones in the literature. The comparison shows that our approach outperforms the previous approximations in several benchmark instances.

■ WC19

19- Ft. Pitt

Decision Diagrams in Optimization II

Cluster: Constraint Programming

Invited Session

Chair: John Hooker, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States of America, jh38@andrew.cmu.edu

1 - Decision Diagrams for Efficient Inference and Optimization in Expressive Continuous Domains

Scott Sanner, Oregon State University, 1148 Kelley Engineering Center, Corvallis, OR, 97331, United States of America, ssanner@gmail.com

I will introduce an extension of the algebraic decision diagram (ADD) to continuous variables — termed the extended ADD (XADD) — to represent arbitrary piecewise functions and show how to define and efficiently compute elementary arithmetic operations, integrals, and maximization for various restrictions of these functions. Following this, I will briefly cover a wide range of applications where the XADD has yielded novel closed-form solutions: (a) probabilistic inference in hybrid graphical models, (b) parametric constrained optimization, and (c) continuous state, action, and observation sequential decision-making problems.

2 - Verifying Power Distribution Network with ZDDs

Takeru Inoue, NTT, Hikarinooka 1-1, Yokosuka, Japan, inoue.takeru@lab.ntt.co.jp, Norihito Yasuda, Yuji Takenobu, Shin-ichi Minato, Yasuhiro Hayashi, Shunsuke Kawano

Power distribution networks should be restored by reconfiguring switches automatically, given several feeders are interrupted in a severe accident. The network's design has to guarantee that it is restorable under any possible failure, but it is a computationally hard task to examine all possible failures. This paper proposes a novel ZDD method to find all the critical (unrestorable) line cuts with great efficiency to verify the network design. The method includes a fast screening algorithm based on hitting set enumeration, which is often used in data-mining. Thorough experiments reveal that the proposed method can find thousands of unrestorable cuts from the trillions of possible cuts in a large 432-Bus network.

3 - Toward Stochastic Optimization with Decision Diagrams

John Hooker, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States of America, jh38@andrew.cmu.edu

Relaxed decision diagrams have recently proved a useful alternative to the linear relaxation in the solution of combinatorial optimization problems. They allow problems with recursive formulations to be solved by branch-and-bound search within the relaxed diagram, without enumerating the state space. This talk presents underlying theory for extending this approach to stochastic optimal control. It defines the idea of a stochastic decision diagram and proposes a scheme for relaxing a diagram based on flow-path decomposition. This leads to a general concept of relaxation in stochastic dynamic programming.

■ WC20

20- Smithfield

Recent Advances in ADMM II

Cluster: Nonsmooth Optimization

Invited Session

Chair: Bingsheng He, Professor, Nanjing University, Department of Mathematics, Nanjing Unive, Nanjing, China, hebma@nju.edu.cn

1 - On the Proximal Alternating Direction Method of Multipliers

Caihua Chen, Dr., Nanjing University, 22 Hankou Road, Nanjing, China, chchen@nju.edu.cn

In this talk, we consider the use of the proximal alternating direction method of multipliers to solve linearly constrained separable programming problems. We first review and develop some convergence and complexity analysis results of the algorithm for convex programming. We also discuss some variants of PADMM, including the inertial PADMM and Bregaman ADMM, for convex programming and extend the algorithm to solve some specific nonconvex programming problems.

2 - The Direct Extension of ADMM for Three-Block Separable Convex Problems when one is Strongly Convex

Xingju Cai, Dr., Nanjing Normal University, caixingju@njnu.edu.cn, Xiaoming Yuan, Deren Han

ADMM is a benchmark for solving a two-block linearly constrained convex minimization model. It is known that the convergence is not guaranteed if the ADMM is directly extended to a three-block convex minimization model. While the original scheme of the direct extension of ADMM works for some applications and under some realistic conditions its convergence can be guaranteed. We give some results for the three-block case and show that when one of them is strongly convex, the direct extension of ADMM is convergent. Note that the strong convexity of one function does hold for many applications. We further estimate the worst-case convergence rate measured by the iteration complexity in both the ergodic and nonergodic senses.

■ WC21

21-Birmingham

Optimization and Variational Problems with Applications II

Cluster: Multi-Objective Optimization

Invited Session

Chair: Akhtar Khan, Associate Professor, Rochester Institute of Technology, Center for Applied and Comp. Math., School of Mathematical Sciences, Rochester, NY, 14623, United States of America, aaksma@rit.edu

Co-Chair: Christiane Tammer, Professor, Martin-Luther-University of Halle-Wittenberg, Institute of Mathematics, Halle-Salle, Germany, christiane.tammer@mathematik.uni-halle.de

Co-Chair: Baasansuren Jadamba, Rochester Institute of Technology, School of Mathematical Sciences, Rochester, NY, 14623, United States of America, bxjsma@rit.edu

1 - On Set-Valued Optimization Problems with Variable Ordering Structure

Christiane Tammer, Professor, Martin-Luther-University of Halle-Wittenberg, Institute of Mathematics, Halle-Salle, Germany, christiane.tammer@mathematik.uni-halle.de, Marius Durea, Radu Strugariu

We introduce and investigate an optimality concept for set-valued optimization problems with variable ordering structure. In our approach, the ordering structure is governed by a set-valued map acting between the same spaces as the objective multifunction. Necessary optimality conditions for the proposed problem are derived in terms of Bouligand and Mordukhovich generalized differentiation objects.

2 - Second-Order Sensitivity Analysis in Set-Valued Optimization

Douglas Ward, Professor, Miami University, Dept of Mathematics, Bachelor Hall, Oxford, OH, 45056, United States of America, wardde@miamioh.edu

In parametric nonlinear programming, second-order directional derivatives of the value function can be estimated in terms of the problem data. This paper explores how such estimates might be extended to a multiobjective, set-valued setting. We obtain estimates for the second-order contingent and adjacent derivatives of the epigraph of the “value multifunction” for a parametrized family of set-valued optimization problems.

3 - On Evolutionary and Elliptic Quasi Variational Inequalities

Akhtar Khan, Associate Professor, Rochester Institute of Technology, Center for Applied and Comp. Math., School of Mathematical Sciences, Rochester, NY, 14623, United States of America, aaksma@rit.edu

This talk will focus on some new existence and stability results for evolutionary and elliptic quasi-variational inequalities. This work is based on a joint work with Prof. Dumitru Motreanu.

■ WC22

22- Heinz

Contributions to Variational Analysis

Cluster: Variational Analysis

Invited Session

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

1 - Strong Convergent Tseng’s Algorithm for Solving Monotone Inclusions

Luis Briceño-Arias, Assistant Professor, Universidad Tècnica Federico Santa Marìa, Av. Vicuna Mackenna 3939, San Joaquin, Santiago, RM, 8940897, Chile, luis.briceno@usm.cl

The Tseng’s algorithm allows us to solve the problem of finding a zero of the sum of a set-valued maximally monotone operator and a single-valued monotone lipschitzian operator in a Hilbert space setting. The algorithm provided by Tseng generates a sequence converging weakly to a solution and strong convergence is guaranteed only under additional assumptions. In this talk we provide a strongly convergent version of Tseng’s method without additional assumptions. Inspired from the work of Haugauzaeau, we include additional projections to appropriate half spaces which guarantees the strong convergence of the iterates to the projection of the initial point onto the solution set. Some applications are examined.

2 - Sensitivity Analysis of Solution Maps to Parameterized Equilibria with Conic Constraints

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

We present new calculations of the graphical derivative, limiting coderivative and others generalized derivatives for the solution map to parameterized KKT systems associated with conic constraints. These computations are first derived provided the feasible set appearing in the KKT system is convex. They provide verifiable conditions for sensitivity properties (e.g., isolated calmness) of the corresponding solution map. We are able to extend the computation of the graphical derivative to the nonconvex case. The latter requires, however, an additional condition of geometric nature imposed on the considered cone.

3 - Large Sample Properties of an Optimization-Based Matching Estimator

Jorge Rivera, Universidad de Chile, DECON, Diagonal Paraguay 257, Santiago, Chile, jrivera@econ.uchile.cl, Roberto Cominetti, Juan Diaz

This paper studies the asymptotic properties of a new non-parametric matching estimator, which is based on the solution of a bi-level optimization problem. We show that this estimator of the average treatment effect attains the standard limit properties, with a rate of convergence of its conditional bias that improves the one obtained by Abadie & Imbens (2006) for the well-known nearest neighbor matching estimator.

■ WC23

23- Allegheny

Nonconvex Sparse Optimization

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Ting Kei Pong, The Hong Kong Polytechnic University, The Hong Kong Polytechnic University, Hong Kong, Hong Kong - PRC, tk.pong@polyu.edu.hk

1 - A Block Coordinate Descent Approach for Orthogonal Constrained Optimization Problems

Xin Liu, Associate Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, ICMSEC510, 55, Zhong Guan Cun East Road, Beijing, China, liuxin@lsec.cc.ac.cn, Ya-xiang Yuan, Xiaojun Chen

In this presentation, we introduce a special block coordinate descent framework for minimizing a nonconvex objective with orthogonal constraints. In this framework, each subproblem can be solved either exactly, when the computational cost is same as solving a trust-region subproblem, or inexactly, when sufficient reduction can be brought by taking a closed-form solution. Global convergence for this approach is established. Preliminary experiments illustrate that this new proposed approach performs well and is of great potential.

2 - Property of a Relaxation Scheme for Rank Constrained Optimization Problems

Xin Shen, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY, 12180, United States of America, shenx5@rpi.edu, John Mitchell

Recently rank constrained optimization problems have received increasing interest because of their wide application in many fields such as communication and signal processing. This class of problems has been considered computationally challenging because of its nonconvex nature. In this talk we focus on a mathematical program with semidefinite cone complementarity constraints (SDCMPCC) formulation of the class. We'll consider a relaxation scheme for the formulation and discuss its properties including constraint qualification, stationary conditions and local optimality.

3 - Splitting Methods for Nonconvex Feasibility Problems

Ting Kei Pong, The Hong Kong Polytechnic University, The Hong Kong Polytechnic University, Hong Kong, Hong Kong - PRC, tk.pong@polyu.edu.hk

We discuss the Douglas Rachford and the Peaceman Rachford splitting methods, which have been extensively studied in the convex scenario, for finding the intersection of a closed convex set and a possibly nonconvex closed set. We establish global convergence of the sequence generated to a stationary point of a certain optimization problem under mild assumptions on the sets and the stepsize. Our convergence analysis relies on a specially constructed new merit function. We also compare numerically the splitting methods with the alternating projection method on finding sparse vectors in an affine set. This is joint work with Guoyin Li.

■ WC24

24- Benedum

Mixed-Integer Nonlinear Optimal Control and Traffic I

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Sebastian Sager, Prof. Dr., Otto-von-Guericke Universitaet Magdeburg, Universitaetsplatz 2, Magdeburg, 39106, Germany, sager@ovgu.de

1 - Approximation Properties of Complementarity Constrained Problems in Mixed-integer Optimal Control

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

We take interest in solving mixed-integer optimal control problems (MIOCPs) that arise in process control and show significant potential for optimization. A framework based on partial outer convexification that results in an MPCC formulation has been proposed to solve MIOCPs efficiently. We show that this framework has an approximation property that results in feasibility and optimality certificates. After discretization, we may also efficiently compute approximate solutions. We propose a new sum-up rounding scheme required to maintain feasibility in the presence of complementarity constraints. We establish tight lower bounds for this approximation scheme that improve upon the best proven bounds for sum-up rounding.

2 - Continuous Stationarity Conditions for Hybrid System Model Predictive Control Problems

Andreas B. Hempel, ETH Zurich, Physikstrasse 3, Zurich, 8092, Switzerland, hempel@control.ee.ethz.ch, John Lygeros, Paul Goulart

Recent results in inverse parametric optimization enable us to represent continuous piecewise-affine (PWA) dynamical systems as optimizing processes. This alternative description makes use of a convex decomposition of the PWA dynamics and can be used to represent the system dynamics without resorting to binary variables to encode the different regions. We exploit this new representation to cast Model Predictive Control problems as mathematical programs with complementarity constraints. The structure inherited from the construction of the optimizing process description leads to strong stationarity conditions for the solutions to these optimization problems.

3 - Optimization of Vehicular Traffic at Traffic Light Intersections

Stephan Sorgatz, Volkswagen AG, Letterbox 011/1896, Wolfsburg, 38436, Germany, stephan.sorgatz@volkswagen.de, Sebastian Sager

Traffic light controlled intersections have a strong impact on traffic flow and emissions. High potential lies in influencing a driver's individual behaviour. We use C2X-Technology to gain knowledge about the signal phases and other relevant information in advance in order to plan and control a vehicle's velocity while approaching a traffic light. Furthermore we are interested in the idea of a junction without any regulation via traffic lights or right of way. We present a Mixed Integer Linear Problem and show first results and solving times.

■ WC25

25- Board Room

Approximate Dynamic Programming for Managing Energy Operations

Cluster: Optimization in Energy Systems

Invited Session

Chair: Selvaprabu Nadarajah, Assistant Professor of Operations Management, College of Business, University of Illinois at Chicago, 601 South Morgan Street, Chicago, IL, 60607, United States of America, selvan@uic.edu

1 - Adaptive Routing and Recharging Policies for Electric Vehicles

Irina Dolinskaya, Assistant Professor, McCormick School of Engineering and Applied Science, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States of America, dolira@northwestern.edu, Diego Klabjan, Timothy Sweda

Recharging costs for an electric vehicle (EV), which increase as the battery's charge level increases, are fundamentally different than for conventional vehicles. Furthermore, the availability of charging stations along the way must be considered. We study the problem of finding an optimal routing and recharging policy for an EV in a grid network. We develop and analyze a variety of models depending on the amount and timing of information available to the EV driver while traveling.

2 - SDDP vs. ADP: Stochastic Optimization for Grid-Level Energy Storage

Warren Powell, Professor, Princeton University, ORFE, Princeton, NJ, 08544, United States of America, powell@princeton.edu, Tsvetan Asamov

In this work we consider the application of grid-level energy storage for the integration of renewable energy from off-shore wind farms into the power grid. We manage the set of storage devices in a coordinated fashion, and explore the application of different methodologies for approximating the solution of the resulting stochastic optimization problem. We perform computational experiments to analyze the performance of the system for various storage configurations and characteristics of the information state, and examine the sensitivity of the storage profile with respect to the size and efficiency of the batteries.

3 - Quasi-Convex Dynamic Programming Approximations

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

Typical dynamic energy problems involve states that evolve according to both controls (e.g., inventory) and exogenous variables (e.g., prices). The combination often leads to quasi-convex relationships. This talk will describe the use of dynamic programming approximations adapted for quasi-convex value functions.

■ WC26

26- Forbes Room

Computational Advances in Stochastic Programming

Cluster: Stochastic Optimization

Invited Session

Chair: Ignacio Grossmann, R. Dean University, Professor, Carnegie Mellon University, Doherty Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, grossmann@cmu.edu

1 - Structure and Algorithms for Dominance Constraints Induced by Stochastic Programs with Recourse

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

Stochastic dominance constraints are flexible tools for bounding risk with respect to benchmark distributions. As with other stochastic programs underlying probability distributions often are subjective or coming from approximations. This raises questions of stability when approximating the distributions, as done in solution methods. We will discuss both algorithmic techniques relying on decomposition and recent results on metric regularity of constraint sets.

2 - A Cross-Decomposition Scheme for Two-Stage Mixed-Integer Stochastic Programming Problems

Pablo Garcia-Herreros, PhD Student, Carnegie Mellon University, Doherty Hall, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, pgarciah@andrew.cmu.edu, Sumit Mitra, Ignacio Grossmann

We describe a cross decomposition algorithm that combines Benders and Lagrangean decomposition for two-stage stochastic programs with mixed-integer first-stage and continuous second-stage decisions. The algorithm integrates primal and dual information with multi-cuts added to the Benders and Lagrangean master problems. The benefits are demonstrated with several instances of a facility location problem with disruptions. In the original formulation with weak LP relaxation, the cross-decomposition method outperforms multi-cut Benders decomposition. If the formulation is strengthened with tightening constraints, the performance of both decomposition methods improves but cross decomposition remains the fastest method for large-scale problems.

3 - An Algorithm for Multistage Mixed Nonlinear Convex Stochastic Problems

Eugenio Mijangos, University of the Basque Country (UPV/EHU), Sarriena s/n, Dept. de Mat. Aplic. y Est, Leioa, Spain, eugenio.mijangos@ehu.es

An algorithm for solving multistage mixed 0-1 stochastic problems with nonlinear convex objective function and convex constraints is presented. These problems have continuous and binary variables in each stage. The algorithm is based on the Branch-and-Fix Coordination method. As constraints are convex we approximate them by means of outer linear approximations. Each convex problem generated in the nodes of the trees of this method is solved by solving sequences of quadratic problems. It has been implemented in C++ with the help of Cplex 12.1 to solve quadratic approximations. Test problems have been randomly generated by a C++ code. Numerical experiments have been performed and its efficiency has been compared with that of BONMIN.

■ WC27

27- Duquesne Room

Network Design II

Cluster: Combinatorial Optimization

Invited Session

Chair: Jochen Könemann, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada, jochen@uwaterloo.ca

1 - Approximating Minimum Cost Connectivity Orientation and Augmentation

Laszlo Vegh, London School of Economics, Houghton street, London, WC2A 2AE, United Kingdom, L.Vegh@lse.ac.uk, Mohit Singh

We investigate problems addressing combined connectivity augmentation and orientations settings. We give a polynomial time 6-approximation algorithm for finding a minimum cost subgraph of an undirected graph G that admits an orientation covering a nonnegative crossing G-supermodular demand function. An important example is (k, l)-edge-connectivity. Our algorithm is based on a non-standard application of the iterative rounding method, requiring a new type of uncrossing on partitions and co-partitions. We also consider the problem setting when the cost of an edge can be different for the two possible orientations. We disprove an earlier conjecture by Khanna, Naor and Shepherd, showing a large integrality gap already in simple settings.

2 - Stochastic Budgeted Allocation with Traffic Spikes

Hossein Esfandiari, University of Maryland & Google Research, A.V. Williams Bldg, College Park, 20742, United States of America, esfandiari.hossein@gmail.com, Vahab Mirrokni, Nitish Korula

Motivated by Internet advertising applications, online allocation problems have been studied extensively in various adversarial and stochastic models. While the adversarial arrival models are too pessimistic, many of the stochastic arrival models do not realistically capture uncertainty in predictions. A significant cause for such uncertainty is the presence of unpredictable traffic spikes, often due to breaking news or similar events. In this work, we propose a robust online stochastic model that captures the nature of traffic spikes in online advertising, and design algorithms that adaptively reacts to inaccurate predictions. We provide provable almost tight bounds for our new algorithms in this framework.

3 - A 1.93-Approximation Algorithm for Submodular PCST on Bounded Treewidth Graphs

Wai Shing Fung, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada, wsfung@uwaterloo.ca, Takuro Fukunaga, Jochen Koenemann

Chekuri et al. and Bateni et al. showed that Prize-Collecting Steiner Tree(PCST) and Prize-Collecting Steiner Forest(PCSF) on planar graphs can be reduced to the same problems on bounded treewidth graphs and gave exact algorithms for PCST on these graphs, thus settling the hardness status of planar PCST. However, for PCSF on bounded treewidth graphs, we don't have an algorithm better than the 2.54-approximation for general graphs. Motivated by this, we consider the closely related Rooted PCSF problem and its generalization, the Submodular PCST problem. We introduced a new tree based LP formulation for Submodular PCST and gave an 1.93-approximation rounding algorithm for Submodular PCST on bounded treewidth graphs.

■ WC28

28- Liberty Room

Special Problems in Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Alexander Mitsos, Professor, Turmstrasse 46, Aachen, Germany, amitsos@alum.mit.edu

1 - A Bundle Algorithm for Solving Bilevel Optimization Problems

Susanne Franke, TU Bergakademie Freiberg, Nonnengasse 22, DG-09, Freiberg, 09596, Germany, susanne.franke@math.tu-freiberg.de, Stephan Dempe

Our basis is the optimistic bilevel programming problem. We apply the optimal value reformulation and assume that all functions are Lipschitz continuous. Using the concept of partial calmness allows us to formulate suitable constraint qualifications. In the talk, an already existing bundle algorithm for convex optimization problems is extended to the nonconvex case such that the method can be applied to our problem. A bundle is a set consisting of trial points, the respective objective function values and a subgradient at every point. The bundle is used for creating an approximation of the original function, and it is updated iteratively such that a sequence of trial points converging to the optimal solution of the problem is constructed.

2 - Convex Envelopes of Product-Separable Edge-Concave Functions

Yannis Guzman, Princeton University, A325 Engineering Quad, Princeton, NJ, United States of America, yguzman@princeton.edu, Christodoulos Floudas

We focus on a broad class of functions which have a vertex polyhedral convex envelope over a polytope domain. A quite general sufficient condition for class membership is to be edge-concave, i.e., to be concave along the edge directions of the domain. We present the explicit convex envelopes of edge-concave functions over a box which are product-separable, a condition which has been conjectured to apply to all non-concave edge-concave functions. The complexity of this diverse class of functions was reduced by defining conditions applicable to component univariate functions. The facets of the convex envelopes of every grouping are then determined explicitly by using the appropriate triangulation of the domain into simplices.

3 - Generalized Semi-Infinite and Bi-Level Programs to Ensure Transmission Electric Grid Security

Stephane Fliscounakis, Research Engineer, RTE/DES, 9 rue de la Porte de Buc, Versailles, France, stephane.fliscounakis@rte-france.com, Patrick Panciatici, Frédérique Verrier

This paper deals with day-ahead security management with respect to a set of contingencies taking into account uncertainties about the next day generation and load. In order to help the system operator, we want to check that no preventive action is required for the worst uncertainty pattern. Two types of optimization are used : discrete bi-level programs for simulation of contingencies, generalized semi-infinite programs for base case analysis.

■ WC29

29- Commonwealth 1

Algorithms for Monotone Variational Inequality and Structured Nonconvex 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 - An Accelerated HPE-Type Algorithm for a Class of Composite Convex-Concave Saddle-Point Problems

Renato Monteiro, Professor, Georgia Tech, School of ISyE, Atlanta, GA, 30338, United States of America, renato.monteiro@isye.gatech.edu, Yunlong He

This talk discusses a new algorithm for solving a class of composite convex-concave saddle-point problems. The new algorithm is a special instance of the hybrid proximal extragradient framework in which a Nesterov's accelerated variant is used to approximately solve the prox subproblems. One of the advantages of the new method is that it works for any constant choice of proximal stepsize. Moreover, a suitable choice of the latter stepsize yields a method with the best known (accelerated inner) iteration complexity for the aforementioned class of saddle-point problems. In contrast to the smoothing technique, our accelerated method does not assume that feasible set is bounded due to its proximal point nature.

2 - Complete Dictionary Recovery over the Sphere

John Wright, Columbia University, 500 W. 120th Street, Room 1312, New York, NY, 10027, United States of America, johnwright@ee.columbia.edu

We consider the problem of recovering a complete dictionary A0, from Y = A0 X0 with Y in R^{n x p}. This recovery setting is central to the theoretical understanding of dictionary learning. We give the first efficient algorithm that provably recovers A0 when X0 has O(n) nonzeros per column, under suitable probability model for X0. Prior results provide recovery guarantees when X0 has only O(n^{1/2}) nonzeros per column. Our algorithm is based on nonconvex optimization with a spherical constraint, and hence is naturally phrased in the language of manifold optimization. Our proofs give a geometric characterization of the high-dimensional objective landscape, which shows that with high probability there are no spurious local minima.

3 - Iteration Bounds for Finding ϵ-Stationary Points for Structured Nonconvex Optimization

Bo Jiang, Assistant Professor, Shanghai University of Finance and Economics, Guoding Road 777, Shanghai, Sh, 200433, China, isyebojiang@163.com, Shuzhong Zhang

In this talk we study proximal conditional-gradient and proximal gradient-projection type algorithms for a block-structured constrained nonconvex optimization model, which arises naturally from tensor data analysis. We introduce a new notion of ϵ-stationarity, which is suitable for the structured problem under consideration. If the gradient of the nonconvex part of the objective f satisfies $\| \nabla f(x) - \nabla f(y)\|_q \le M \|x-y\|_p^\delta$ where $\delta=p/q$ with $1/p+1/q=1$, then we prove that the new algorithms have an overall iteration complexity bound of $O(1/\epsilon^q)$ in finding an ϵ-stationary solution. If f is concave then the iteration complexity reduces to $O(1/\epsilon)$.

■ WC30

30- Commonwealth 2

Approximation and Online Algorithms IX

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Jens Vygen, Professor, University of Bonn, Research Institute for Discrete Math., Lennestr. 2, Bonn, 53113, Germany, vygen@or.uni-bonn.de

1 - Approximation Algorithms for Regret-Bounded Vehicle Routing and Applications

Chaitanya Swamy, University of Waterloo, University of Waterloo, 200 University Avenue West, Waterloo, On, N2L 3G1, Canada, cswamy@uwaterloo.ca, Zachary Friggstad

We consider vehicle-routing problems (VRPs) that incorporate the notion of regret of a client, which is a measure of its waiting time relative to its shortest-path distance from the depot r. We obtain the first O(1)-approximation algorithm for additive-regret-bounded VRP, wherein we seek the fewest number of r-rooted paths that visit all nodes by time at most their shortest-path distance from r + a given regret bound. This also yields improved guarantees for distance-constrained VRP.

2 - Effective Resistance Reducing Flows, Spectrally Thin Trees and Asymmetric TSP

Shayan Oveis Gharan, University of Washington, CSE 636, Box 352350,, University of Washington, Seattle, WA, 94720, United States of America, shayan@cs.washington.edu, Nima Anari

We show that the integrality gap of the natural LP relaxation of the Asymmetric Traveling Salesman Problem (ATSP) is at most polyloglog(n). In other words, there is a polynomial time algorithm that approximates the value of the optimum tour within a factor of polyloglog(n). This is the first significant improvement over the classical O~(log n) approximation factor for ATSP. Our proof builds on recent developments in operator theory, in particular recent resolution of the Kadison Singer conjecture by Marcus, Spielman and Srivastava. In this talk, I will highlight the main ideas of our proof. This is a joint work with Nima Anari.

3 - Reassembling Trees for the Traveling Salesman

Jens Vygen, Professor, University of Bonn, Research Institute for Discrete Math., Lennestr. 2, Bonn, 53113, Germany, vygen@or.uni-bonn.de

Many recent approximation algorithms for variants of the traveling salesman problem exploit the fact that a solution of the natural linear programming relaxation can be written as convex combination of spanning trees. They randomly sample a tree from such a distribution and complete the tree to a tour at minimum cost. We argue that an additional step can help: reassembling the spanning trees before sampling. Exchanging two edges in a pair of spanning trees can improve their properties under certain conditions. We demonstrate the usefulness for the metric s-t-path TSP by devising a deterministic polynomial-time algorithm that improves on Sebo's previously best approximation ratio of 8/5.

Wednesday, 2:45pm - 4:15pm

■ WD01

01- Grand 1

Complementarity/Variational Inequality III

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Uday Shanbhag, Pennsylvania State University, 353 Leonhard Building, University Park, PA, 16802, United States of America, udaybag@psu.edu

1 - Vanishing Duality Gap in Non-Monotone Nearly Separable Variational Inequalities

Mengdi Wang, Princeton University, Sherrerd Hall ORFE, Princeton, NJ, 08544, United States of America, mengdiw@princeton.edu

Consider an n-dimensional VI that is not necessarily monotone. Assume that the objective function is "nearly separable": each component function is determined only by the corresponding component decision and a public variable which is a linear mapping of all decisions. An example is the equilibrium problem of a multi-person game subject to some public resource constraints. We show that an approximate solution to the nearly separable VI exists and can be computed efficiently. The approximation error can be estimated by the lack of monotonicity of the objective but is invariant under scaling the dimension n. This implies that the approximate solution is asymptotically optimal as the dimension n goes to infinity.

2 - A Unified Distributed Algorithm for Nonconvex Noncooperative Games

Meisam Razaviyayn, Stanford University, meisamr@stanford.edu, Jong Shi Pang

This talk introduces a unified framework for the design and analysis of distributed algorithms for computing first-order stationary solutions of non-cooperative games with non-differentiable player objective functions. The unified framework employs convex surrogate functions to handle non-smooth non-convex functions and covers many variants of distributed algorithms such as parallel versus sequential, scheduled versus randomized, and synchronous versus asynchronous transfer of information. We present the convergence analysis based on the contraction and potential approaches and discuss randomized extensions of the algorithms that require less coordination and hence are more suitable for big data problems.

3 - Misspecified Optimization and Variational Inequality Problems

Uday Shanbhag, Pennsylvania State University, 353 Leonhard Building, University Park, PA, 16802, United States of America, udaybag@psu.edu, Hao Jiang

We consider an imperfectly misspecified optimization/variational inequality problem and present recently developed iterative schemes for resolving this misspecification while solving the original problem in deterministic and stochastic regimes. Asymptotic statements and error bounds are provided.

■ WD02

02- Grand 2

Optmization in Energy Systems

Cluster: Optimization in Energy Systems
Invited Session

Chair: Konstantin Vandyshev, Delft University of Technology, Mekelweg 4, Delft, Netherlands, k.vandyshev@tudelft.nl

1 - Contingency Generation by Interior Point Methods for Optimal Power Flow

Andreas Grothey, University of Edinburgh, West Mains Road, Edinburgh, EH9 3JZ, United Kingdom, A.Grothey@ed.ac.uk, Nai-Yuan Chiang

Security Constrained Optimal Power Flow is an important problem for power systems operators. The structure of the problem resembles stochastic programming problems. Due to the presence of AC power flow constraints, the resulting problem is a large scale nonlinear programming problem. However only a small subset of the contingencies is active at the solution. We present an IPM based scheme that starts with a small base problem, generates likely active contingencies on-the-fly and integrates them into the algorithm using warmstarting techniques. The final problem solved by this scheme is significantly smaller than the full problem, resulting in speed gains. Numerical and theoretical results of our algorithm will be presented.

2 - Application of Semidefinite Programming to Secure Constrained Optimal Power Flow Problem

Konstantin Vandyshev, Delft University of Technology, Mekelweg 4, Delft, Netherlands, k.vandyshev@tudelft.nl, Dion Gijswijt, Karen Aardal

Recently, Semidefinite Programming (SDP) has been effectively applied to solve the Optimal Power Flow (OPF) problems. We extend this method to the Security Constrained OPF (SCOPF). Additional security constraints are added to the OPF formulation by applying the Current Injection method to predict the power flow along each line in the network. The SCOPF problem is then solved via SDP relaxation and the obtained results are compared with solutions from conventional optimization approaches.

3 - Tight Formulations for a Thermal Generator

Jim Ostrowski, University of Tennessee, 519 John Tickle Building, Knoxville, TN, 37996, United States of America, jostrows@utk.edu

We describe a polynomial sized convex hull for a thermal generator considering many types of constraints such as minimum up/downtime, startup/shutdown constraints, and ramping constraints. While polynomial, this formulation is very large and not computationally useful. However, it motivates a different formulation than has been used in the literature, one that can lead to significant computational speedups.

■ WD03

03- Grand 3

Discrete Convex Analysis I

Cluster: Combinatorial Optimization
Invited Session

Chair: Akiyoshi Shioura, Tokyo Institute of Technology, Oh-okayama, Meguro-ku, Tokyo, Japan, shioura.a.aa@m.titech.ac.jp

1 - On Polyhedral Approximation of L-convex and M-convex Functions

Kazuo Murota, University of Tokyo, Bunkyo-ku, Tokyo, Japan, murota@mist.i.u-tokyo.ac.jp

In discrete convex analysis, L-convexity and M-convexity are defined for functions in both discrete and continuous variables. Polyhedral L-/M-convex functions connect discrete and continuous versions. Here we show another role of polyhedral L-/M-convex functions: every closed L-/M-convex function in continuous variables can be approximated, uniformly on every compact set, by polyhedral L-/M-convex functions. The proof relies on L-M conjugacy under Legendre-Fenchel transformation.

2 - Some Specially Structured Assemble-to-Order Systems

Paul Zipkin, Professor, Duke University, Durham, NC, United States of America, paul.zipkin@duke.edu

Assemble-to-order systems are important in practice but challenging computationally. This paper combines some notions from combinatorial optimization, namely polymatroids and discrete convexity, to ease the computational burden significantly, for certain specially structured models. We point out that polymatroids have a concrete, intuitive interpretation in this context.

3 - Fixed-dimensional Stochastic Dynamic Programs: An Approximation Scheme and an Inventory Application

Wei Chen, The University of Texas at Dallas, 800 West Campbell Rd, SM30, Richardson, TX, 75080, United States of America, wxc103020@utdallas.edu, Milind Dawande, Ganesh Janakiraman

We study fixed-dimensional stochastic dynamic programs in a discrete setting over a finite horizon. Under the primary assumption that the cost-to-go functions are discrete L-natural convex, we propose a pseudo-polynomial time approximation scheme that solves this problem to within an arbitrary prespecified additive error. The main technique we develop for obtaining our scheme is approximation of a fixed-dimensional L-natural convex function on a bounded rectangular set, using only a selected number of points in its domain. Our approximation scheme is illustrated on a well-known problem in inventory theory, the single-product problem with lost sales and lead times.

■ WD04

04- Grand 4

Convex Conic Optimization: Models, Properties, and Algorithms II

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 - DSOS and SDSOS: More Tractable Alternatives to Sum of Squares and Semidefinite Programming

Anirudha Majumbar, MIT, MIT 32-380 Vassar Street, Cambridge, MA, United States of America, anirudha@mit.edu, Amir Ali Ahmadi, Russ Tedrake

Sum of squares optimization has undoubtedly been a powerful addition to the theory of optimization in the past decade. Its reliance on relatively large-scale semidefinite programming, however, has seriously challenged its ability to scale in many practical applications. In this presentation, we introduce DSOS and SDSOS optimization as more tractable alternatives to sum of squares optimization that rely instead on LP and SOCP. We show that many of the theoretical guarantees of sum of squares optimization still go through for DSOS and SDSOS optimization. Furthermore, we show with numerical experiments from diverse application areas that we can handle problems at scales that are currently far beyond reach for sum of squares approaches.

2 - An Improved Bound for the Lyapunov Rank of a Proper Cone

Muddappa Gowda, Professor of Mathematics, University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore, MD, 21250, United States of America, gowda@umbc.edu, Michael Orlitzky

The Lyapunov rank (also called the bilinearity rank) of a proper cone in an n-dimensional real inner product space is the number of linearly independent Lyapunov-like linear transformations (also called bilinearity relations) needed to express its complementarity set. Such a set arises, for example, in conic optimization in the form of optimality conditions. In any symmetric cone (such as the nonnegative orthant or the semidefinite cone), the rank is at least the dimension of the ambient space and the complementarity set can be described by a square system of independent bilinear relations. With the goal of seeking such `perfect' cones, in this talk, we describe an improved bound for the Lyapunov rank.

3 - On a Generalized Second Order Cone

Roman Sznajder, Professor, Bowie State University, 14000 Jericho Park Road, Bowie, MD, 20715, United States of America, RSznajde@bowiestate.edu

In this paper, we study various properties of a generalized second order cone, considered as a multivariate version of topheavy cone with respect to arbitrary norm in a Euclidean space. Among other properties, we investigate the structure of Lyapunov-like transformations on such a cone and compute its Lyapunov rank.

■ WD05

05- Kings Garden 1

Choosing Optimal Software for Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Margaret Wright, Professor, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, NY, 10012, United States of America, mhw@cs.nyu.edu

1 - Relative Minimization Profiles: A New Benchmarking Tool for Comparing General Optimization Methods

Tim Mitchell, Courant Institute of Mathematical Sciences, New York University, 251 Mercer St., New York, NY, 10012, United States of America, tim.mitchell@cims.nyu.edu, Michael L. Overton, Frank E. Curtis

We propose a new visualization tool called relative minimization profiles for comparing and benchmarking methods for general optimization problems, where there may be constraints and the objective and constraint functions may be nonsmooth and nonconvex. On a collection of heterogenous test problems, relative minimization profiles are able to elucidate the overall relative performances of multiple methods in terms of three metrics simultaneously: amount of objective minimization attained, feasibility error, and speed of progress.

2 - Computational Performance of Solution Techniques Applied to the ACOPF

Richard O'Neill, Federal Energy Regulatory Commission, richard.oneill@ferc.gov, Anya Castillo

We solve the Alternating Current Optimal Power Flow (ACOPF) using Conopt, Ipopt, Knitro, Minos, and Snopt. We report numerical results on various test problems in which we apply various mathematically equivalent ACOPF formulations. We run simulations on starting points that include starting from hot starts, randomized starting points, and the solution to a linearized model as an initialization. Our experimental results indicate a clear advantage to employing a multi-start strategy, which leverages parallel processing in order to solve the ACOPF on large-scale networks for time-sensitive applications.

3 - Choosing Optimal Software for Complicated Nonlinear Problems

Margaret Wright, Professor, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, NY, 10012, United States of America, mhw@cs.nyu.edu

A large amount of information about nonlinear optimization software is available online—-even a Wikipedia article. The associated data come in multiple forms: detailed and extensive battery testing; sets of test problems in a variety of formats; published performance and data profiles; and lists of software in categories defined by problem features, methods, and accessibility. Even so, users seeking to solve complicated problems, especially from real-world applications in which derivatives are lacking, can benefit from additional information that is not easy to discern in the available resources. This talk will illustrate some forms of this added information and discuss strategies for obtaining it.

■ WD06

06- Kings Garden 2

Decision Making Algorithms for Robotic Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Sivakumar Rathinam, Asst. Professor, Texas A & M University, 3123 TAMU, Mechanical Engg, College Station, TX, 77843, United States of America, srathinam@tamu.edu

1 - Tight Lower Bounds for the Dubins Traveling Salesman Problem

Sivakumar Rathinam, Asst. Professor, Texas A & M University, 3123 TAMU, Mechanical Engg, College Station, TX, 77843, United States of America, srathinam@tamu.edu

The Dubins Traveling Salesman Problem (DTSP) has received significant interest over the last decade due to its occurrence in several civil and military surveillance applications. Currently, there is no algorithm that can find an optimal solution to the problem. In addition, relaxing the motion constraints and solving the resulting Euclidean TSP (ETSP) provides the only lower bound available for the problem. However, in many problem instances, this lower bound computed by solving the ETSP is far away from the cost of the best feasible solution available for the DTSP. This talk addresses this fundamental issue and presents the first systematic procedure with computational results for developing tight lower bounds for the DTSP.

2 - Exact Algorithms for Routing Multiple Unmanned Aerial Vehicles with Motion Constraints

Kaarthik Sundar, Texas A&M University, Dept. of Mechanical Engineering, College Station, United States of America, kaarthik01sundar@gmail.com

Unmanned aerial vehicles (UAVs) are being used in several monitoring applications to collect data from a set of targets. Routing a group of UAVs poses novel challenges because of the inherent non-holonomic motion constraints of the UAVs. In this talk, we will introduce exact algorithms for the minimum time motion planning and routing problem for a group of non-holonomic vehicles constrained to move along planar paths of bounded curvature. We will formulate the problem as a mixed integer linear program, study the facial structure of the polytope of feasible solutions and discuss algorithms to solve the the problem to optimality.

3 - State Aggregation based Approximate Dynamic Programming Methods and Bounds

Krishna Kalyanam, Research Scientist, InfoSciTex Corporation, AFRL/RQQA, Dayton, OH, United States of America, krishna.kalyanam@gmail.com, Meir Pachter, Swaroop Darbha

A common approximate dynamic programming method entails state partitioning and the use of linear programming, i.e., the state-space is partitioned and the optimal value function is approximated by a constant over each partition. By minimizing a positive cost function defined on the partitions, one can construct an upper bound for the optimal value function. We show that this approximate value function is independent of the positive cost function and that it is the least upper bound, given the partitions. A novel feature of this work is the derivation of a tractable lower bound via LP and the construction of a sub-optimal policy whose performance improves upon the lower bound.

■ WD07

07- Kings Garden 3

Advances in Integer Programming VII

Cluster: Integer and Mixed-Integer Programming

Invited Session

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

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

1 - Wide Split Disjunctions in MILP - Handling Holes in the Domains of Variables

Sven Wiese, University of Bologna, Viale Risorgimento 2, Bologna, 40136, Italy, sven.wiese@unibo.it, Andrea Tramontani, Andrea Lodi, Pierre Bonami

In MI(N)LP, unlike CP, we are able to express non-contiguous domains by auxiliary variables only. We explore the trade-off between using a black-box solver on such a MILP model on the one hand, and relaxing the constraints describing the arising holes in the domains and handling them algorithmically only, on the other. This is done by tailored branching and cutting planes derived from the wide split disjunctions arising from these holes.

2 - Solving Vertex Coloring Problems as Maximum Weighted Stable Set Problems

Enrico Malaguti, DEI - University of Bologna, Viale Risorgimento 2, Bologna, Italy, enrico.malaguti@unibo.it, Denis Cornaz, Fabio Furini

We solve coloring problems formulated as Maximum Weighted Stable Set Problems on an associated graph. We exploit the transformation proposed by Cornaz and Jost [Operations Research Letters 36 (2008)], where given a graph G, an auxiliary graph G' is constructed, such that the family of all stable sets of G' is in one-to-one correspondence with the family of all feasible colorings of G. We extend the transformation to some generalizations of the Vertex Coloring, and compare the method with the state-of-the art algorithms for the respective problems.

3 - A Theoretical Model of Branching Decisions in a Branch-and-Bound Algorithm

Pierre Le Bodic, H. Milton Stewart School of Industrial & Systems Engineering, Georgia Institute of Technology, 765 Ferst Drive, NW, Atlanta, GA, 30332-0205, United States of America, lebodic@gatech.edu, George Nemhauser

The purpose of this study is to theoretically model the branching decisions of a branch-and-bound algorithm from the dual standpoint. In this model, a variable is defined as a pair of dual gains, and a given dual gap must be closed. In this setting, we prove that minimizing the tree-size is #P-hard. We then consider a simpler model, and prove that there exists a closed-form formula for the tree-size. Early experiments yield promising results.

■ WD08

08- Kings Garden 4

Optimizing Donor Exchanges

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Joris Van de Klundert, Professor, Erasmus University Rotterdam, burg oudlaan 50, M5-29, rotterdam, 3000 DR, Netherlands, vandeklundert@bmg.eur.nl

1 - Robust Models for the Kidney Exchange Problem

Kristiaan Glorie, VU University Amsterdam, De Boelelaan 1081a, Amsterdam, Netherlands, km.glorie@vu.nl, Paul Bouman, Ana Viana, Margarida Carvalho, Miguel Constantino

Kidney exchanges aim to enable transplants between incompatible donor-patient pairs. A set of pairs must be chosen such that each selected patient can receive a kidney from a compatible donor from another pair in the set. The pairs are then notified and final compatibility tests are performed. We study the case in which if a test fails or a partaker withdraws, a new set of pairs may be selected. The new set should be as close as possible to the initial set so as to minimize the material and emotional alteration costs. Various recourse policies that determine the allowed post-matching actions are proposed. For each recourse policy a robust model is developed and techniques are presented to solve exactly the optimization problems in hand.

2 - Combining Human Value Judgments and Machine Learning to Match in Dynamic Environments

John Dickerson, PhD Candidate, Carnegie Mellon University, 9219 Gates-Hillman Center, Pittsburgh, PA, 15213, United States of America, dickerson@cs.cmu.edu, Tuomas Sandholm

Kidney exchange enables patients with kidney failure to swap willing but incompatible donors. Typically, a committee of experts directly creates a matching policy that tries to optimize some objective (e.g., “maximize matches”). We present a framework that takes as input a high-level objective determined by humans, then automatically learns based on data how to make this objective concrete and learns the means to accomplish this goal. We validate our method on real fielded exchange data.

■ WD09

09- Kings Garden 5

Inverse Optimization Theory and Applications

Cluster: Robust Optimization

Invited Session

Chair: Timothy Chan, University of Toronto, 5 King’s College Rd., Toronto, Canada, tcychan@mie.utoronto.ca

1 - Inverse Optimization of Electricity Markets

John Birge, Jerry W. and Carol Lee Levin, Professors of Operations Management, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States of America, john.birge@chicagobooth.edu

Electricity markets provide both prices and quantities for energy and transmission, but many characteristics such as external commitments and specific physical features are not publicly observed. Since the price and quantities result from the primal and dual solutions of an optimization problem, the unknown characteristics can be revealed through inverse optimization. This talk will describe this process and an example with the Midcontinent ISO.

2 - Inverse Optimization in Countably Infinite Linear Programs

Archis Ghate, University of Washington, Box 352650, Seattle, WA, 98195, United States of America, archis@uw.edu

Given the costs and a feasible solution for a linear program, inverse optimization involves finding new costs that are close to the original ones and make the given solution optimal. We present an inverse optimization formulation for countably infinite linear programs (CILPs). Using the absolute sum metric, we reformulate this problem as another CILP. We propose a convergent algorithm, which solves a sequence of finite-dimensional LPs, to tackle this CILP. We apply this to non-stationary Markov decision processes.

3 - Goodness-of-Fit in Inverse Optimization

Timothy Chan, University of Toronto, 5 King’s College Rd., Toronto, Canada, tcychan@mie.utoronto.ca, Taewoo Lee, Daria Terekhov

Inspired by goodness-of-fit in regression, we develop a measure that is comparable to R^2 for inverse optimization. When there is imperfect fit between model and data in inverse optimization, minimizing the error in the fit (e.g., duality gap) is one way to impute the desired model parameters. We begin with a general framework for inverse linear optimization that specializes into different formulations depending on the specific measure of error. For each, we develop a goodness-of-fit measure that retains many of the attractive properties of R^2: it takes on values in [0,1], is non-decreasing in the number of parameters to be imputed, and is maximized when applied to its corresponding model variant.

■ WD10

10- Kings Terrace

Nonlinear Financial Optimization

Cluster: Finance and Economics

Invited Session

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

1 - A Robust Perspective on Transaction Costs in Portfolio Selection

Victor DeMiguel, Professor, London Business School, avmiguel@london.edu, Alba V. Olivares Nadal

We show that transaction costs can result in portfolios that are robust with respect to estimation error. Theoretically, we show that the portfolio optimization problem with transaction costs is equivalent to: (i) a robust portfolio optimization problem, (ii) a robust regression problem, and (iii) a Bayesian portfolio problem. Empirically, we propose a data-driven approach to portfolio selection. Specifically, we show how the transaction cost term can be calibrated to compute portfolios that are both efficient in terms of turnover, and robust with respect to estimation error. We demonstrate using five different empirical datasets that the proposed data-driven portfolios attain good out-of-sample performance.

2 - Risk-Budgeting Multi-Portfolio Optimization with Portfolio and Marginal Risk Constraints

Ran Ji, PhD Candidate, George Washington University, 2201 G St, NW, Funger Hall 415, Washington, DC, 20052, United States of America, jiran@gwu.edu, Miguel Lejeune

We propose a class of new stochastic risk budgeting multi-portfolio optimization models with portfolio and marginal risk constraints. The models permit the simultaneous and integrated optimization of multiple sub-portfolios in which a risk budget defined with a downside risk measure is assigned to each security and sub-portfolio. Each model includes a joint probabilistic constraint with multi-row random technology matrix. We expand a combinatorial modeling framework to represent the feasible set of the chance constraint as a set of mixed-integer linear inequalities. The efficiency and scalability of the method, numerical assessment on the performance of models, impact of parameters and diversification types are evaluated.

3 - Robust Investment Management with Uncertainty in Fund Managers’ Asset Allocation

Aurelie Thiele, Lehigh University, 200 W Packer Ave, Bethlehem, PA, United States of America, aut204@lehigh.edu, Yang Dong

We consider a problem where an investment manager must allocate an available budget among a set of fund managers, whose asset allocations are not precisely known to the investment manager. We propose a robust framework that takes into account the uncertainty stemming from the fund managers’ allocation, as well as the more traditional uncertainty due to uncertain asset returns, in the context of manager selection and portfolio management. We assume that only bounds on the fund managers’ holdings are available. We propose two exact approaches (of different complexity) and an heuristic one to solve the problem efficiently, and provide numerical results.

■ WD11

11- Brigade

Computational Geometry

Cluster: Combinatorial Optimization

Invited Session

Chair: Tamon Stephen, Simon Fraser University, Department of Mathematics, 250-13450 102nd Ave., Surrey, BC, V3T 0A3, Canada, tamon@sfu.ca

1 - A Recursive Approach to Square Packing Problem

Azam Asl, NYU, 251 Mercer St, New York, Ne, 10012, United States of America, aa2821@nyu.edu

Consider the set of squares s = {s_0, s_1, ...,s_n-1}, in descending order and s_i < 1 for i=0,..,n-1 that would like to pack to the unit size square (bin). We present a recursive left-most_bottom-most algorithm which given that we can fit s_0 and s_1 into the bin (that is; iff s_0+s_1<=1), our packing algorithm will run for at least 2 iterations (k=2) and we prove to be able to cover at least 7/18 area of the bin. In general, if we have: s_0+s_1<=1, s_0+s_3+s_4<=1, ..., s_0+s_3+s_6+ ...+s_3p + s_(3p+1)<=1. Then k = p+2 and we prove to cover at least (1/2 - 1/(k+1)^2) area of the bin.

2 - An Efficient Local Search Algorithm for Nesting Problems of Rasterized Shapes

Shohei Murakami, Osaka University, 2-1 Yamadaoka, Suita, Osaka, Japan, syouhei.murakami@ist.osaka-u.ac.jp, Shunji Umetani, Yusuke Nakano, Hiroshi Morita

The raster models are simple to code and (approximately) represent non-convex and complex shapes, while they often need much memory and computational effort as their accuracy is improved. We develop an efficient algorithm to compute the overlap between a pair of shapes independent to the accuracy of the raster models. Based on this, we develop an efficient local search algorithm for the overlap minimization problem that minimizes the total amount of overlap between shapes.

3 - On the Diameter of Lattice Polytopes

George Manoussakis, PhD, University Paris 11, 39 Rue Paul Fort, Paris, 75014, France, gomanous@gmail.com, Antoine Deza

Finding a good bound on the maximal diameter D(d,n) of the vertex-edge graph of a polytope in terms of its dimension d and the number of its facets n is one of the basic open questions in polytope theory. The Hirsch conjecture, formulated in 1957 states that D(d,n) is at most n-d. While the conjecture was disproved by Santos in 2011, it is known to hold in small dimensions along with other specific pairs of d and n. However, the asymptotic behaviour of D(d,n) is not well understood: the best upper bound is quasi-polynomial. The behaviour of D(d,n) is not only a natural question of extremal discrete geometry, but is historically closely connected with the theory of the simplex method. We present older and recent results dealing with the diameter of lattice polytopes.

■ WD12

12- Black Diamond

Revenue Management and Dynamic Pricing

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Mikhail Nediak, Queen's University, 143 Union St., Kingston, ON, K7L3N6, Canada, mnediak@business.queensu.ca

1 - Robust Pricing for a Capacitated Resource

Shuyi Wang, Lehigh University, 200 W Packer Ave, Bethlehem, PA, United States of America, shw210@lehigh.edu, Aurelie Thiele

We investigate robust pricing strategies for capacitated resources in the presence of demand uncertainty. We consider uncertainty sets of the type proposed by Bertsimas and Bandi (2012) to incorporate moderate amounts of distributional information, provide theoretical insights and discuss extensions to dynamic pricing policies.

2 - Scalable Dynamic Bid Prices for Revenue Management in Continuous Time

Mikhail Nediak, Queen's University, 143 Union St., Kingston, ON, K7L3N6, Canada, mnediak@business.queensu.ca, Samuel Kirshner

We develop an approximate optimal control problem to produce time-dependent bid prices for network revenue management. The resulting bid prices are monotonic. Using sign-constrained splines we transform the problem into an approximate second-order cone program (ASOCP) where the number of variables depends solely on the number of resources and not on the length of the booking horizon. We highlight ASOCP's scalability by solving for dynamic bid prices on an industrial sized network in seconds.

3 - A Tractable Lagrangian Relaxation for General Discrete-Choice Network Revenue Management

Sumit Kunnumkal, Indian School of Business, Gachibowli, Hyderabad, India, Sumit_Kunnumkal@isb.edu, Kalyan Talluri

We propose a new Lagrangian relaxation method for the choice network revenue management problem. Our solution method applies to a general discrete-choice model of demand and remains tractable as long as the consideration sets of the different customer segments are small in size. We show that our solution method obtains an upper bound on the value function. We compare the quality of the upper bound obtained by the proposed method with existing benchmark methods both analytically and numerically.

■ WD13

13- Rivers

Cones of Completely Positive Matrices, Copositive Matrices and Related Topics

Cluster: Conic Programming

Invited Session

Chair: Gomatam Ravindran, Professor, SETS Campus, MGR Knowledge City, CIT campus, Taramani, Chennai, Taramani, 600113, India, gravi@hotmail.com

1 - Semidefinite and Completely Positive Relaxation of Polynomial Optimization by Using Symmetric Tensors

Xiaolong Kuang, Lehigh University, 14 Duh Drive Apartment 324,, Bethlehem, PA, 18015, United States of America, kuangxiaolong0731@gmail.com, Luis Zuluaga

We study relaxations of general polynomial optimization problems over the cone of positive semidefinite and completely positive tensors, which are natural extensions of the cones of positive semidefinite and completely positive matrices. Then we extend related results for quadratic polynomial optimization problems by characterizing the relationship between lagrangian, semidefinite, and comletely positive bounds for general polynomial optimization problems.

2 - Copositive Programming and Linear Complementarity Problems

Chandrashekaran Arumugasamy, Assistant Professor, Central University of Tamil Nadu, School of Mathematics and Computer Scien, Neelakudi Village, Kangalancheri Post, Thiruvarur, 610101, India, chandrashekaran@cutn.ac.in

In this talk we observe copositive programming as linear complementarity problems over the cone of copositive matrices. Linear complementarity problems over general cones have been studied in the literature and we shall review some of the known results. Then we discuss some new results in the theory of linear complementarity problems over the cone of copositive matrices.

3 - On Copositive and Codefinite Matrices

Kavita Bisht, Research Scholar, IIT Madras, Department of Mathematics, Chennai, 600036, India, kavitabishtiitm2512@gmail.com, Gomatam Ravindran, K.C. Sivakumar

In this paper we consider the concept of a copositive matrix introduced by Motzkin and obtain new results on copositive and strictly copositive matrices new results on the class of copositive matrices in the context of generalized inverses. We also extend a result relating copositive and codefinite matrices to singular matrices.We also present certain generalizations of some properties of self conditionally positive definite matrices and their connection to copositive matrices . Finally, we derive inheritance properties for the pseudo Schur complement for copositive and self conditionally positive definite matrices.

■ WD14

14- Traders

Behavioral Game Theory

Cluster: Game Theory

Invited Session

Chair: Albert Jiang, Trinity University, One Trinity Place, San Antonio, TX, 78212, United States of America, albertjiang@gmail.com

1 - Monotonic Maximin: A Robust Stackelberg Solution Against Boundedly Rational Followers

Albert Jiang, Trinity University, One Trinity Place, San Antonio, TX, 78212, United States of America, albertjiang@gmail.com, Milind Tambe, Thanh Nguyen, Ariel Procaccia

There has been recent interest in applying Stackelberg games to infrastructure security, in which a defender must protect targets from attack by an adaptive adversary. In real-world security settings the adversaries are humans and are thus boundedly rational. Most existing approaches for computing defender strategies against boundedly rational adversaries try to optimize against specific behavioral models of adversaries, and provide no quality guarantee when the estimated model is inaccurate. We propose a new solution concept, monotonic maximin, which provides guarantees against all adversary behavior models satisfying monotonicity, including all in the family of Regular Quantal Response functions.

2 - On Adversary Bounded Rationality in Green Security Domains: Payoff Uncertainty and Elicitation

Thanh Nguyen, University of Southern California, SAL, Los Angeles, United States of America, thanhhng@usc.edu, Milind Tambe, Noa Agmon, Manish Jain, Francesco Delle Fave, Amulya Yadav, Richard Van Deventer

Research on Stackelberg Security Games has recently shifted to green security domains, e.g., protecting wildlife from illegal poaching. Previous research on this topic has advocated the use of behavioral (bounded rationality) models of adversaries. This paper, for the first time, provides validation of these behavioral models based on real-world data from a wildlife park. The paper's next contribution is the first algorithm to handle payoff uncertainty in the presence of such behavioral models. Finally, given the availability of mobile sensors such as Unmanned Aerial Vehicles in green security domains, we introduce new payoff elicitation strategies to strategically reduce uncertainty over multiple targets at a time.

3 - Computation in Behavioural Game Theory using Gambit

Theodore Turocy, Professor of Economics, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, United Kingdom, T.Turocy@uea.ac.uk

I illustrate some of the facilities of Gambit: Software Tools for Game Theory (http://www.gambit-project.org) for analysing finite games using concepts from behavioural and statistical game theory. Using the Python extension, planned topics will include constructing game models programmatically, fitting quantal response equilibria and cognitive hierarchy models, and simulating trajectories of replicator dynamics, experience-weighted attraction, and other models of learning or adaptation.

■ WD16

16- Sterlings 1

Mathematical Programming in Data Science I

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Dolores Romero Morales, Professor in Operations Research, Copenhagen Business School, Porcelaenshaven 16 A, Copenhagen, Denmark, drm.eco@cbs.dk

1 - Increasing Sparsity in Support Vector Machines in the Presence of Categorical Data

Dolores Romero Morales, Professor in Operations Research, Copenhagen Business School, Porcelenshaven 16 A, Copenhagen, Denmark, drm.eco@cbs.dk, Emilio Carrizosa, Amaya Nogales Gomez

We propose the Cluster Support Vector Machines (CLSVM) methodology to increase the sparsity of the SVM classifier in the presence of categorical features. Four strategies for building the CLSVM classifier are presented based on solving: the original SVM formulation, a QCQP formulation, and an MIQP formulation as well as its continuous relaxation. We illustrate that our methodology achieves comparable accuracy to that of the SVM with original data but with a dramatic increase in sparsity.

2 - Similarity-Based Machine Learning in Large-Scale Data Sets

Philipp Baumann, University of California, Berkeley, Etcheverry Hall, Berkeley, IEOR Department, CA, 94720, United States of America, philipp.baumann@berkeley.edu, Dorit S. Hochbaum

Leading data mining algorithms require as input pairwise similarities between objects. This poses a challenge in terms of scalability as the number of pairwise similarities grows quadratically in the size of the data set. We address this challenge with a method called sparse computation that generates only relevant similarities. Sparse computation is used here in combination with support vector machines, the k-nearest neighbor algorithm and the supervised normalized cut algorithm to tackle large real-world classification problems. It turns out that the running time of these algorithms can be reduced significantly with minimal loss in accuracy.

3 - Data-Driven Risk-Averse Stochastic Optimization with Wasserstein Metric

Chaoyue Zhao, Assistant Professor, Oklahoma State University, 322 Engineering North, Stillwater, OK, 74078, United States of America, chaoyue.zhao@okstate.edu, Yongpei Guan

In this talk, we study the data-driven risk-averse stochastic optimization problem. Instead of assuming the distribution of random parameter is known, a series of historical data, drawn from the true distribution, are observed. Based on the obtained historical data, we construct the confidence set of the ambiguous distribution of the random parameters, and develop a risk-averse stochastic optimization framework to minimize the total expected cost under the worst-case distribution. We introduce the Wasserstein metric to construct the ?confidence set and by using this metric, we can successfully reformulate the risk-averse two-stage stochastic program to its tractable counterpart. Moreover, we perform convergence analysis to show that the risk-averseness of our proposed formulation vanishes as the amount of historical data grows to infinity, and accordingly, the optimal objective value converges to that of the traditional risk-neutral two-stage stochastic program. Finally, numerical experiments on facility location and stochastic unit commitment problems verify the effectiveness of our proposed solution approach.

■ WD17

17- Sterlings 2

Nonconvex, Non-Lipschitz, and Sparse Optimization II

Cluster: Nonlinear Programming

Invited Session

Chair: 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

1 - A Comparison of Lipschitz and Non-Lipschitz Functions for Nonconvex Compressive Sensing

Rick Chartrand, Descartes Labs, Inc., 1350 Central Ave., Ste. 204, Los Alamos, NM, 87544, United States of America, rick@descarteslabs.com

That nonconvex functions can give better results for compressive sensing is well established. The best-known of these, the p-norms (or Lp quasinorms), are also non-Lipschitz. A drawback the p-norms have is that they lack closed-form proximal mappings (except for special values of p, like 1/2). This led to the introduction of functions constructed to have specified proximal mappings, yet be similar to p-norms. The biggest difference is that the new functions happen to be Lipschitz. Since these functions were introduced for reasons of computational efficiency, and not reconstruction performance, an unsettled question is whether they perform better than the p-norms. In this talk we will present results attempting to answer this question.

2 - SAA Regularized Methods for Multiproduct Price Optimization under Pure Characteristics Demand Models

Che-Lin Su, University of Chicago, 5807 S Woodlawn Ave, Chicago, IL, 60637, United States of America, csu1@chicagobooth.edu, Hailin Sun, Xiaojun Chen

Utility-based choice models are often used to provide an estimate of product demands, and when data on purchase decisions or market shares are available, to infer consumers' preferences over observed product characteristics. They also serve as a building block in modeling firms' price and assortment optimization problems. We consider a multi-product price optimization problem under the pure characteristics model. We use a sample average approximation (SAA) method to approximate the expected market share of products and the firm's profit. We apply a regularized method to compute a solution of the SAA problem and study the convergence of the SAA solutions when the sample size increases.

3 - Fast Approximate Solutions of High Dimensional Affine VIs and LCPs Using Random Projections

Ankur Kulkarni, Assistant Professor, Indian Institute of Technology Bombay, Powai, Mumbai, India, kulkarni.ankur@iitb.ac.in, Bharat Prabhakar

We present a method for dimensionality reduction of affine VIs and LCPs. Centered around the Johnson Lindenstrauss lemma, our method is a randomized algorithm that produces with high probability an approximate solution for the given AVI by solving a lower-dimensional AVI. This approximation can be used to hot start an exact algorithm. The lower-dimensional AVI is obtained by appropriately projecting the original AVI on a randomly chosen subspace. From the solution of the lower-dimensional AVI an approximate solution to the original AVI is recovered through an inexpensive process. Our numerical experiments validate that the algorithm provides a good approximation at low dimensions and substantial savings in time for an exact solution.

■ WD18

18- Sterlings 3

Optimization Computing and Analysis in Statistical Methods

Cluster: Nonlinear Programming

Invited Session

Chair: Shu Lu, Assistant Professor, University of North Carolina at Chapel Hill, 355 Hanes Hall, Cb#3260, UNC-Chapel Hill, Chapel Hill, NC, 27599, United States of America, shulu@email.unc.edu

1 - Optimization of Some Recent Statistical Methods

Lingsong Zhang, Assistant Professor of Statistics, Purdue University, Department of Statistics, Purdue University, 150 N University St., West Lafayette, IN, 47907, United States of America, lingsong@purdue.edu

Optimization is an integrated part in statistical theory and methodology. In this paper, we discuss several important new methodology developments in statistics, and address important optimization aspects in optimization, which include linear programming, conic programming, etc. In addition, some computational considerations on extending these approaches to big data context will be addressed as well.

2 - Convex Optimization in Synthesis of Stationary Gaussian Fields

Stefanos Kechagias, SAS Institute, 100 SAS Campus Dr, Cary, NC, 27513, United States of America, stefanoskeh@gmail.com, Vladas Pipiras, Hannes Helgason

Stationary Gaussian random fields are used as models in a range of applications such as image analysis or geostatistics. One of the most effective and exact methods to synthesize such fields is based on the so-called circulant matrix embedding (CME). But the standard version of the method works only under suitable assumptions, which are well-known to fail for many practical covariance structures of interest. In this talk, I will present a novel methodology, which adaptively constructs feasible CMEs based on constrained quadratic optimization. Moreover I will show how a well-known interior point optimization strategy called primal log barrier method can be suitably adapted to solve the quadratic problem faster than commercial solvers.

3 - Confidence Interval Computation for Stochastic Variational Inequalities

Michael Lamm, University of North Carolina at Chapel Hill, Hanes Hall, CB 3260, Chapel Hill, NC, United States of America, mlamm@live.unc.edu, Shu Lu, Amarjit Budhiraja

Stochastic variational inequalities provide a means for modeling various optimization and equilibrium problems where model data are subject to uncertainty. Often the true form of these problems cannot be analyzed and some approximation is used. This talk considers the use of a sample average approximation (SAA). To quantify the uncertainty in the SAA solution, we consider the computation of individual confidence intervals for components of the true solution. The proposed methods directly account for the possibly piecewise structure of the SAA solution's limiting distribution and maintain their desired asymptotic properties in general settings.

■ WD19

19- Ft. Pitt

Joint Session CP/IP: Graphical Structures for Integer Programming

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 - Combined Benders Decomposition and Column Generation for Stochastic Multiactivity Tour Scheduling

Maria Restrepo, PhD Candidate, Applied Mathematics, Polytechnique Montreal and CIRRELT, 2920, Chemin de la Tour, of 3502, Montreal, QC, Canada, maria-isabel.restrepo-ruiz@polymtl.ca, Bernard Gendron, Louis-Martin Rousseau

We present a combined Benders decomposition and column generation (CG) approach to solve multiactivity tour scheduling problems under demand uncertainty. The solution approach iterates between a master problem (solved by CG) that links daily shifts with tour patterns, and a set of subproblems which assign work activities and breaks to the shifts. We exploit the expressiveness of context-free grammars to model the subproblems. Our approach was able to find high-quality solutions on stochastic and deterministic instances dealing respectively with up to three and seven work activities. In addition, our model outperforms the Dantzig-Wolfe reformulation when evaluated on deterministic problems.

2 - Resource Constrained Shortest Hyperpaths in Shift Scheduling

Eric Prescott-Gagnon, Operational Researcher, Jda Software Canada, 4200 Saint-Laurent #407, Montreal, Qc, H2W2R2, Canada, Eric.PrescottGagnon@jda.com, Louis-Martin Rousseau

Resource constrained shortest-paths problems have generated a lot of interest due to their implication as subproblems to column generation formulations of vehicle routing problems. Grammar-based column generation formulations for shift scheduling generate shortest hyper-path subproblems where many side constraints can be modeled through the use of resource and resource extension functions in the subproblems in a similar way to resource constrained shortest paths. Some example of side constraints and corresponding resources will be provided.

3 - Polar Cuts from Relaxed Decision Diagrams

Christian Tjandraatmadja, PhD Student, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, ctjandra@andrew.cmu.edu, Willem-Jan van Hoeve

The most common approach to generate cuts in integer programming is to derive them from the linear programming relaxation. We study the alternative approach of extracting cuts from discrete relaxations known as relaxed decision diagrams, focusing on 0-1 integer programs. Through a connection between decision diagrams and polarity, the proposed algorithm generates cuts that are facet-defining for the convex hull of this discrete relaxation. As proof of concept, we provide computational evidence that this algorithm generates strong cuts for the maximum independent set problem.

■ WD20

20- Smithfield

Recent Advances in ADMM III

Cluster: Nonsmooth Optimization

Invited Session

Chair: Sangwoon Yun, Professor, Sungkyunkwan University, Sungkyunkwan-ro 25-2, Jongro-gu, Seoul, 110-745, Korea, Republic of, sangwoony@gmail.com

1 - A Parallel Splitting Method for Separable Convex Programming with Linear Inequality Constraints

Lingling Xu, Dr., Nanjing Normal University, School of Mathematical Sciences, Nanjing, 210023, China, naco@njnu.edu.cn, Deren Han

In this paper, we proposed an alternating direction method for solving the convex programs where the object function is separable with two operators and the constraint is composed of linear inequalities under some assumptions, we proved the convergence of the proposed method. The linear convergence is obtained when the object function is quadratic.

2 - Convergence of ADMM for Nonconvex Problems Based on the Kurdyka-{\L}ojasiewicz Inequality

Tingting Wu, Dr., School of Science, Nanjing University of Posts and Telecommunications, #9 Culture Gardens Road, Nanjing, China, Nanjing, Al, 210023, China, wutt@njupt.edu.cn, Deren Han

The efficiency of the classic alternating direction method of multipliers (ADMM) has been exhibited by various applications for large scale separable optimization problems. In this talk, we first give a review on the Kurdyka-{\L}ojasiewicz (KL) function. Specially, under the assumption that the associated function satisfies the KL inequality, we analyze the convergence of ADMM for solving two-block linearly constrained nonconvex minimization model whose objective function is the sum of two nonconvex functions without coupled variables. Under some further conditions on the problem's data, we also analyze the rate of convergence of the algorithm, which are related to the flatness of the functions by means of KL exponents.

■ WD21

21-Birmingham

Advances in Derivative-Free Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Francesco Rinaldi, Department of Mathematics University of Padua, via Trieste, 73, Padua, Italy, rinaldi@math.unipd.it

1 - Parallelized Hybrid Optimization Methods for Nonsmooth Problems using NOMAD and Linesearch

Klaus Truemper, Prof. Em. of CS, University of Texas at Dallas, 800 W Campbell Rd, Richardson, TX, 75080, United States of America, klaus@utdallas.edu, Giampaolo Liuzzi

A parallelized hybrid method is presented for single-function optimization problems with side constraints. It consists of the well-known method NOMAD and two new methods called DENCON and DENPAR that are based on the linesearch scheme CS-DFN. The method has been tested on a set of difficult optimization problems produced by a certain seeding scheme for multiobjective minimization. The results are compared with solution of the problems by NOMAD, DENCON, and DENPAR running as stand-alone methods. It turns out that in the stand-alone comparison, NOMAD is significantly better than DENCON and DENPAR, but that the hybrid method is definitely superior to NOMAD.

2 - A Linesearch Derivative-Free Method for Bilevel Minimization Problems

Stefano Lucidi, University of Rome, La Sapienza, via Ariosto, 25, Rome, Italy, lucidi@dis.uniroma1.it, Stefania Renzi

In this work we propose a new linesearch derivative-free algorithm for bilevel minimization problems. Under suitable assuptions we prove that an accumulation point of the sequence produced by the argorithm is a stationary point of the considered problem. We also report the results of a preliminary numerical experience showing a possible practical interest of the proposed approach.

3 - Global Optimization Applied to a Fluids Simulation in an Automated Workflow

Taylor Newill, North American Technical Manager, Noesis Solutions, 35 E Main St., Ste 300, Carmel, IN, 46032, United States of America, taylor.newill@noesissolutions.com

Recent advancements in machine learning and adaptive simulation strategies has enhanced both the speed and accuracy for optimizing computer assisted engineering (CAE) physics problems. In this presentation we will demonstrate methods for capturing a workflow that includes fluid and structural simulation and then compare classical derivative free optimization methods with new machine learning and advanced derivative free optimization methods that are available inside of a commercial process integration and design optimization tool (PIDO). The machine learning and adaptive methods that are used will be discussed in detail.

■ WD22

22- Heinz

Variational Analysis in Nonsmooth Optimization III

Cluster: Variational Analysis

Invited Session

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

1 - Selective Linearization Algorithm for Multi-block Convex Optimization

Yu Du, Rutgers University, 100 Rockafeller Road, Room 5111, Piscataway, NJ, 08854, United States of America, duyu@rutgers.edu, Xiaodong Lin, Andrzej Ruszczynski

We consider the problem of minimizing the multi-block structured convex non-smooth functions. We introduce the Selective Linearization(SLIN) Algorithm which iteratively solves a series of subproblems by linearizing some blocks and approaches the optimal solution. Global convergence is achieved and SLIN algorithm is proven to converge at rate of O(1/k), where k is the number of iterations. We apply the SLIN algorithm on image recovery and matrix completion applications, showing fast running time for large scale problems.

2 - Too Relaxed? Tight Relaxation using Non-Convex Regularization

Ankit Parekh, Department of Mathematics, School of Engineering, New York University, 6, Metrotech, Jay Street, Brooklyn, NY, 11201, United States of America, ankit.parekh@nyu.edu, Ivan Selesnick

We consider the problem of signal denoising using a sparse tight-frame analysis prior. The L1 norm has been extensively used as a regularizer to promote sparsity; however, it tends to under-estimate non-zero values of the underlying signal. To more accurately estimate non-zero values, we propose the use of a non-convex regularizer, chosen so as to ensure convexity of the objective function. The convexity of the objective function is ensured by constraining the parameter of the non-convex penalty. We use ADMM to obtain a solution and show how to guarantee that ADMM converges to the global optimum of the objective function. We illustrate the proposed method for 1D and 2D signal denoising.

3 - Minimization of Locally Lipschitzian Functions using Outer Subdifferentials

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

The theory of subdifferentials provides adequate methods and tools to put descent methods for nonsmooth optimization problems into practice. But there is often no exact information about the whole subdifferential. In this cases the semismoothness of the cost functions cannot be proven or is violated. Basing on the continuous outer subdifferentials we developed, this talk presents a new strategy for optimization problems with local Lipschitzian cost functions. Especially the semismoothness of the cost function will not be taken for granted. A descent method based on this outer subdifferentials will be developed and its convergence will be proven.

■ WD23

23- Allegheny

Multi-Objective Branch and Bound

Cluster: Multi-Objective Optimization

Invited Session

Chair: Kim Allan Andersen, Aarhus University, Fuglesangs Allé 4, Aarhus, 8210, Denmark, kia@econ.au.dk

1 - PolySCIP - A Solver for Multi-Criteria Mixed Integer Programs

Sebastian Schenker, TU Berlin / Zuse Institute, Strafle des 17. Juni 136, Berlin, 10623, Germany, schenker@zib.de

Multi-criteria optimization can be considered as a generalization of single-objective optimization. However, compared to the single-objective case the variety of solvers available to the community is very sparse. Furthermore, there exist no common input format or common language for modeling multi-criteria problems. In this talk I want to present PolySCIP - a solver for multi-criteria mixed integer programs. It is based on the free non-commercial solver SCIP. In this talk I will present the underlying theoretical approach which uses a weight space partition as well as practical issues like modeling options and input formats.

2 - A Parallel Bi-Objective Branch and Bound Algorithm

Kim Allan Andersen, Aarhus University, Fuglesangs Allé 4, Aarhus, 8210, Denmark, kia@econ.au.dk, Thomas Stidsen

Two of the authors have earlier developed a Branch and Bound algorithm for bi-objective problems, that can determine all non-dominated points. That algorithm is parallelized. We present the parallelized algorithm, and explain how the algorithm can be designed such that it can be implemented in an efficient way. Computational experiments has revealed that the algorithm performs well.

3 - Optimized Parallelization of a Bi-Objective Branch & Cut Algorithm

Thomas Stidsen, Technical University of Denmark, Produktionstorvet, Bygning 426, Lyngby, 2800, Denmark, thst@dtu.dk, Kim Allan Andersen

To solve Bi-Objective TSP problems of non-trivial size, a parallel Branch & Cut algorithm is developed. The problem is solved in parallel, divided in such a way that no communication between the different algorithms is needed. The division is optimized, such that an efficient parallelization is achieved. Optimal solutions, i.e. the full Pareto front, is found for the most used dataset.

■ WD24

24- Benedum

Theory of Mixed-integer Optimization

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Alberto Del Pia, Assistant Professor, University of Wisconsin - Madison, Madison, WI, United States of America, delpia@wisc.edu

1 - Techniques for Gomory and Johnson's Infinite Group Problem

Amitabh Basu, Johns Hopkins University, Whitehead Hall, 3400 N Charles St, Baltimore, MD, 21218, United States of America, abasu9@jhu.edu, Robert Hildebrand, Matthias Koeppe

We describe some of the tools recently developed for analyzing Gomory and Johnson's Infinite Group problem. In particular, we will present higher dimensional generalizations of the so-called Interval Lemma, and give the details of the first ever algorithm for testing extremality of piecewise linear functions with rational breakpoints.

2 - On the Polyhedrality of the t-branch Closure

Diego Moran, Assistant Professor, ISE, Virginia Tech, 227 Durham Hall, 1145 Perry Street, Blacksburg, VA, 24061, United States of America, damr@vt.edu, Sanjeeb Dash, Oktay Gunluk

In this talk we study properties of the t-branch split cuts introduced by Li and Richard (2008). A t-branch split cut is an inequality that is valid for the set obtained by removing from a polyhedron the union of t split sets. This notion is a generalization of split cuts (1-branch split cuts). Cook et al. (1990) showed that the split closure of a rational polyhedron is again a polyhedron and Dash et al (2013) showed that cross cuts (2-branch splits cuts) also yield closures that are rational polyhedra. We further extend these results and show that the t-branch split closure is a polyhedron for all t=1,2,... .

3 - Extreme Cut Generating Functions are Dense in Set of Minimal Functions

Robert Hildebrand, Postdoc, ETH Zurich, Karstlernstrasse, 2, Zurich, 8048, Switzerland, robert.hildebrand@ifor.math.ethz.ch, Amitabh Basu, Marco Molinaro

In the context of general purpose cutting planes for linear integer programs, several models have been used for studying cut generating functions. This study focuses on determining valid cut generating functions based only on the optimal solution to the linear programming relaxation. These functions take as input the coefficients on the non-basic variables in the simplex tableau. Non-dominated valid functions are called minimal, and minimal functions that are not the convex combination of others are called extreme. For Gomory and Johnson's model for studying these functions, we show that the set of extreme functions is dense in the set of minimal functions.

■ WD25

25- Board Room

Energy Market Modelling

Cluster: Optimization in Energy Systems

Invited Session

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

1 - A Dynamic Equilibrium Model of the US Crude Oil Market

Olufolajimi Oke, Systems Institute, Department of Civil Engineering, Johns Hopkins University, 3400 N Charles St, Baltimore, MD, 21218, United States of America, ooke1@jhu.edu, Max Marshall, Daniel Huppmann, Sauleh Siddiqui

The recent US shale oil boom has been constrained by a lack of refinery capacity, insufficient transportation infrastructure and an export ban on crude oil. One notable consequence of the refinery and transit limitations is the rise of crude oil shipments via rail, which has been of great concern for the environment and public safety. We adapt Huppmann and Egging's dynamic energy market equilibrium model to the current US crude oil system and its interaction with other global players. We quantitatively characterize the US market and analyze scenarios to inform appropriate policy responses to critical economic and environmental impacts of crude oil production and movement within the US.

2 - Energy and Climate Market Policy using Multiobjective Programs with Equilibrium Constraints

Sauleh Siddiqui, Assistant Professor, Systems Institute, Departments of Civil Engineering and Applied Math & Statistics, Johns Hopkins University, 3400 N Charles St, Baltimore, MD, 21218, United States of America, siddiqui@jhu.edu, Adam Christensen

Energy and climate market policy is inherently multiobjective and multilevel, in that a set of desired choices often conflict and are made at a higher level than influenced actors. Multiobjective optimization problems allow the study of tradeoff between choices, while equilibrium problems model the networks and players over which these policies are chosen. Combining these two types of optimization problems produces a formulation called a Multiobjective Program with Equilibrium Constraints (MOPEC). We present a MOPEC to model the biofuels market, with the upper-level giving policy choices of volume obligations for the Renewable Fuel Standard.

3 - Congestion Management in a Stochastic Dispatch Model for Electricity Markets

Endre Björndal, Associate Professor, Norwegian School of Economics, Helleveien 30, Bergen, 5045, Norway, Endre.Bjorndal@nhh.no, Golbon Zakeri, Mette Björndal, Kjetil Midthun

We discuss the design of electricity markets with stochastic dispatch. Our discussion is based on a model framework similar to that in (Pritchard et al. 2010) and (Morales et al. 2014), where an electricity market with two sequential market clearings is used. The stochastic market clearing is compared to the (standard) myopic market model in a small example, where wind power generation is uncertain. We examine how changes in market design influence the efficiency of the stochastic dispatch. In particular, we relax the network flow constraints when clearing the day ahead market. We also relax the balancing constraints when clearing the day ahead market to see if this additional flexibility can be valuable to the system.

■ WD26

26- Forbes Room

Bounding and Sampling Methods

Cluster: Stochastic Optimization

Invited Session

Chair: Harikrishnan Sreekumaran, Purdue University, West Lafayette IN 47906, United States of America, harikrishnan@purdue.edu

1 - Monotonic Bounds and Approximation in Multistage Stochastic Programs

Francesca Maggioni, Assistant Professor, University of Bergamo, Via dei Caniana n 2, Bergamo, BG, 24127, Italy, francesca.maggioni@unibg.it

Consider multistage stochastic programs, which are defined on scenario trees as the basic data structure. The computational complexity of the solution depends on the size of the tree, which itself increases typically exponentially fast with the number of decision stages. For this reason approximations which replace the problem by a simpler are of importance. In this talk we study several methods to obtain lower and upper bounds for multistage stochastic programs both in linear and non-linear cases. Chains of inequalities among the new quantities are provided and proved in relation to the optimal objective value, WS and EEV. Numerical results on a multistage inventory problem and on a real case transportation problem are provided.

2 - Adaptive Importance Sampling via Stochastic Convex Programming

Ernest Ryu, Stanford University, 243 Packard, Stanford, CA, 94305, United States of America, eryu@stanford.edu, Stephen Boyd

In this talk we present a new application of convex optimization: Monte Carlo simulation. We first show that the variance of the Monte Carlo estimator that is importance sampled from an exponential family is a convex function of the natural parameter of the distribution. With this insight, we propose an adaptive importance sampling algorithm that simultaneously improves the choice of sampling distribution while accumulating a Monte Carlo estimate. Exploiting convexity, we prove that the method's unbiased estimator has variance that is asymptotically optimal over the exponential family.

3 - Distributed Algorithms for Games under Exogenous Uncertainty

Harikrishnan Sreekumaran, Purdue University, 315 N Grant St., West Lafayette, IN, 47906, United States of America, harikrishnan.sreekumaran@gmail.com, Andrew Liu

We analyze distributed/parallel algorithms for computing Nash equilibria of certain classes of games under exogenous uncertainty. Specifically we study potential games and supermodular games, with the purpose of establishing conditions under which sequential Gauss Seidel or parallel Gauss Jacobi type methods converge to equilibria under uncertainty, when combined with various sampling schemes. Numerical results for the proposed approach will be presented for applications such as network design games.

■ WD27

27- Duquesne Room

Efficient Algorithms for Inventory Control with Combinatorially Growing State-space

Cluster: Combinatorial Optimization

Invited Session

Chair: David Goldberg, Assistant Professor, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30332-0205, United States of America, dgoldberg9@isye.gatech.edu

1 - Asymptotic Optimality of TBS Policies in Dual-Sourcing Inventory Systems

David Goldberg, Assistant Professor, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30332-0205, United States of America, dgoldberg9@isye.gatech.edu, Linwei Xin

Dual-sourcing inventory systems arise in many supply chains, but are notoriously difficult to optimize due to the curse of dimensionality. Recently, Tailored Base-Surge (TBS) policies have been proposed as a heuristic, and have been found to perform well in numerical experiments. We provide a theoretical foundation for this good performance by proving that a simple TBS policy is asymptotically optimal as the lead time of the regular source grows large. Our proof combines novel convexity and lower-bounding arguments, an interchange of limits, and ideas from the theory of random walks, significantly extending the methodology and applicability of a novel framework recently introduced by Goldberg et al.

2 - Distributionally Robust Inventory Control when Demand is a Martingale

Linwei Xin, Georgia Institute of Technology, 765 Ferst Dr. NW, Atlanta, GA, 30332, United States of America, lwxin@gatech.edu, David Goldberg

Independence of random demands across different periods is typically assumed in multi-period inventory models. In this talk, we consider a distributionally robust model in which the sequence of demands must take the form of a martingale with given mean and support. We explicitly compute the optimal policy and value, and shed light on the interplay between the optimal policy and worst-case distribution. We also draw some interesting conclusions about the difference between the “independence” and “martingale” models.

3 - Data-Driven Algorithms for Nonparametric Multi-Product Inventory Systems

Cong Shi, Assistant Professor, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, shicong@umich.edu, Weidong Chen, Izak Duenyas

We propose a data-driven algorithm for the management of stochastic multi-product inventory systems with limited storage as well as production cost uncertainty. The demand distribution is not known a priori and the manager only has access to past sales data (often referred to as censored demand data). In addition, the manager does not know the production cost distribution for each product and can only collect past realized cost data. We measure performance of our proposed policy through regret, the difference between the expected cost of the policy and that of an oracle with access to the true demand and cost distributions acting optimally. We characterize the rate of convergence guarantee of our algorithm.

■ WD28

28- Liberty Room

Bilevel Optimization

Cluster: Global Optimization

Invited Session

Chair: Oleg A. Prokopyev, University of Pittsburgh, 3700 O’Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, prokopyev@engr.pitt.edu

1 - Bilevel Integer Optimization: Theory and Algorithms

Ted Ralphs, Professor, Lehigh University, 200 W Packer Avenue, Bethlehem, PA, 18015, United States of America, ted@Lehigh.edu, Sahar Tahernajad

Bilevel integer optimization problems form a challenging but important class of problems that arise in many real applications. In this talk, we first present a theoretical framework, focusing on the challenges that must be overcome in order to develop solution techniques, as well as on providing some insight into the source of the apparent empirical difficulty of solving these problems. In the second part, we describe several related algorithms and our recent attempts at solving these problems in practice.

2 - Reformulation and Decomposition Method for Bilevel Mixed Integer Nonlinear Programs

Liang Xu, USF, 4202 E Fowler, Tampa, United States of America, liangxu@mail.usf.edu, Yu An, Bo Zeng

Based on our study on bilevel mixed integer linear problems, we consider a few classes of bilevel mixed integer nonlinear problems, including those with a mixed integer quadratic program and a mixed integer second order conic program as their lower level problems. Structural analysis and computational studies will be presented to validate our algorithm.

3 - On Pessimistic Versus Optimistic Bilevel Linear Programs

M. Hosein Zare, University of Pittsburgh, 1048 Benedum Hall, Pittsburgh, PA, 15261, United States of America, mhossein.zare@gmail.com, Osman Ozaltin, Oleg A. Prokopyev

We study the relationships between Pessimistic and Optimistic Bilevel Linear Programs. In particular, we focus on the case when the upper-level decision-maker (i.e., the leader) needs to consider the uncertain behavior of the lower-level decision maker (i.e., the follower). We derive some computational complexity properties, and illustrate our results using a defender-attacker application.

■ WD29

29- Commonwealth 1

First Order Optimization Methods for Nonsmooth Problems

Cluster: Nonsmooth Optimization

Invited Session

Chair: Olivier Fercoq, Post-doctoral Fellow, Telecom ParisTech, 37 rue Dareau, Paris, 75014, France, olivier.fercoq@telecom-paristech.fr

1 - Doubly Stochastic Primal-Dual Coordinate Descent Method for the Recovery of Random Reduction

Qihang Lin, Assistant Professor, The University of Iowa, S380 Pappajohn Business Building, The University of Iowa, Iowa City, IA, 52242-1994, United States of America, qihang-lin@uiowa.edu, Tianbao Yang, Adam Wei Yu

Randomized reduction methods can be applied to large-scale and high-dimensional machine learning problems in order to reduce either the dimensionality or the number of training instances. However, the lack of fast algorithms for recovering the parameters for the original model has hindered the broad application of randomized reduction methods in data analysis. In this paper, we propose a doubly stochastic primal-dual coordinate descent method for the recovery of random reduction. By utilizing the factorized structure of reduced models, our method achieve a low computational complexity than existing coordinate methods when the size of data is huge.

2 - Primal-Dual Coordinate Descent

Olivier Fercoq, Post-doctoral fellow, Telecom ParisTech, 37 rue Dareau, Paris, 75014, France, olivier.fercoq@telecom-paristech.fr, Walid Hachem, Pascal Bianchi

Many optimization problems can be formulated as saddle point problems of the form “max min f(x) + g(x) - h*(y) + < K x, y >,” where K is a linear map, f, g, h are convex functions, f is differentiable, g and h have simple proximal operators. Basing on the theory of monotone operators, Bianchi et al. proposed a coordinate descent method for this problem. However, the efficiency of coordinate descent for large scale problems comes from its stepsizes that are longer than the gradient method’s. We extend Bianchi et al.’s method in order to combine long stepsizes and the ability to deal with saddle point problems. We prove that the gap of the Lagrangian function decreases at a rate O(1/k) and recover the convergence of Vu-Condat algorithm.

3 - Linearly Convergent Conditional Gradient Variants for Non-strongly Convex Functions

Shimrit Shtern, Technion - Israel Institute of Technology, Department of Industrial Engineering,, Technion City, Haifa, 3200003, Israel, shimrits@tx.technion.ac.il, Amir Beck

Two variants of the conditional gradient algorithm — the local conditional gradient and the away step conditional gradient — are known to converge linearly for minimizing a strongly convex function over a polyhedral set. We prove that these algorithms also admit a linear rate of convergence for well-structured functions, which are not strongly convex. Moreover, for the version that incorporates away steps, we provide a new convergence rate with computable constants that also enables the comparison between the two algorithms.