■ WD30

30- Commonwealth 2

Approximation and Online Algorithms X

Cluster: Approximation and Online Algorithms
Invited Session

Chair: Clifford Stein, Columbia University, Columbia University, New York, NY, 10027, United States of America, cliff@ieor.columbia.edu

1 - Stochastic Scheduling of Heavy-tailed Jobs

Kirk Pruhs, University of Pittsburgh, Computer Science Department, Pittsburgh, PA, 16059, United States of America, kirk@cs.pitt.edu, Benjamin Moseley, Sungjin Im

We revisit the classical stochastic scheduling problem of nonpreemptively scheduling n jobs so as to minimize total completion time on m identical machines, P | | E[Sum C_j] in the standard 3-field scheduling notation. Previously it was only known how to obtain reasonable approximation if jobs sizes have low variability. We show that the natural list scheduling algorithm Shortest Expected Processing Time has a bad approximation ratio for high variability jobs. We develop a list scheduling algorithm that is O(log^2 n + m log n)-approximate. Intuitively our list scheduling algorithm finds an ordering that not only takes the expected size of a job into account, but also takes into account the probability that job will be big.

2 - Hallucination Helps: Energy Efficient Virtual Circuit Routing

Clifford Stein, Columbia University, Columbia University, New York, NY, 10027, United States of America, cliff@ieor.columbia.edu, Sungjin Im, Benjamin Moseley, Antonios Antoniadis, Viswanath Nagarajan, Kirk Pruhs, Ravishankar Krishnaswamy

We give online and offline approximation algorithms for energy efficient circuit routing protocols for a network of components that are speed scalable, and that may be shutdown when idle. The components may be either edges or nodes. For edges, we describe a polynomial-time offline algorithm that has a poly-log approximation ratio. The key step of the algorithm design is a random sampling technique that we call hallucination. The algorithm extends to an online algorithm, whose analysis introduces a natural ``priority" multicommodity flow problem, and bounds the priority multicommodity flow-cut gap. We will then extend the results to the more involved case when the components are vertices and give an offline algorithm.

3 - Resource Augmentation Algorithm for Single Machine Scheduling with Job-Dependent Convex Cost

Rodrigo Carrasco, Universidad Adolfo Ibanez, Diagonal Las Torres 2640, Santiago, Chile, rodrigo.carrascos@uai.cl

We present an algorithm that combines resource augmentation and alpha-point scheduling techniques, both of which have resulted in very good performance scheduling algorithms, to compute approximate solutions for a general family of scheduling problems: each job has a convex non-decreasing cost function and the goal is to compute a schedule that minimizes the total cost subject to precedence constraints. We show that our algorithm is a O(1)-speed 1-approximation algorithm and our numerical experiments show that the speed-scaling ratio required is close to 1.

Wednesday, 4:35pm - 5:25pm

■ WE01

01- Grand 1

A Geometric Approach to Cut-Generating Functions

Cluster: Plenary
Invited Session

Chair: Gerard Cornuejols, Carnegie Mellon Univ., Tepper School of Business, Pittsburgh, United States of America, gc0v@andrew.cmu.edu

1 - A Geometric Approach to Cut-Generating Functions

Michele Conforti, Universita degli Studi di Padova, Via Trieste 63, Department of Mathematics, Padova, Italy, conforti@math.unipd.it

The cutting-plane approach to integer programming was initiated more that 40 years ago: Gomory introduced the corner polyhedron as a relaxation of a mixed integer set in tableau form and Balas introduced intersection cuts for the corner polyhedron. This line of research was left dormant for several decades until relatively recently, when a paper of Andersen, Louveaux, Weismantel and Wolsey generated renewed interest in the corner polyhedron and intersection cuts. Recent developments rely on tools drawn from convex analysis, geometry and number theory, and constitute an elegant bridge between these areas and integer programming. We survey these results and highlight recent breakthroughs in this area.

■ WE02

02- Grand 2

Optimization Challenges in Tensor Factorization

Cluster: Plenary
Invited Session

Chair: Sven Leyffer, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, United States of America, leyffer@mcs.anl.gov

1 - Optimization Challenges in Tensor Factorization

Tamara G. Kolda, Sandia Labs, tgkolda@sandia.gov

Tensors are multiway arrays, and tensor decomposition is a powerful tool for compression and data interpretation. In this talk, we demonstrate the utility of tensor decomposition with several examples and explain the optimization challenges, both theoretical and practical. The optimization problems are nonconvex, but they can typically be solved via an alternating approach that yields convex subproblems. We consider open problems such as determining the model complexity, tensor completion, incorporating symmetries and other constraints, handling ambiguities in scaling and permutation, enforcing structure like sparsity, and considering alternative objective functions.

Wednesday, 5:30pm - 6:20pm

■ WF06

01- Grand 1

Tseng Memorial Lecture

Cluster: Plenary
Invited Session

Chair: Yinyu Ye, Professor, Stanford University, Dept. of Management Science and Eng., Stanford University, Stanford, CA, 94305, United States of America, yinyu-ye@stanford.edu

1 - Tseng Memorial Lectureship

Yinyu Ye, Professor, Stanford University, Dept. of Management Science and Eng., Stanford University, Stanford, CA, 94305, United States of America, yinyu-ye@stanford.edu

The purposes of the lectureship are to commemorate the outstanding contributions of Professor Tseng in continuous optimization and to promote the research and applications of continuous optimization in the Asia-Pacific region.

Thursday, 9:00am - 9:50am

■ ThA01

01- Grand 1

A Distributionally Robust Perspective on Uncertainty Quantification and Chance Constrained Programming

Cluster: Plenary
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 - A Distributionally Robust Perspective on Uncertainty Quantification and Chance Constrained Programming

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

The objective of uncertainty quantification is to certify that a given physical, engineering or economic system satisfies multiple safety conditions with high probability. A more ambitious goal is to actively influence the system so as to guarantee and maintain its safety, a scenario which can be modeled through a chance constrained program. In this talk we assume that the parameters of the system are governed by an ambiguous distribution that is only known to belong to an ambiguity set characterized through generalized moment bounds and structural properties such as symmetry, unimodality or independence patterns. We delineate the watershed between tractability and intractability in ambiguity-averse uncertainty quantification and chance constrained programming. Using tools from distributionally robust optimization, we derive explicit conic reformulations for tractable problem classes and suggest efficiently computable conservative approximations for intractable ones.

Thursday, 10:20pm - 11:50pm

■ ThB01

01- Grand 1

Linear Complementarity Problem and Related Matrix Classes

Cluster: Complementarity/Variational Inequality/Related Problems
Invited Session

Chair: Samir Kumar Neogy, Professor, Indian Statistical Institute, Room No. 318 (Faculty Block), 7, S. J. S. Sansanwal Marg, New Delhi, 110016, India, skn@isid.ac.in

1 - On Various Subclasses of P0, N0, Q0 Matrices and the Linear Complementarity Problem

Samir Kumar Neogy, Professor, Indian Statistical Institute, Room No. 318 (Faculty Block), 7, S. J. S. Sansanwal Marg, New Delhi, 110016, India, skn@isid.ac.in

Various classes of matrices that are defined based on their principal minors have been considered in the literature on matrix analysis and the linear complementarity problem (LCP). A subclass of P0 occurs in Markov chain analysis and a subclass of N0-matrices arises in the theory of global univalence of functions, multivariate analysis. In this talk, we study sub-classes of three matrix classes, namely, P0, N0, Q0 matrices that are relevant to LCP and discuss properties of these subclasses. Further we identify some new subclasses. Our observations on the properties of these subclasses can motivate further applications in matrix theory and extend the class of LCPs solvable by Lemke's algorithm.

2 - On Linear Complementarity Problem with a Hidden-Z Matrix

Dipti Dubey, NBHM Post-Doctoral Student, Indian Statistical Institute, Faculty Block (Room no. 315), 7, S. J. S. Sansanwal Marg, New Delhi, 110016, India, diptidubey@isid.ac.in

A variety of classes of matrices are introduced in the context of the linear complementarity problem (LCP). These matrix classes play an important role for studying the theory and algorithms of LCP. Most of the matrix classes encountered in the context of LCP are commonly found in several applications. The class of hidden Z-matrices was studied by Mangasarian and Pang in 80s and linear programming formulations are given to solve LCP for various special cases. Recently Chu studied a subclass of Hidden Z-matrices. We again revisit the classes of hidden Z-matrices and discuss some new results.

3 - Bilevel Programming Models: Reduction of Dimension of the Upper Level Problem

Vyacheslav Kalashnikov, Assist. Prof., TecnolÓgico de Monterrey, Avenida Eugenio Garza Sada 2501 Sur, Monterrey, NL, 64849, Mexico, kalash@itesm.mx, Nataliya Kalashnykova

We treat a problem of reducing the upper level dimension in bilevel programs. In order to diminish the number of the leader's variables, we create a second follower with the same objective function as the leader's, and drop some variables to the lower level. The lower level problem is also modified to a Nash equilibrium problem for both followers. We search conditions guaranteeing that the modified and the original bilevel programming problems share optimal solutions.

■ ThB02

02- Grand 2

Transmission Planning and Operations with Integer Decisions

Cluster: Optimization in Energy Systems
Invited Session

Chair: Ross Baldick, Professor, University of Texas at Austin, 1 University Station C0803, Austin, TX, 78712, United States of America, baldick@ece.utexas.edu

1 - Modeling and Reformulations of Flexible AC Transmission System (FACTS) Devices in Power Systems

Mostafa Ardakani, Post Doctoral Scholar, Arizona State University, P.O. Box 875706, GWC 206, School of ECEE, Tempe, AZ, 85287-5706, United States of America, mostafa@asu.edu, Kory Hedman

Inclusion of variable impedance FACTS devices in the DC optimal power flow problem, originally a linear program (LP), changes it to a non-linear program (NLP). This paper reformulates the NLP to a mixed integer linear program. Engineering insight is then introduced to create a very efficient LP approximation. This would make enhanced operation of FACTS devices an immediate practical possibility. The application of the method for economic and corrective of FACTS adjustment is discussed.

2 - Reducing the Candidate Line List for Practical Integration of Switching into Power System Operation

Mohammad Majidi, University of Texas at Austin, 1616 Guadalupe UTA 2.304, Austin, TX, 78712-1684, United States of America, m.majidi@utexas.edu, Ross Baldick

Optimized operation of the transmission network is one solution to supply extra demand by more efficient use of transmission facilities, and line switching is one main tool to achieve this goal. In this paper, we add extra constraints to OPF formulation to limit the maximum number of switching operations in every hour based on network conditions, and add switching cost in the objective function to represent extra maintenance cost as a result of frequent switching. We also propose an algorithm to remove less important lines for switching in different loading conditions, so OPF with transmission switching will be solved faster for real-time operation. It is applied to a case study with several operation hours.

3 - Economic Valuation of Topology Changes in a Power Network

Alex Rudkevich, President, Newton Energy Group LLC, 75 Park Plaza, 4th floor, Boston, Ma, 02116, United States of America, arudkevich@negll.com, Michael Caramanis, Evegeniy Goldis, Pablo Ruiz, Richard Tabors

Changes in power transmission networks make significant impact on physical operation and economics of power systems. Attributing the economic value of changing topology is often difficult due to a finite (non-marginal) impact of each topology variation. Our approach is to value topology changes as specially defined point-to-point transactions. We illustrate the validity of this approach by solving the problem of revenue adequacy caused by changes in transmission topology in markets for Financial Transmission Rights (FTRs).

■ ThB03

03- Grand 3

Polyhedral Methods for Combinatorial Optimization Problems

Cluster: Combinatorial Optimization
Invited Session

Chair: Volker Kaibel, OvGU Magdeburg, Universitätsplatz 2, Magdeburg, SA, 39106, Germany, kaibel@ovgu.de

1 - Polyhedral Description of Star Colorings

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

Star colorings are graph colorings in which no path with four nodes is colored with two colors. They appear in the context of the computation of sparse Hessians. We investigate the corresponding partial star coloring polytope and its facets. In particular, we deal with complete linear descriptions for special graphs. Although this seems to be very hard already for path graphs and two colors, we give a complete description of the projection onto variables that indicate whether a node is colored in this case. We also present computational experiments with a branch-and-cut algorithm.

2 - Structural Investigation of Piecewise Linearized Flow Problems

Maximilian Merkert, FAU Erlangen-Nürnberg, Department Mathematik, Cauerstrafle 11, Erlangen, 91058, Germany, Maximilian.Merkert@math.uni-erlangen.de, Frauke Liers

We study polyhedra in the context of network flow problems, where the flow value on each arc lies in one of several predefined intervals. This is motivated by nonlinear problems on transportation networks, where nonlinearities are handled by piecewise linear approximation or relaxation. We show how to strengthen the formulation for specific substructures consisting of multiple arcs. For paths of degree-two-nodes we give a complete description. Computational results show the effectiveness of our cutting planes.

3 - Partitioning into Induced Connected Isomorphic Subgraphs

Hendrik Lüthen, Technische Universität Darmstadt, Dolivostrafle 15, Darmstadt, 64293, Germany, luethen@mathematik.tu-darmstadt.de, Marc Pfetsch

Given a graph G and a number k what is the biggest induced connected subgraph H such that G can be partitioned into k isomorphic copies of H and a connected remaining part? We discuss integer programming formulations for this problem and investigate the structure of the polytope of induced connected subgraphs, including facet-defining inequalities.

■ ThB04

04- Grand 4

Copositive and Completely Positive Programming

Cluster: Conic Programming
Invited Session

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

1 - Genericity and Stability in Linear Conic Programming

Mirjam Dür, University of Trier, Department of Mathematics, Trier, 54286, Germany, duer@uni-trier.de, Bolor Jargalsaikhan, Georg Still

We discuss the genericity and stability of properties of linear conic problems. A property is said to be stable at a problem instance if the property still holds under a small perturbation of the problem data. We say that a property is weakly generic if it holds for almost all problem instances. We investigate genericity and stability of Slater's condition, uniqueness of the optimal solution, nondegeneracy, and strict complementarity in conic programming. Moreover, we characterize first order optimal solutions and discuss their stability.

2 - An Algorithm for Computing the CP-Factorization of a Completely Positive Matrix

Kurt Anstreicher, Professor, University of Iowa, Dept. of Management Sciences, Iowa City, IA, 52242, United States of America, kurt-anstreicher@uiowa.edu, Sam Burer, Peter Dickinson

A real symmetric matrix C is completely positive (CP) if C has a CP-factorization of the form C=AA' where A is a nonnegative matrix. Determining whether or not a matrix is CP is an NP-hard problem. We consider a cutting-plane algorithm to determine whether or not a matrix is CP, and if so provide an explicit CP-factorization. Our construction is based on applying a polynomial-time cutting-plane method (for example, the ellipsoid algorithm) using an exponential-time separation oracle for the copositive cone. The resulting algorithm has the best known complexity for computing the CP-factorization of a CP matrix.

3 - A Nonlinear Semidefinite Approximation for Copositive Optimisation

Juan Vera, Assistant Professor, Tilburg University, Room K 533, P.O. Box 90153, Tilburg, 5000 LE, Netherlands, j.c.veralizcano@tilburguniversity.edu, Peter Dickinson

Copositive optimisation has numerous applications, e.g.~exact formulations for combinatorial problems. When solving copositive optimisation problems, one often considers approximations to the copositive cone, e.g.~the Parrilo-cones. While the copositive cone is invariant under scaling these approximations are not, which make the ``approximated solution" sensitive to the scaling of the data. In this talk a method is presented to optimise over the closure under scalings of the approximation cones. This is done using nonlinear semidefinite optimisation, which is in general intractable. However for some problems, including the stability number, quasiconvexity in our method makes it tractable.

■ ThB05

05- Kings Garden 1

Real-Time Optimization and Predictive Control I

Cluster: Nonlinear Programming
Invited Session

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

1 - A Parametric Non-Convex Decomposition Algorithm with Application to Distributed Energy Systems

Jean-Hubert Hours, EPFL, Station 9, Lausanne, Switzerland, jean-hubert.hours@epfl.ch, Colin Jones

A novel decomposition scheme to solve parametric non-convex programs as they arise in dynamic optimization is presented. It consists of a fixed number of alternating proximal gradient steps and a dual update per time step. Assuming that the nonlinear program is semi-algebraic and that its critical points are strongly regular, contraction of the sequence of primal-dual iterates is proven, implying stability of the sub-optimality error, under some mild assumptions. Moreover, it is shown that the performance of the optimality-tracking scheme can be enhanced by combining it with an inexact Newton method in a trust-region framework. Efficacy of the proposed decomposition method is demonstrated by solving various problems in power systems.

2 - Stability and Robustness of Model Predictive Control with Discrete Actuators

James Rawlings, Professor, Department of Chemical and Biological Engineering, University of Wisconsin, Madison, WI, 53705, United States of America, rawlings@engr.wisc.edu, MIchael Risbeck

Model predictive control (MPC) has become the dominant advanced control method deployed by the process industries. As MPC continues to spread into other industrial fields it becomes increasingly relevant to consider discrete-valued (on/off switches) as well as continuous-valued (flows, voltages, torques) actuators. This paper reviews the extensive research literature discussing the control theoretic properties of MPC in this setting, and proposes a unifying framework for assessing and extending these known results. Topics covered include: nominal stability and recursive feasibility for both optimal and suboptimal MPC, robustness to disturbances, and extensions to distributed and economic MPC.

3 - Bridging the Gap Between Multigrid, Hierarchical, and Receding-horizon Control

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

We analyze the structure of the Euler-Lagrange conditions of a lifted long-horizon optimal control problem. The analysis reveals that the conditions can be solved by using block Gauss-Seidel schemes and we prove that such schemes can be implemented by solving sequences of short-horizon problems. The analysis also reveals that a receding-horizon control scheme is equivalent to performing a single Gauss-Seidel sweep. We also derive a strategy that uses adjoint information from a coarse long-horizon problem to correct the receding-horizon scheme and we observe that this strategy can be interpreted as a hierarchical control architecture. Our results bridge the gap between multigrid, hierarchical, and receding-horizon control.

■ ThB06

06- Kings Garden 2

Mixed-Integer Nonlinear Optimal Control and Traffic II

Cluster: Mixed-Integer Nonlinear Programming
Invited Session

Chair: Sebastian SagerProf. Dr., Otto-von-Guericke Universität Magdeburg, Universitätsplatz 2, Magdeburg, 39106, Germany, sager@ovgu.de

1 - Convex Control Synthesis for Semiautonomous Vehicles

Ram Vasudevan, Assistant Professor, University of Michigan, G058 WE Auto Lab, 1231 Beal Avenue, Ann Arbor, MI, 48105, United States of America, ramv@umich.edu

Active safety systems in vehicles rely upon first predicting when a driver's input renders a vehicle unsafe and then determining an appropriate intervention policy to maintain safety. Due to the presence of friction, vehicle dynamics are modeled as hybrid dynamical systems. In this talk, we describe a novel semidefinite programming hierarchy, with provably vanishing conservatism, to efficiently propagate uncertainty through vehicle dynamics with semialgebraic state and input constraints while simultaneously synthesizing feedback control inputs for a semiautonomous architecture that preserve safety.

2 - Bilevel Structure Arising in Optimal Scheduling Problems

Konstantin Palagachev, Bundeswehr Universität, Werner-Heisenberg-Weg 39, Neubiberg, 85577, Germany, konstantin.palagachev@unibw.de, Matthias Gerdts

We consider the problem of scheduling multiple tasks and minimising the overall duration of the process. In our formulation, each task is represented by a bilevel optimal control problem, where certain cost functions have to be minimised under imposed constraints. We investigate two different approaches for reducing the bilevel problem into a single level one. In the first one, local necessary optimality conditions are formulated for the lower level problem. In the second one, we reduce the problem to a single level one, introducing new constraints involving the value function of the lower level problem. Both methods lead to a nonlinear mixed-integer optimal control problem, which can be solved by Branch and Bound algorithm.

3 - Real-time Optimal Control of Constrained Hybrid Systems

Damian Frick, PhD Student, ETH Zurich, Physikstrasse 3, Zurich, ZH, 8092, Switzerland, dafrick@control.ee.ethz.ch, Alexander Domahidi, Manfred Morari, Juan Jerez

Optimal control problems involving physical dynamics and logic rules can be formulated using the framework of mixed logical dynamical systems as mixed integer programs. These problems can be solved employing powerful branch-and-bound heuristics. In resource constrained embedded systems it remains unclear how to solve these problems in acceptable runtime. We propose an operator splitting method that performs Euclidean projection computations on non-convex sets at every iteration. These operations are still NP-hard but of lower dimensionality than the original problem. For piecewise affine systems the method converges in few iterations leading to computational times that are not significantly larger than solving convex problems.

ThB07

07- Kings Garden 3

Integer Programming Approaches for Routing Problems

Cluster: Integer and Mixed-Integer Programming

Invited Session

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

1 - The r-cycle Inequalities for the Time-Dependent Traveling Salesman Problem

Cynthia Rodriguez, University of Waterloo, 200 University Ave W, Waterloo, ON, Canada, ca7rodri@uwaterloo.ca, Ricardo Fukasawa

The Time-Dependent Travelling Salesman Problem (TDTSP) is a generalization of the Travelling Salesman Problem (TSP) in which the cost of the edges depends on their position in the tour. We consider the polytope associated to a formulation for the TDTSP by Picard and Queyranne and focus on the r-cycle inequalities. It is known that the 2-cycle inequalities are facet-defining for the TDTSP polytope. In this talk, we show that the r-cycle inequalities for $r \geq 3$ are (in most cases) also facet-defining for the TDTSP polytope. Finally, we present some computational experiments using the r-cycle inequalities.

2 - Branch-Cut-and-Price for the Chance-Constrained Vehicle Routing Problem with Stochastic Demands

Thai Dinh, Graduate Student/Research Assistant, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States of America, tndinh@wisc.edu, Ricardo Fukasawa, James Luedtke

We study a chance-constrained model for the vehicle routing problem with stochastic demands. We first derive a valid edge-based formulation, using a lower bound on the minimum number of vehicles required to serve a subset of customers to adapt the well known rounded capacity cuts. We then present a branch-cut-and-price solution framework that requires mild assumptions on the random demands. In particular, the framework can solve problems in which random demands are represented by a scenario model, where the scenarios could be sampled from any distribution. Columns are generated using a dynamic programming algorithm executed over small-cycle-free q-routes with a relaxed capacity constraint. Computational experiments will be presented.

3 - Numerically Safe Lower Bounds for the Capacitated Vehicle Routing Problem

Laurent Poirrier, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada, lpoirrier@uwaterloo.ca, Ricardo Fukasawa

In a branch-and-bound tree, node subproblems are solved in floating-point arithmetic, so numerical errors can occur, leading to inappropriate pruning. We propose two methods for avoiding this issue, in the special case of Capacitated Vehicle Routing Problems (CVRP). With both methods, we construct safely dual feasible solutions of the subproblems and obtain, by weak duality, bounds on their objective function. We show that, in practice, our bounds are stronger than those usually employed, obtained with unsafe arithmetic plus some heuristic tolerance. Moreover, CVRP subproblems are solved by column generation, and we are sometimes able to prune a node before column generation has converged, yielding a modest improvement in performance.

ThB08

08- Kings Garden 4

Convex Optimization and Statistical Learning

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Benjamin Recht, UC Berkeley, 465 Soda Hall, MC 1776, Berkeley, CA, 94720, United States of America, brecht@berkeley.edu

1 - Optimization for Sparse Estimation with Strongly Correlated Variables

Robert Nowak, University of Wisconsin-Madison, 1415 Engineering Drive, Madison, United States of America, nowak@ece.wisc.edu

This talk considers ordered weighted L1 (OWL) norm optimization for sparse estimation problems with strongly correlated variables. We show that OWL norm optimization automatically clusters strongly correlated variables, in the sense that the coefficients associated with such variables have equal estimated values. Furthermore, we characterize the statistical performance of OWL norm regularization for generative models in which certain clusters of regression variables are strongly (even perfectly) correlated, but variables in different clusters are uncorrelated.

2 - Sharp Data – Computation Tradeoffs for Linear Inverse Problems

Mahdi Soltanolkotabi, Assistant Professor, University of Southern California, Ming Hsieh Dept. of Elect. Engineeriing, 3740 McClintock Avenue, Los Angeles, CA, 90089, United States of America, soltanol@usc.edu

In many applications one wishes to estimate an unknown but structured signal from linear measurements where the number of measurements is far less that the dimension of the signal. A common approach is to minimize a function subject to linear measurement constraints where the cost function is meant to captures some notion of the complexity of the signal. In this talk, we present a unified theoretical framework for convergence rates of various optimization schemes for solving such problems. Our framework covers convex and non-convex functions. We sharply characterize the convergence rate in terms of the signal size, number of measurements and a precise measure of complexity of the unknown signal. Joint work with B. Recht and S. Oymak.

3 - Resource Allocation for Statistical Estimation

Quentin Berthet, CMI Postdoctoral Fellow, California Institute of Technology, Annenberg Center, Pasadena, CA, 91120, United States of America, qberthet@caltech.edu

Statistical estimation often involves the acquisition, analysis, and aggregation of datasets from heterogenous sources. The appropriate division and assignment of a collection of resources to a set of data sources can therefore substantially impact the overall performance of an inferential strategy. We adopt a general view of the notion of a resource and its effect on the quality of a data source and describe a framework for the allocation of a given set of resources to a collection of sources in order to optimize statistical efficiency. We discuss several inference problems based on heterogeneous data sources, in which optimal allocations can be computed either in closed form or via convex optimization.

ThB09

09- Kings Garden 5

Statistics and Optimization

Cluster: Robust Optimization

Invited Session

Chair: Dimitris Bertsimas, Professor of Operations Research and Statistics, Sloan School of Management, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-147, Cambridge, MA, 02139, United States of America, dbertsim@mit.edu

1 - Kalman Filtering through a Robust Optimization Lens

Nishanth Mundru, MIT, United States of America, nmundru@mit.edu, Dimitris Bertsimas

We consider the classical problem of filtering, where we want to estimate the true signal of a linear discrete time system, in the presence of noisy measurements. We analyze this problem using the framework of robust optimization, a tractable methodology of dealing with uncertainty. We show that our approach can accommodate constraints on the state space variables, as well as non Gaussian distributed noise two key drawbacks of the Kalman filter.

2 - On the Equivalence of Robustification and Regularization in Linear, Median, and Matrix Regression

Martin S. Copenhaver, MIT, United States of America, mcopen@mit.edu, Dimitris Bertsimas

Sparsity is a key driver in modern statistical estimation problems, yet reliably sparse solutions remain elusive. Despite this, many regularization methods often perform well in the face of noise in the data. In the domains of linear, median, and matrix regression, we characterize precisely when regularization problems correspond to simple robust optimization problems. In doing so, we contend that it is robustness, not sparsity, which is critical to the success of modern statistical methods.

3 - Regression under a Modern Optimization Lens

Dimitris Bertsimas, Professor of Operations Research and Statistics, Sloan School of Management, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-147, Cambridge, MA, 02139, United States of America, dbertsim@mit.edu, Angie King

Linear regression models are traditionally built through trial and error in order to balance many competing goals such as predictive power, interpretability, significance, robustness to error in data, and sparsity, among others. This problem lends itself naturally to a mixed integer quadratic optimization (MIQO) approach, but has not been modeled this way due to the belief in the statistics community that MIQO is intractable for large scale problems. However, in the last twenty-five years (1990-2014), algorithmic advances in integer optimization combined with hardware improvements have resulted in an astonishing 200 billion factor speedup in solving mixed integer optimization problems. We present an MIQO-based algorithm for designing high-quality linear regression models that explicitly addresses various competing objectives, and demonstrate our algorithm's effectiveness on both real and synthetic datasets.

ThB10

10- Kings Terrace

Life Sciences and Healthcare

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Paul Brooks, Virginia Commonwealth University, P.O. Box 843083, Richmond, VA, United States of America, jpbrooks@vcu.edu

1 - Incorporating Coverage for Emergency Calls in Scheduling Patient Transportations

Pieter van den Berg, Delft University of Technology, Mekelweg 4, Delft, 2628 CD, Netherlands, p.l.vandenberg@tudelft.nl, Theresia van Essen

Many ambulance providers operate both advanced life support (ALS) and basic life support (BLS) ambulances. Typically, emergency calls can only be executed by ALS vehicles, whereas non-urgent patient transportations can either be served by an ALS or a BLS ambulance. BLS vehicle capacity does normally not suffice for all transportation requests. The remaining transportations are performed by ALS ambulances, which reduces coverage for emergency calls. We present a model to determine routes for BLS vehicles, so as to maximize the remaining coverage by ALS ambulances.

2 - The L1-Norm Best-Fit Subspace Problem for Robust PCA

Paul Brooks, Virginia Commonwealth University, P.O. Box 843083, Richmond, VA, United States of America, jpbrooks@vcu.edu, Jose Dula

Hospital-level antibiotic resistance data and human microbiome data serve as a motivation for developing robust methods for PCA. We present two methods for PCA based on minimizing the L1 distance of points to fitted (1) hyperplanes and (2) lines. Both problems are naturally written as nonlinear nonconvex optimization problems. Surprisingly, the L1-norm best-fit hyperplane can be found by solving a small number of linear programs. Whether the L1-norm best-fit line can be found in polynomial time remains an open problem. Analysis of relevant linear programming formulations reveals properties of L1 projection on a line. These properties suggest a method for estimating the best-fit line that can also be used for variable selection.

3 - Sparse Mixed-Membership Matrix Factorization via Mixed-Integer Programming

Andrew Trapp, Assistant Professor, Worcester Polytechnic Insitute, 100 Institute Rd., Worcester, MA, 01609, United States of America, atrapp@wpi.edu, Hachem Saddiki, Patrick Flaherty

We consider regularized mixed-membership matrix factorization, where one factor matrix can have a limited number of non-zero entries, and the other has simplex constraints. This provides a mixed-membership representation for each column of the original matrix with sparse mixing components. This problem is known to be NP-Hard, and occurs in a wide variety of contexts, including computational biology, recommendation systems, and image processing. We transform the original biconvex optimization problem into a mixed-integer linear program, and show that moderate-size problems can be solved to global optimality, and that approximate solutions to larger problems can be found via a sequential refinement approach.

ThB11

11- Brigade

Combinatorial Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Francisco Barahona, IBM Research, P.O. Box 218, Yorktown Heights, NY, 10607, United States of America, barahon@us.ibm.com

1 - The Maximum Profit Heterogeneous mTSP with Time Windows

Michal Penn, Prof., Technion, Fac. of Ind. Eng. & Mng, Haifa, Israel, mpenn@ie.technion.ac.il, Ilan Tchernowitz, Segev Shlomov, Liron Yedidsion, Amir Beck

We present an algorithm for the heterogeneous multiple traveling salesman problem (mTSP) that consists of determining a set of routes for m heterogeneous salesmen, starting and ending at the depot. We consider time windows, service times and a value for each served customer. The aim is to maximize the total value of the served customers under travel time constraints. Set partitioning formulation over the set of admissible routes is used. To overcome the impracticability of the formulation we create a partial set of admissible routes and then solve to optimality the set partitioning formulation over the chosen partial set. Using this method, we can solve practical problems with more than 70 customers and 12 salesmen.

2 - Simple Extended Formulation for the Dominating Set Polytope via Facility Location

Mourad Baiou, CNRS-LIMOS, mourad.baiou@isima.fr, Francisco Barahona

In this talk we present an extended formulation for the dominating set polytope via facility location. This formulation describes the dominating set polytope for some class of graphs as cacti graphs, though its description in the natural node variables dimension has been only partially obtained. In this case, an important property says that for any integer p, there exists a facet defining inequality having coefficients in 1,...,p. In our extended formulation the inequalities have 0, -1, 1 coefficients. We also give a linear time algorithm to separate the inequalities defining the extended formulation.

3 - On Some Spanning Tree Games

Francisco Barahona, IBM Research, P O Box 218, Yorktown Heights, NY, 10607, United States of America, barahon@us.ibm.com, Mourad Baiou

Given a graph G=(V,E), we study a two-person zero-sum game, where one player, the ''evader,'' picks a spanning tree every few minutes, and sends a signal. A second player, the "inspector," inspects an edge every few minutes. If the signal is being sent through the edge e, the inspector will detect it with probability p(e). We give an "inspection strategy" that maximizes the average probability of detecting the signal, and a "tree-selection" strategy which minimizes the average detection probability. Then we consider a second game, where an "attacker" destroys a set of edges. Then an "inspector" chooses edges to find the attacker. We give optimal strategies for the attacker and the inspector for a particular payoff function.

ThB13

13- Rivers

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

Cluster: Conic Programming

Invited Session

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

1 - An Extended Frank-Wolfe Method, with Applications to Low-Rank Matrix Completion

Paul Grigas, MIT Operations Research Center, 77 Massachusetts Ave., Cambridge, MA, 02139, United States of America, pgrigas@mit.edu, Robert Freund, Rahul Mazumder

We present an extension of the Frank-Wolfe method that is designed to induce near-optimal solutions on low-dimensional faces of the feasible region. We present computational guarantees for the method that trade off efficiency in computing near-optimal solutions with upper bounds on the dimension of minimal faces of iterates. We apply our method to the matrix completion problem, where low-dimensional faces correspond to low-rank matrices. We discuss practical implementation issues and present computational results for large-scale low-rank matrix completion problems that demonstrate its effectiveness. We demonstrate significant speed-ups in computing low-rank near-optimal solutions.

2 - Composite Conditional Gradient with Stochastic Approximation

Zaid Harchaoui, Researcher, NYU and Inria, NYU. CIMS, 715 Broadway, New York, NY, 10003, United States of America, zaid.harchaoui@inria.fr

We introduce a composite conditional gradient algorithm with stochastic approximation for stochastic convex optimization with composite objectives. The proposed algorithm requires a stochastic first-order oracle and a stochastic linear minimization oracle, in contrast to usual stochastic first-order optimization algorithms in a proximal setting. We establish the theoretical rate of convergence of several variants of the algorithm. We present experimental results for large-scale machine learning applications.

3 - On The Primal - Dual Rate Relation Of Dual Block Coordinate Descent Methods

Yakov Vaisbourd, Technion, Technion City, Haifa, 32000, Israel, yakov.vaisbourd@gmail.com, Ariel Shemtov, Luba Tetruashvili, Amir Beck

We consider the problem of minimizing the sum of a strongly convex function and several general extended valued convex functions. We establish a relation between the primal and the dual sequences that provide the rate of convergence of the primal sequence for any given convergence result on the dual sequence. We demonstrate the applicability of such methods for the TV denoising problem.

■ ThB14

14- Traders

Optimization under Uncertainty

Cluster: Stochastic Optimization

Invited Session

Chair: Alois Pichler, NTNU, Norway, Trondheim, Norway, Alois.Pichler@univie.ac.at

1 - Distributionally Robust Multistage Stochastic Optimization

Alexander Shapiro, Professor, Georgia Tech, Atlanta, GA, United States of America, alex.shapiro@isye.gatech.edu

In this talk we consider static and dynamic approaches to formulations of distributionally robust multistage stochastic programming problems. In particular we discuss decomposability and time consistency of such formulations and its relation to risk averse stochastic programming.

2 - Multistage Stochastic Convex Programs with a Random Number of Stages: Modelling and Solution Methods

Vincent Guigues, Prof, FGV, 190 Praia de Botafogo, Botafogo, Rio de Janeiro, RJ, 22250-900, Brazil, vguigues@fgv.br

We show how to write dynamic programming equations for risk-averse multistage stochastic convex programs with a random number of stages. This formulation allows us to solve these problems using decomposition methods such as SDDP. We study the convergence of various variants of these decomposition methods. In particular, we will consider inexact decomposition methods where all subproblems are solved with a bounded error.

■ ThB15

15- Chartiers

Optimization Software and Applications in Julia

Cluster: Implementations and Software

Invited Session

Chair: Miles Lubin, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-149, Cambridge, MA, 02139, United States of America, mlubin@mit.edu

1 - Convex Optimization in Julia

Madeleine Udell, Stanford University, udell@stanford.edu, David Zeng, Jenny Hong, Steven Diamond, Karanveer Mohan, Stephen Boyd

Convex.jl is a convex optimization modeling framework in Julia. Convex.jl translates problems from a user-friendly functional language into an abstract syntax tree describing the problem. This concise representation of the global structure of the problem allows Convex.jl to infer whether the problem complies with the rules of disciplined convex programming (DCP), and to pass the problem to a suitable solver. Convex.jl uses the MathProgBase abstraction for solver-independent mathematical optimization, enabling users to seamlessly switch between multiple backend solvers. We will give an overview of how Convex.jl works, and demonstrate its use in a few advanced applications.

2 - Calling Nonlinear and MINLP Solvers from Julia: Interfaces, Formats, Expression Trees and AD Tools

Tony Kelman, University of California - Berkeley, Berkeley, CA, kelman@berkeley.edu

While canonical interfaces for LP's are largely standardized across different solvers and programming languages, this is not the case for nonlinear or mixed-integer nonlinear optimization. Two existing tools in this area are the AMPL Solver Library and the COIN-OR Optimization Services project. We will discuss technical challenges and performance tradeoffs in using these tools from the Julia language, which is uniquely able to be simultaneously high-level, high-performance, user-friendly, and provide efficient interfaces to widely used optimization libraries. The JuliaOpt organization and the MathProgBase set of protocols present new levels of interoperability between solvers and different styles of optimization modeling environments.

3 - Robust Inventory Routing for the Real World: Using Julia, JuMP and JuMPeR

Joel Tay, Operations Research Center, MIT, 77 Massachusetts Ave, Bldg. E40-149, Cambridge, MA, 02139, United States of America, joeltay@mit.edu, Dimitris Bertsimas, Swati Gupta

We propose an efficient formulation for the finite horizon inventory routing problem with uncertain demand. While current stochastic optimization techniques do not scale well, we present a model implemented in Julia, using JuMP and JuMPeR (a JuMP extension for Robust Optimization) with Gurobi, with very promising computational results. We will share our experience developing this model in Julia and scaling it to problems of real-world size.

■ ThB16

16- Sterlings 1

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Eduardo Uchoa, Universidade Federal Fluminense, Escola de Engenharia, Rua Passo da Pàtria, 156, Niteroi, RJ, 24210, Brazil, eduardo.uchoa@gmail.com

1 - Symmetric Linear Programming Formulations for Minimum Cut with Applications to TSP

Robert Carr, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM, United States of America, bobcarr@swcp.com, Benjamin Moseley, Giuseppe Lancia

We introduce new symmetric LP relaxations for minimum cut problems. Our relaxations give optimal and approximate solutions when the input is a Hamiltonian cycle. We show that this leads to one of two interesting results. In one case, these LPs always give optimal and near optimal solutions, and then they would be the smallest known symmetric LPs for the problems considered. Otherwise, these LP formulations give strictly better LP relaxations for the traveling salesman problem than the subtour relaxation.

2 - Big Improvements in Exact Algorithms for Vehicle Routing Problems

Eduardo Uchoa, Universidade Federal Fluminense, Escola de Engenharia, Rua Passo da Patria, 156, Niteroi, RJ, 24210, Brazil, eduardo.uchoa@gmail.com, Marcus Poggi

The best recent CVRP algorithms combine cut and column generation. This talk reviews those algorithms, highlighting the contributions in Baldacci, Christofides, Mingozzi (2008), Baldacci, Mingozzi , Roberti (2011), Ropke (2012), and Contardo, Martinelli (2014). It also presents the developments in Pecin et al. (2014), where a very sophisticated branch-cut-and-price using the limited memory technique could solve instances with more 300 customers. Improved results on other classical VRP variants are also mentioned.

3 - Construction and Improvement Heuristics for Vehicle Routing with Flexible Delivery Locations

Markus Frey, Technische Universitaet München, Arcisstrafle 21, Munich, Germany, markus.frey@tum.de, Alexander Doege, Daniel Gartner

In this paper, we study the problem of routing vehicles with flexible delivery locations and time points (VRPFLTP). We provide a Mixed-Integer Programming (MIP) formulation of the problem and develop construction and improvement heuristics to solve it. Instances are generated by the well-known Solomon test instances and extended to fit to our problem. In a thorough computational analysis, we evaluate computation times as well as the utility of flexible delivery locations. Our computational study reveals that the MIP fails to solve even small problems. However, our heuristic algorithm demonstrates relatively fast computation times and shows the economic potential of location flexibility.

■ ThB17

17- Sterlings 2

Uncertainty in Games

Cluster: Game Theory

Invited Session

Chair: Reshef Meir, Cambridge, Massachusetts, reshef24@gmail.com

1 - Learning Cooperative Games

Yair Zick, Postdoc, Carnegie-Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, yairzick@gmail.com, Maria Balcan, Ariel Procaccia

This paper explores a PAC (probably approximately correct) learning model in cooperative games. Specifically, we are given m random samples of coalitions and their values, taken from some unknown cooperative game; can we predict the values of unseen coalitions? We study the PAC learnability of several well-known classes of cooperative games, such as network flow games, threshold task games, and induced subgraph games. We also establish a novel connection between PAC learnability and core stability: for games that are efficiently learnable, it is possible to find payoff divisions that are likely to be stable using a polynomial number of samples.

2 - Reconstructing Preferences and Priorities from Opaque Transactions

Avrim Blum, Professor, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, avrim@cs.cmu.edu

Suppose you can observe who wins (but not the bids) in a repeated auction, plus participate yourself. Can you reconstruct buyers' distributions? How about for a repeated combinatorial auction: can you learn buyers' preferences and the seller's mechanism? In this talk I will discuss algorithms for both of these problems, with connections to decision-list learning in learning theory and Kaplan-Meier estimators in medical statistics. This is joint work with Yishay Mansour and Jamie Morgenstern.

3 - Simultaneous Abstraction and Equilibrium Finding in Games

Tuomas Sandholm, Professor, CMU, 9205 Gates-Hillman Center, Pittsburgh, PA, 15213, United States of America, sandholm@cs.cmu.edu, Noam Brown

The leading approach to large imperfect-information games is finding an equilibrium in an abstraction. We introduce a method that enables actions to be added to the abstraction during equilibrium finding — to points that the computed strategies deem important — while provably not needing to restart the equilibrium finding. The strategies improve as quickly as equilibrium finding in coarse abstractions, and converge to better solutions than equilibrium finding in fine-grained abstractions.

■ ThB18

18- Sterlings 3

Nonlinear Optimization and Applications

Cluster: Nonlinear Programming

Invited Session

Chair: Hande Benson, LeBow College of Business, Drexel University, Philadelphia, PA, 19104, United States of America, hvb22@drexel.edu

1 - Cubic Regularization in Quasi-Newton Methods

Hande Benson, LeBow College of Business, Drexel University, Philadelphia, PA, 19104, United States of America, hvb22@drexel.edu, David Shanno

Regularization techniques have been used to help existing algorithms solve "difficult" nonlinear optimization problems. Just over the last decade, regularization has been proposed as a remedy to handle equality constraints, equilibrium constraints, and other sources of nonconvexity, to bound Lagrange multipliers, to identify infeasible problems. In this talk, we will focus on the application of cubic regularization in the context of quasi-Newton methods.

2 - Numerical Optimization Applied to Space-Related Problems

Robert Vanderbei, Princeton University, 209 Sherrerd Hall, Princeton, NJ, 08544, United States of America, rvdb@princeton.edu

I will describe two "space related" optimization problems. The first is the design of telescopes that can achieve unprecendentedly high-contrast making it possible to directly image Earth-like extra-solar planets. The second application is to use optimization to find new, interesting, and often exotic solutions to the n-body problem. Finding such orbits could inform us as to what type of exoplanetary systems might exist around other nearby stars. In these two applications, I will explain the physics to make the optimization problem clear and then I will show some of the results we have been able to find using state-of-the-art numerical optimization algorithms.

3 - Blessing of Massive Scale: Multitask Optimization Total Cardinality Constraint

Ethan X. Fang, Princeton University, ORFE Sherrerd Hall, Charlton Street, Princeton, NJ, 08544, United States of America, xingyuan@princeton.edu, Han Liu, Mengdi Wang

We propose a novel framework for estimating of large-scale spatial graphical models with a total cardinality constraint. This work has two major contributions. (i) We minimize the summation of massive amounts of localized loss functions coupled by a global cardinality constraint. Theoretically, we show that the computational accuracy of our algorithm increases when the problem scale increases. Thus we see a bless of massive scale. We rigorously characterize the diminishing rate of the duality gap. (ii) In Gaussian or Ising graph estimation, we justify the obtained graph estimator achieves the minimax optimal rate of convergence under weak assumptions. We provide a through numerical investigation using both simulated and fMRI data.

■ ThB19

19- Ft. Pitt

Computational Sustainability

Cluster: Constraint Programming

Invited Session

Chair: Bistra Dilkina, Georgia Institute of Technology, Klaus Bldg 1304, Atlanta, GA, 30332-0765, United States of America, bdilkina@cc.gatech.edu

1 - Leveraging Moral-Motivation for Green Behavior Change in Networks

Gwen Spencer, Smith College, 180 Pleasant Street, Apt 306, Easthampton, MA, 01027, United States of America, gwenspencer@gmail.com

When spread models from behavioral economics are considered, optimal seeding of networks looks strongly different from the high-exposure/maximization-of-submodular-functions paradigm. We discuss several interesting byproducts of studying a model from environmental economics that describes when individuals will choose to engage in personally-costly provision for environmental quality. The optimal seeding problem is very hard (and slow in practice), but we discover a compelling prediction of network clustering, as well as a mechanism-design-oriented view of objective formulation in the management of landscape-scale natural systems under piecemeal management by risk/cost-averse local decision makers.

2 - Joint Mobilization and Planning for Large-Scale Evacuations

Pascal Van Hentenryck, Professor, NICTA/ANU, Australia, pvh@nicta.com.au, Victor Pillac, Caroline Even

Large-scale evacuations require authorities to decide and stage evacuation routes, mobilize resources, and issue evacuation orders under strict time constraints. These decisions must consider both the capacity of the road network and the evolution of the threat (e.g., a bushfire or a flood). This paper proposes, for the first time, an optimization model that jointly optimizes the mobilization and evacuation planning, taking into account the behavioural response of evacuees and the allocation of resources for communicating and implementing evacuation orders.

3 - Optimization Approaches for Robust Conservation Planning

Bistra Dilkina, Georgia Institute of Technology, Klaus Bldg 1304, Atlanta, GA, 30332-0765, United States of America, bdilkina@cc.gatech.edu

In the face of human development and climate change, it is important that wildlife conservation plans for protecting landscape connectivity exhibit certain level of robustness. We formalize this as a node-weighted bi-criteria network design problem with connectivity requirements on the number of disjoint paths between pairs of nodes. In contrast to previous work on survivable network design minimizing cost, our goal is to optimize the quality of the selected paths within a specified budget. We provide a MILP encoding, as well as a hybrid local search, based on solving small MIPs in the context of a large neighborhood search.

■ ThB20

20- Smithfield

Nonsmooth and Sparse Optimization with Applications

Cluster: Nonsmooth Optimization

Invited Session

Chair: Yuesheng Xu, Mathematics and Scientific Computation, Sun Yat-sen University, Guangzhou, China, yxu06@syr.edu

1 - Wavelet Inpainting with Sparse Regularization

Lixin Shen, Professor, Syracuse University, Mathematics, Syracuse, NY, United States of America, lshen03@syr.edu

In this talk we proposed a constrained inpainting model to recover an image from its incomplete and/or inaccurate wavelet coefficients. The objective function of the proposed model uses the ℓ_0 norm to promote the sparsity of the resulting image in a tight framelet system. A fixed-point proximity algorithm was developed to solve the model. Our numerical experiments show that the proposed model and the related fixed-point algorithm can recover images with much higher quality in terms of the PSNR values and visual quality of the restored images than the models based on the ℓ_1 norm and the total variation.

2 - Nonconvex Relaxation for Photon-Limited Sparse Optimization

Lasith Adhikari, Graduate Student, University of California, Merced, 5200 Lake Rd, Merced, Ca, 95343, United States of America, ladhikari@ucmerced.edu, Roummel Marcia

Critical to accurate reconstruction of sparse signals from low-dimensional Poisson observations is the solution of nonlinear optimization problems that promote sparse solutions. In this talk, we propose nonconvex regularizers to penalize the negative Poisson log-likelihood function in sparsity recovery problems in photon-limited imaging. We validate the effectiveness of the proposed approach by solving problems from image deblurring and fluorescence molecular tomography.

3 - Solving Linearly Constrained Convex Optimization Problems with Coupled Objective Functions

Cui Ying, PhD Student, Department of Mathematics, NUS, Department of Mathematics, NUS, Block S17, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, cuiying@nus.edu.sg, Xudong Li, Defeng Sun, Kim-Chuan Toh

In this talk, we present an augmented Lagrangian framework for solving large scale linearly constrained convex optimization problems with coupled objective functions. In order to achieve fast convergence for the method, we introduce an inexact accelerated block coordinate descent (ABCD) algorithm to deal with the inner subproblems. Numerical results show that our proposed algorithm is efficient and robust.

■ ThB21

21-Birmingham

Constrained and Parallel Derivative-Free Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

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

1 - A Derivative-Free Optimizer with Locally Convexified Constraints for Nonlinear Programming

Florian Augustin, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, fmaugust@mit.edu, Youssef Marzouk

We present a derivative free trust-region framework for solving nonlinear constrained optimization problems. The algorithm is based on minimum Frobenius norm models for the objective function and the constraints. We handle the constraints by adding a convex offset, the inner boundary path, to the constraint approximations. Additionally, we propose a noise detection feature that indicates inaccurate objective function and constraint evaluations. We close with numerical examples demonstrating the efficiency of the algorithm.

2 - Optimizing Agricultural Fertilizer Application using Derivative-Free Methods

Anahita Hassanzadeh, The Climate Corporation, 201 3rd Street #1100, San Francisco, CA, 94103, United States of America, anahita@climate.com

Fertilizer optimization is a key component of precision agriculture. The type, amount and timing of fertilizers applied to a field directly affect the yield, profitability and the environment. In this talk, we focus on optimizing the timing and amount of fertilizer applications with the goal of maximizing the expected revenue, which in turn depends on the expected yield. Given the complex system of natural processes involved, an analytic formula that captures the fertilizer-yield relationship is not available. We present our formulation of this problem as a constrained black-box optimization problem and use the DFO solver to solve it. We show our computational results on the performance comparison of this solver with several alternatives.

3 - Globalizing Local Search using Parallel Hybrid Derivative-Free Optimization

Scott Pope, SAS Institute, 100 SAS Campus Dr, Cary, NC, United States of America, Scott.Pope@sas.com, Joshua Griffin

We present potential enhancements to a SAS high performance procedure for black-box derivative-free optimization. We outline strategies to improve performance in a parallel hybrid environment by using global search algorithms to guide and coordinate multiple instances of local search routines. In particular we explore how these ideas can be used with DIRECT, a method for global Lipschitzian optimization, and Nelder-Mead, a method for simplex based optimization.

■ ThB22

22- Heinz

Variational Analysis in Stability of Variational Systems

Cluster: Variational Analysis

Invited Session

Chair: Nghia Tran, Oakland University, 2200 N. Squirrel, Rochester, MI, 48309, United States of America, nttran@oakland.edu

1 - Characterizations of Tilt Stability in Nonlinear Programming Under Weakest Qualification Conditions

Helmut Gfrerer, Johannes Kepler University, Altenbergerstrasse 69, Linz, 4040, Austria, Helmut.Gfrerer@jku.at, Boris Mordukhovich

Tilt-stability locally ensures the single-valuedness and Lipschitz continuity of local minimizers with respect to small linear perturbations of the objective function. It can be characterized via the positive definiteness of the second-order subdifferential of the objective. In this talk we characterize tilt-stability in classical nonlinear programming (NLP) with smooth data by means of first-order and second-order derivatives of the problem functions at the reference point. We provide sufficient and necessary conditions for tilt-stability under some qualification conditions on the constraints which are weaker than the Mangasarian-Fromovitz constraint qualification.

2 - Full Stability for Parametric Variational Systems

Nghia Tran, Oakland University, 2200 N. Squirrel, Rochester, MN, 48309, United States of America, nttran@oakland.edu

We introduce new notions of Lipschitzian and Holderian full stability of solutions to general parametric variational systems described via partial subdifferential and normal cone mappings acting in Hilbert spaces. These notions are closely related to local strong maximal monotonicity of associated set-valued mappings. Based on advanced tools of variational analysis and generalized differentiation, we derive verifiable characterizations of these full stability notions via some positive-definiteness conditions involving second-order constructions of variational analysis. The general results obtained are specified for important classes of variational inequalities and variational conditions in both finite and infinite dimensions.

3 - Normal and Nondegenerate Forms of Optimality Conditions for Control Problems with State Constraints

Fernando Fontes, Professor, Universidade do Porto, Systec-ISR, Faculdade de Engenharia, Universidade do Porto, Porto, 4200-465, Portugal, faf@fe.up.pt

For some optimal control problems with pathwise state constraints, the standard forms of the maximum principle may not provide adequate information to select minimizers. This is the case when the scalar multiplier associated with the objective function is equal to zero — the abnormal case, or when the set of multipliers is such that any admissible candidate to solution satisfies the optimality conditions — the degenerate case. We discuss recently proposed stronger forms of optimality conditions, valid under suitable constraint qualifications, that do not allow abnormal or degenerate multipliers.

■ ThB23

23- Allegheny

Graphs of Polyhedra

Cluster: Combinatorial Optimization

Invited Session

Chair: Timothy Yusun, Simon Fraser University, Faculty of Science, 250-13450 102 Ave, Surrey, BC, V3T0A3, Canada, tyusun@sfu.ca

1 - Edges vs Circuits: a Hierarchy of Diameters in Polyhedra

Steffen Borgwardt, Visiting Assistant Professor, UC Davis, Department of Mathematics, Davis, CA, 95616, United States of America, sborgwardt@math.ucdavis.edu, Jesus De Loera, Elisabeth Finhold

The study of the graph diameter of polyhedra is a classical open problem in the theory of linear optimization. We introduce a vast hierarchy of generalizations to the notion of graph diameter. This hierarchy provides some interesting lower bounds for the usual graph diameter. After explaining the structure of the hierarchy and discussing these bounds, we focus on explaining the differences and similarities among the many diameter notions of our hierarchy. Finally, we fully characterize the hierarchy in dimension two. It collapses into fewer categories, for which we exhibit the ranges of values that can be realized as diameters.

2 - The Circuit Diameter of the Klee-Walkup Polyhedron

Timothy Yusun, Simon Fraser University, Faculty of Science, 250-13450 102 Ave, Surrey, BC, V3T0A3, Canada, tyusun@sfu.ca, Tamon Stephen

Consider a variant of the edge-vertex diameter of a polyhedron where each step travels in a circuit direction, i.e. the direction of any edge or potential edges under a translation of the facets, and is maximal subject to feasibility. This is the notion of circuit diameter. In this talk we investigate the circuit diameter of the Klee-Walkup polyhedron, a critical example in the study of polyhedron diameters.

3 - A Mihalisin-Klee Theorem for Fans

Walter Morris, George Mason University, Departmentr of Mathematical Sciences, 4400 University Drive, Fairfax, VA, 22030, United States of America, wmorris@gmu.edu, Rachel Locke

The Mihalisin - Klee Theorem states that an orientation of a 3-polytopal graph is induced by an affine function on some 3-polytope realizing the graph if the orientation is acyclic, has a unique source and a unique sink, and admits three independent monotone paths from the source to the sink. We replace the requirement that the orientation is acyclic with the assumption that it has no directed cycle contained in a face of the orientation, and show that such orientations are induced by 3-dimensional fans.

■ ThB24

24- Benedum

MINLP: Non-Standard Approaches and Applications II

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

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

1 - Continuous Location under the Effect of Refraction

Justo Puerto, Universidad de Sevilla, Dpto. Estadística e Investigación Operat, Sevilla, Spain, puerto@us.es, Victor Blanco, Diego Ponce

In this paper we address the problem of locating a new facility on a d-dimensional space when the distance measure is different at each one of the sides of a given hyperplane H. We relate this problem with the physical phenomenon of refraction, and extend it to any finite dimensional space and different distances at each one of the sides of any hyperplane. Extensive computational experiments run in Gurobi are reported in order to show the effectiveness of the approach. Some extensions of these models are also presented.

2 - Alternative Methods in Linear Regression

Victor Blanco, Universidad de Granada, Facultad de CC Economicas, Granada, Spain, vblanco@ugr.es, Roman Salmeròn, Justo Puerto

We present a wide family of new methods to estimate the coefficients of a linear body to fit a given sample of data. We combine the choice of alternative distance-based residuals with ordered weighted averaging aggregation operators for the residuals. The general optimization problem for those methods is formulated as MINLP. Special cases of the general family are analyzed. For instance, we analyze the classical methods that fit such a general shape, and also the cases when the residuals are measured with block or lp norms. Several experiments, coded in R, have been performed to show the differences and similarities between the new estimations.

3 - A Mixed-Integer Nonlinear Program for the Design and Dispatch of Hybrid Power Generation Systems

Alexandra Newman, Professor, Colorado School of Mines, Department of Mechanical Engineering, Golden, CO, 80401, United States of America, anewman@mines.edu, Johanna Stark Goodman, Sven Leyffer, Mike Scioletti

Renewable energy technologies, combined with battery storage and diesel generators, form hybrid energy systems capable of independently powering locations isolated from the grid. We present an optimization model to determine design and dispatch strategies while minimizing costs, and adhering to constraints on load, power supply, and the way in which the technologies operate. Procurement and some dispatch decisions are integer, while battery behavior introduces nonlinearities. We demonstrate how to solve large instances using linear approximations.

■ ThB25

25- Board Room

Distributed Algorithms for Optimization and Control in Power Systems

Cluster: Optimization in Energy Systems

Invited Session

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

1 - Privacy-Preserving Distributed Optimization and Control of the Smart Grid

Minghui Zhu, Penn State University, muz16@psu.edu

Distributed optimization and control has emerged as a major tool to manage distributed energy resources in the smart grid. Distributed optimization and control necessitates information sharing among spatially distributed entities. This raises the important issue that private information of legitimate entities could be leaked to malicious entities. In this talk, we will present our recent results on distributed optimization and control algorithms which have provable information-theoretic privacy guarantees.

2 - Synchronous and Asynchronous ADMM Algorithms for Eigenvalue Estimation in Power Systems

Aranya Chakrabortty, Assistant Professor, NC State University, 1791 Varsity Drive, Raleigh, NC, 27695, United States of America, achakra2@ncsu.edu, Jianhua Zhang

We propose a distributed-ADMM algorithm for estimating eigenvalues arising from the swing dynamics of power systems. The estimators, distributed over a wide-area communication network, receive real-time dynamic data from the sensors following a disturbance, run local estimation loops using a Prony algorithm, and communicate their estimates with each other through a given communication graph to execute a distributed consensus, and thereby converge to a global estimate iteratively. We impose a probability distribution model for the communication delays between the estimators, and implement two strategies of distributed averaging to cope with the asynchrony resulting from the delays.

3 - A Distributed Approach for Optimal Power Flow Problem

Hesam Ahmadi, ahmadi.hesam@gmail.com, Uday Shanbhag

In this paper, an ADMM-based distributed approach for the solution of the DC optimal power flow problem is presented. We consider a dual formulation and utilize the structure to develop a distributed scheme. We show that the resulting sequence of primal and dual iterates are provably convergent. Preliminary numerics are provided.

■ ThB27

27- Duquesne Room

The Knapsack Problem

Cluster: Combinatorial Optimization

Invited Session

Chair: James Orlin, MIT, E62-570, Cambridge, MA, 02139, United States of America, jorlin@mit.edu

1 - Approximation of the Knapsack Problem with Conflicts

Ulrich Pferschy, University of Graz, pferschy@uni-graz.at, Joachim Schauer

We consider the classical 0-1 Knapsack Problem with additional conflict restrictions on pairs of items, which state that for certain pairs of items at most one item can be contained in any feasible solution. This can also be seen as a Maximum Weight Independent Set Problem with an additional budget constraint. The conflicts between items can be represented by a conflict graph. We will give an overview on the status of approximability for different graph classes. In particular, we will describe an FPTAS for graphs of bounded treewidth and for (weakly) chordal graphs and a PTAS for planar graphs. Also modular and clique decompositions will be discussed leading to an FPTAS for certain graph classes characterized by forbidden subgraphs.

2 - Approximation Algorithms for the Incremental Knapsack Problem

Chun Ye, Columbia University, 500 W120th St., Mudd 315, New York, NY, 10027, United States of America, cy2214@columbia.edu, Daniel Bienstock, Jay Sethuraman

We consider an incremental version of the knapsack problem (IK), where we wish to find an optimal packing of items in a knapsack whose capacity grows weakly as a function of time. We will first show that the problem is strongly NP-hard. We will then discuss a constant factor approximation algorithm for IK, under mild restrictions on the growth rate of the knapsack capacity, and a PTAS for IK when the time horizon T is a constant. Both of our algorithms uses ideas from disjunctive programming.

3 - Faster Approximation Schemes for Knapsack Problems

James Orlin, MIT, E62-570, Cambridge, MA, 02139, United States of America, jorlin@mit.edu, David Rhee

We present a new fully polynomial time approximation scheme (FPTAS) for each of several variants of knapsack problems. These schemes obtain solutions that are guaranteed to have a relative error of at most epsilon, and run in time polynomial in the data and in 1/epsilon. We have developed FPTASes that are faster than the previous best FPTASes for each of the following problems: (1) the nonlinear knapsack problem, (2) the unbounded knapsack problem, (3) the 0-1 knapsack problem, (4) the integer knapsack problem, and (5) the knapsack problem with generalized upper bounds.

■ ThB28

28- Liberty Room

Convexification Techniques in Global Optimization

Cluster: Global Optimization

Invited Session

Chair: Akshay Gupte, Clemson University, Department of Mathematical Sciences, Clemson, SC, 29634, United States of America, agupte@clemson.edu

1 - Semidefinite Approximations of the Copositive Cone

Sergio Camelo, Universidad de los Andes, Cra 1 N∫ 18A- 12, Depto de Matematicas, Bogota, Colombia, sa.camelo38@uniandes.edu.co, Mauricio Velasco

Linear optimization over the copositive cone C (i.e. the cone of quadratic forms which are nonnegative in the positive orthant) has applications in mixed quadratic optimization and in combinatorial optimization. Although convex, this problem is not tractable directly. A construction due to A. Barvinok and E. Veomett and independently J.B. Laserre produces a sequence $(P_k)_{k\in\mathbb{N}}$ of nested spectrahedral cones that contain C. In this work we study this hierarchy and compare its empirical performance with that of the polyhedral and SOS approximations to the copositive cone. In particular, we show results on its practical performance for estimating the clique number of a graph. These results are joint work with M. Velasco.

2 - Valid Inequalities for Separable Concave Constraints

Cong Han Lim, University of Wisconsin - Madison, 3009 University Ave, Apt #305, Madison, United States of America, conghan@cs.wisc.edu, James Luedtke, Jeff Linderoth

Relaxations of separable concave constraints are usually obtained by considering each constraint individually and using the secant obtained from the bounds of the associated variable. We propose a technique for incorporating other variables to tighten the relaxation. In particular, we study the convex hull of a simple set with separable concave constraints, and we derive classes of strong valid inequalities. Computational results for concave-cost flow networks will be presented.

3 - New Multi-Commodity Flow Formulations for the Generalized Pooling Problem

Fabian Rigterink, University of Newcastle, University Drive, Callaghan NSW, 2308, Australia, fabian.rigterink@uon.edu.au, Martin Savelsbergh, Thomas Kalinowski, Natashia Boland

The generalized pooling problem (GPP) is a nonconvex nonlinear programming problem with numerous applications. Much attention has been paid to reformulating the GPP such that linear relaxations provide better bounds. We present new multi-commodity flow formulations for the GPP and discuss their strengths. We conclude the talk by presenting a variation of the GPP arising in mining and solve a real-world blending problem for the port of Newcastle (Australia), the world's largest coal export port.

■ ThB29

29- Commonwealth 1

Solution of Variational Inequalities and Applications

Cluster: Nonsmooth Optimization

Invited Session

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

1 - A Variational-Inequality-Based Algorithm for Locating Multiple Interactive Facilities under Gauge

Jianlin Jiang, Dr., Nanjing University of Aeronautics and Astronautics, 29 Jiangjun Rd., Jiangning District, Nanjing, China, jiangjianlin_nju@163.com

This talk considers a generalized multi-source Weber problem (GMWP), i.e., locating multiple facilities under gauge with considering the locational constraints on facilities and the interactive transportations between facilities. With a variational inequality approach (VI) proposed for solving the involved constrained multi-facility subproblems in the location phase, a new variational-inequality-based location-allocation heuristic algorithm is presented for GVWP. The convergence of the VI approach and the location-allocation algorithm is proved under mild assumptions. Some preliminary numerical results are reported which verify the efficiency of the proposed variational-inequality-based heuristic algorithm.

2 - Lp Regularization for Optimization over Permutation Matrices

Bo Jiang, Dr., Nanjing Normal University, No. 1 Wenyuan Road, Qixia District, Nanjing, China, jiangbo@njnu.edu.cn, Zaiwen Wen, Ya-Feng Liu

Optimization problem over permutation matrices has wide applications in graph matching, computer manufacturing, scheduling, etc. In this talk, we shall consider the Lp regularization for optimization over permutation matrices. Some theoretic properties of the Lp regularization will be introduced and analyzed. The preliminary numerical results on QAPLIB instances show that our Lp regularization approach is very promising for the quadratic assignment problem.

3 - A General Inertial Proximal Point Method for Mixed Variational Inequality Problem

Junfeng Yang, Dr., Nanjing University, 22 Hankou Road, Nanjing, 210093, China, jfyang@nju.edu.cn, Caihua Chen, Shiqian Ma

We first propose a general inertial proximal point method for the mixed variational inequality problem. Under certain conditions, we are able to establish the global convergence and a $o(1/k)$ convergence rate result of the proposed method. By applying the proposed method to linearized augmented Lagrangian method and the linearized alternating direction method of multipliers, we obtain their inertial versions whose global convergence are guaranteed. We also demonstrate the effect of the inertial extrapolation step via experimental results on the compressive principal component pursuit problem.

■ ThB30

30- Commonwealth 2

Approximation and Online Algorithms

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Andreas Karrenbauer, Max Planck Institute for Informatics, Campus E1 4, Saarbruecken, 66123, Germany, andreas.karrenbauer@mpi-inf.mpg.de

1 - Improved Algorithms for Vertex Cover with Hard Capacities on Multigraphs and Hypergraphs

Wang Chi Cheung, PhD Student, MIT, 77 Massachusetts Ave, Cambridge, MA, 02139, United States of America, wangchi@mit.edu, Michel Goemans, Chiu-wai Wong

We consider the minimum unweighted vertex cover problem with hard capacity constraints. Given a graph, the objective is to find a smallest multiset of vertices covering all edges; each selected vertex only covers a limited number of incident edges, and the number of available copies of each vertex is bounded. This problem was first studied by Saha and Khuller (ICALP 2012), who proposed 38 and max{6f, 65} approximation algorithms for multigraphs and f-hypergraphs respectively. We improve these ratios to 2.155 and 2f respectively. Our algorithms consist of a two-step process, each based on rounding an appropriate LP. For multigraphs, the analysis in the second step relies on identifying a matching structure within any extreme point solution.

2 - Almost Tight Approximation Results for Biclique Cover and Partition

Andreas Karrenbauer, Max Planck Institute for Informatics, Campus E1 4, Saarbruecken, 66123, Germany, andreas.karrenbauer@mpi-inf.mpg.de, Parinya Chalermsook, Sandy Heydrich, Eugenia Holm

We consider the problems of covering/partitioning the edgeset of a bipartite graph with/into a minimum number of complete bipartite subgraphs (a.k.a. bicliques). We show that both problems are as hard to approximate as Coloring. By exploiting properties of graph products, we obtain lower bounds for the approximation guarantee of poly-time algorithms, which grow almost linearly in the number of nodes. We thereby raise the previous best lower bound for Minimum Biclique Cover by a power of 3. The improvement for Minimum Biclique Partition is even more significant, where only APX-hardness was known before. Furthermore, we provide sub-linear approximation factors, which almost closes the remaining gap between upper and lower bounds.

3 - Cutting Plane Methods for Minimax Distributionally Robust Optimization

Huifu Xu, University of Southampton, Highfield, Southampton, United Kingdom, h.xu@soton.ac.uk

Slater-type conditions have been widely used for solving minmax distributionally robust optimization (DRP) problems. This paper introduces new weaker and more verifiable conditions based on a stability result due to Shapiro for minimax DRP with matrix moment constraints. Moreover, it introduces a randomization scheme for approximating the semi-infinite constraints and relates approach to discretization of the ambiguity set defined through moments. Cutting plane methods have been proposed for both minimax DRO with distretized ambiguity set and its Lagrange dual. Convergence analysis has been presented for the approximation schemes in terms of the optimal value, optimal solutions and stationary points.

Thursday, 1:10pm - 2:40pm

■ ThC01

01- Grand 1

Complementarity/Variational Inequality IV

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Jong Shi Pang, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089, United States of America, jongship@usc.edu

1 - Modeling Dynamic Traffic Assignment Problems using Differential Complementarity Systems

Xuegang Ban, Associate Professor, Rensselaer Polytechnic Institute, 110 8th St, JEC 4034 CEE RPI, Troy, NY, 12180, United States of America, banx@rpi.edu, Jong Shi Pang, Rui Ma

Dynamic Traffic Assignment (DTA) problems are one of the most challenging problems in transportation science. Extensive research has been done in the past on modeling/solving DTA problems, mainly in the discrete-time domain. This talk concerns about modeling and solving DTA in the continuous-time domain, which enables the investigation of some fundamental issues of DTA such as discretization, convergence, etc. By applying a recent mathematical paradigm, named Differential Complementarity Systems (DCS), it is shown that DCS can better capture the key characteristics of continuous-time DTA and allows more rigorously modeling of DTA. Challenges and future research directions of using DCS to model and solve DTA will also be presented.

2 - A Stochastic Multi-Agent Optimization Model for Energy Infrastructure System Planning

Yueyue Fan, Associate Professor, University of California-Davis, Dept. of Civil and Environmental Eng., Davis, CA, 95616, United States of America, yyfan@ucdavis.edu, Zhaomiao Guo

This paper presents a stochastic multi-agent optimization model that supports renewable energy infrastructure planning under uncertainty. The interdependence between different stakeholders in the system is captured in an energy supply chain network, where new entrants of renewable investors compete among themselves and with existing generators for natural resources, transmission capacities, and demand markets. Solution algorithm based on variational inequalities and stochastic decomposition is designed to overcome computational difficulties. A real-world application based on Sacramento Municipal Utility District (SMUD) power network is implemented to draw engineering and policy insights.

3 - Computing B-Stationary Points of Nonsmooth DC Programs

Jong Shi Pang, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089, United States of America, jongship@usc.edu, Meisam Razaviyayn, Alberth Alvarado

This paper studies a nonsmooth, difference-of-convex (dc) minimization problem. The contributions of this paper are: (i) clarify several kinds of stationary solutions and their relations; (ii) develop and establish the convergence of a novel algorithm for computing a d-stationary solution of a problem with a convex feasible set that is arguably the sharpest kind among the various stationary solutions; (iii) extend the algorithm in several directions including: a randomized choice of the subproblems that could help the practical convergence of the algorithm, a distributed penalty approach for problems whose objective functions are sums of dc functions, and problems with a specially structured (nonconvex) dc constraint.

■ ThC02

02- Grand 2

Optimization Under Uncertainty in Electric and Gas Energy Systems

Cluster: Optimization in Energy Systems

Invited Session

Chair: Andy Sun, Assistant Professor, Georgia Institute of Technology, 765 Ferst Drive, Room 444 Groseclose Bld., Atlanta, GA, 30332, United States of America, andy.sun@isye.gatech.edu

1 - Two-stage Distributionally Robust Unit Commitment With Extended Linear Decision Rules

Ruiwei Jiang, Assistant Professor, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48109, United States of America, ruiweijiang@email.arizona.edu, Jianhui Wang, Yuanyuan Guo

It can be challenging to accurately estimate the joint probability distribution of the renewable energy. In this talk, based on a small amount of marginal historical data, we propose a two-stage distributionally robust unit commitment model that considers a set of plausible probability distributions. Numerical results show that this approach is less conservative than the classical robust unit commitment models and more computationally tractable by using extended linear decision rules.

2 - Reinforcement of Gas Transportation Networks with Uncertain Demands

Frederic Babonneau, Vice president, Ordecsys, Rue du Gothard, 5, Chéne-Bourg, Switzerland, fbabonneau@gmail.com

The present work extends an earlier paper of Babonneau, Nesterov and Vial on the reinforcement of gas transmission networks to include uncertainty on the demands via robust optimization, fixed costs and commercial restrictions on pipe sizes. The model in continuous variables is SOCP and combines reinforcement and robust constraints. The handling of discrete variables leads to a mixed SOCP. Numerical results will be presented.

3 - Sub-Hourly Optimization Effects in the European Power Grid under Deep Renewable Energy Integration

Ignacio Aravena, PhD Student, Center for Operations Research and Econometrics, UC Louvain, Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, ignacio.aravena@uclouvain.be, Antony Papavasiliou

Day-ahead electricity markets are usually managed using an hourly resolution which masks the sub-hourly fluctuations of renewable supply. We present a detailed model of the European day-ahead market (hourly resolution), and compare its performance against deterministic and stochastic unit commitment (hourly and 15’ minutes resolution) in terms of real-time operation cost, estimated using a Monte Carlo scheme and a 15’ real-time model. Numerical experiments are conducted using a detailed instance of Central Western European system.

■ ThC03

03- Grand 3

Combinatorial Optimization: Beyond Linear Relaxations

Cluster: Combinatorial Optimization

Invited Session

Chair: Jose Correa, Universidad de Chile, Republica 701, Santiago, Chile, correa@uchile.cl

1 - Easy or Selfish Scheduling on Related Machines

Neil Olver, VU University Amsterdam & CWI, De Boelelaan 1105, 1081 HV, Amsterdam, Netherlands, olver@cwi.nl, Jose Correa, Mona Rahn, Guido Schaefer

We consider a question about the weighted sum of completion times on related machines, one with two equivalent formulations. What is the approximation ratio of the natural greedy list scheduling heuristic? Alternatively, what is the worst-case price of anarchy of the scheduling game in this setting? This is well understood for the case of unrelated machines, but we will discuss an approach (based on convex relaxations) for obtaining better bounds in the related machines case.

2 - Approximating ATSP by Relaxing Connectivity

Ola Svensson, EPFL, EPFL-IC, Building INJ (INJ112), Lausanne, 1015, Switzerland, ola.svensson@epfl.ch

A long standing open problem is to understand whether the asymmetric traveling salesman problem admits a constant factor approximation algorithm. We propose a new approach for tackling this problem and show that our approach yields a constant factor approximation algorithm when restricted to shortest path metrics of node-weighted graphs. The considered case is more general than the directed analog of the special case of the symmetric traveling salesman problem for which there were recent improvements on Christofides' algorithm.

3 - Strong LP Formulations for Scheduling Splittable Jobs on Unrelated Machines

Jose Verschae, Assistant Professor, Ponthifical Catholic University of Chile, Av Vicuña 4860, Las Condes, Santiago, RM, 7580641, Chile, jverschae@uc.cl, Leen Stougie, Ola Svensson, Alberto Marchetti-Spaccamela, Jannik Matuschke, Victor Verdugo, Jose Correa

We consider a natural scheduling problem where we need to assign jobs to machines in order to minimize the makespan. In our variant jobs may be split into parts, where each part can be (simultaneously) processed on different machines. Splitting jobs helps balancing the load, but this is not for free: each part requires a setup time, increasing the processing requirement of the job. I will introduce the problem and present approximation algorithms based on the rounding of different types of relaxations. Our main result is a (1+f)-approximation algorithm, where f~1.618 is the golden ratio. This ratio is best possible for the relaxation used. On the negative side we show that the problem is NP-hard to approximate within a factor of 1.582.

ThC04

04- Grand 4

Nonnegative Matrix Factorization and Related Topics I

Cluster: Conic Programming

Invited Session

Chair: Nicolas Gillis, Rue de Houdain 9, Mons, 7000, Belgium, nicolasgillis@gmail.com

Co-Chair: Stephen A. Vavasis, University of Waterloo, 200 University Avenue W., Waterloo, ON, N2L 3G1, Canada, vavasis@uwaterloo.ca

1 - Fast Hierarchical Nonnegative Matrix Factorization for Clustering

Da Kuang, Postdoctoral Researcher, Georgia Institute of Technology, 2042 Oak Park Cir NE, Atlanta, GA, 30324, United States of America, kdmaths@gmail.com

I will present fast algorithms for Rank-2 nonnegative matrix factorization (NMF) for large-scale clustering. The algorithms are architecture-aware, incurring contiguous memory access for higher throughput. Recursively applying Rank-2 NMF to a data set generates a hierarchy of clusters efficiently, which can be easily converted into a flat partitioning as well. Examples on topic modeling, hyperspectral imaging, and community detection will be used to demonstrate the significantly improved efficiency of our algorithms.

2 - Near-Separable Non-Negative Matrix Factorization with l1 and Bregman Loss Functions

Abhishek Kumar, IBM T.J. Watson Research Center, Yorktown Heights, NY, 10598, United States of America, abhishek@umiacs.umd.edu, Vikas Sindhwani

Recently, a family of tractable NMF algorithms have been proposed under the assumption that the data matrix satisfies a separability condition. Geometrically, this condition reformulates the NMF problem as that of finding the extreme rays of the conical hull of a finite set of vectors. We propose separable NMF algorithms with l1 loss and Bregman divergences that extend the conical hull procedures proposed in our earlier work (Kumar et al., 2013). On foreground-background separation problems in computer vision, the proposed near-separable NMF algorithms match the performance of Robust PCA, considered state of the art on these problems, with an order of magnitude faster training time. We also demonstrate applications in exemplar selection.

3 - Constrained Orthogonal Nonnegative Matrix Factorization

Vamsi Potluru, Comcast Cable, 1110 Vermont Ave NW, Washington, DC, 20005, United States of America, vamsi_potluru@cable.comcast.com

Nonnegative matrix factorization has been successfully applied to a wide range of applications such as document clustering, hyperspectral image analysis, and speech enhancement. Additional constraints such as sparsity, orthogonality have been imposed to incorporate prior domain knowledge. We present a new model for imposing orthogonal constraints which are better aligned with user-defined requirements. Empirical evaluations are shown on real-world datasets.

ThC05

05- Kings Garden 1

Recent Advances in Computational Optimization II

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

1 - SQP methods for Optimization Problems in Simulation and Control

Philip E. Gill, UC San Diego, Department of Mathematics, La Jolla, CA, 92039-0112, United States of America, pgill@ucsd.edu, Michael Saunders, Elizabeth Wong

Many practical problems in simulation and control require the solution of a sequence of related nonlinear optimization problem with a large, but sometimes dense constraint Jacobian. In this context, we consider some aspects of the formulation and analysis of "fast" sequential quadratic programming (SQP) methods.

2 - An Augmented Lagrangian Filter Method for Nonlinear Optimization

Sven Leyffer, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, United States of America, leyffer@mcs.anl.gov

We present a new augmented Lagrangian filter method that incorporates a new augmented Lagrangian filter to control the accuracy of the approximate minimization of the augmented Lagrangian. We show that the method converges globally, and present numerical results.

3 - Sparse Techniques for Polyhedral Projection

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

An efficient algorithm is developed for projecting a point onto a polyhedron. The algorithm solves a dual version of the primal projection problem and then uses the relationship between the primal and dual to recover the projection. The techniques exploit sparsity. SpaRSA (Sparse Reconstruction by Separable Approximation) is used to approximately identify active constraints in the polyhedron, and the Dual Active Set Algorithm (DASA) is used to compute a high precision solution. A new Q-linear convergence result is established for SpaRSA. An algorithmic framework is developed for combining SpaRSA with an asymptotically preferred algorithm such as DASA. It is shown that only the preferred algorithm is executed asymptotically.

ThC06

06- Kings Garden 2

Geometry and MINLP

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Jon Lee, University of Michigan, jonxlee@umich.edu

1 - Optimal Double McCormick for Trilinear Monomials

Emily Speakman, University of Michigan, Ann Arbor, MI, United States of America, eespeakm@umich.edu, Jon Lee

When using the standard McCormick inequalities iteratively to linearize trilinear monomials, there is a choice of which variables to group first. In this talk, we explore the effect of this choice on the feasible regions of the resulting linear relaxations. By computing the 4-dimensional volumes of appropriate polytopes (which are dependent on the upper and lower bounds of the variables), we describe the optimal way to perform this double McCormick linearization.

2 - Mixed-integer Optimization of Unconstrained Polynomials

Sönke Behrends, PhD Student, Georg-August-Universitaet Goettingen, Lotzestr. 16-18, Goettingen, 37083, Germany, s.behrends@math.uni-goettingen.de, Anita Schöbel

Given a multivariate polynomial, we consider the problem to find its unconstrained mixed-integer minimum. As the general case is undecidable, we rely on a sufficient condition for the existence of minimizers: If the leading form is positive definite, we give explicit bounds on the norm of all minimizers, which improves on a result on continuous minimizers from the literature. The problem can then be solved using branch and bound - which requires lower bounds. To this end we introduce a class of underestimators; choosing the best underestimator can be recast as a sum-of-squares program. Using ideas from real algebraic geometry, the lower bound can be further tightened. For the integer case, we present results on random instances.

3 - Advances in Mixed-Integer Black Box Optimization with Expensive Function Evaluation

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

We study the problem of optimizing an unknown function given as an oracle (black box) over a mixed-integer set. We assume that the oracle is expensive to evaluate. Our approach is based on the Radial Basis Function method originally proposed by Gutmann (2001). Our main methodological contributions are an approach to exploit a noisy but less expensive oracle to accelerate convergence to the optimum of the exact oracle, and an automatic model selection phase during the optimization process. Numerical experiments show that these contributions significantly improve the performance of the algorithm on a test set of continuous and mixed-integer nonlinear unconstrained problems. Our implementation is available under Revised BSD license.

■ ThC07

07- Kings Garden 3

Mathematical Programming in Data Science II

Cluster: Integer and Mixed-Integer Programming

Invited Session

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

1 - Rectangular Maps for Graph Visualization: A Mixed Integer Nonlinear Approach

Vanesa Guerrero Lozano, University of Seville, C/ Tarfia s/n, 41012, Sevilla, 41012, Spain, vguerrero@us.es, Emilio Carrizosa, Dolores Romero Morales

In this talk we address the problem of representing a weighted graph by means of a rectangular map, i.e., a subdivision of a rectangle into rectangular portions, so that each portion is associated with one individual, the areas of the portions reflect the weights, and portions adjacencies reflect adjacencies in the binary relation. This visualization problem is formulated as a three-objective Mixed Integer Nonlinear problem. Our numerical results demonstrate that is is possible to provide a collection of rectangular maps with different tradeoffs between an accurate representation of the weights by areas versus an accurate representation of the relation by adjacencies.

2 - Exact Mathematical Programming Formulations for Balanced Tree Partitioning Problems

Onur Seref, Virginia Tech, Pamplin 1007, Blacksburg, VA, 24061, United States of America, seref@vt.edu, Paul Brooks

In this paper, we study variations of the Balanced Tree Partitioning problem. Some versions of this problem such as the k-Balanced Tree Partitioning problem are known to be NP-hard. Although there are a number of studies on approximation algorithms, exact mathematical programming formulations are not well understood. We introduce compact exact mixed integer programming formulations to solve different variations of the Balanced Tree Partitioning problem. We explore the effect of different sets of constraints on our formulations and provide comparative computational results among our formulations as well as other exact formulations and approximation algorithms.

3 - Network-based Data Mining via Clique Relaxations

Eugene Lykhovyd, Texas A&M University, TAMU-3131, College Station, TX, 77843, United States of America, lykhovyd@tamu.edu, Austin Buchanan, Sergiy Butenko

We discuss network-based data mining techniques that utilize clique relaxation models in networks. In particular, the methodology is applied to analyze bitcoin transaction data.

■ ThC08

08- Kings Garden 4

(Co)Sparsity in Tomography and Inverse Problems

Cluster: Sparse Optimization and Applications

Invited Session

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

1 - Cosparse Image Recovery from Few Tomographic Projections

Stefania Petra, Heidelberg University, Speyerer Strafle 6, HCI, Heidelberg, 69115, Germany, petra@math.uni-heidelberg.de

We consider the reconstruction problem in discrete tomography from the viewpoint of compressed sensing (CS). We present an average-case relation between image cosparsity and sufficient number of tomographic measurements for exact recovery similar to the settings in CS, and observe a phase transition known in CS, but not established for the tomographic set-up. In addition, we present a large-scale total-variation minimization approach for reconstructing 3D solid bodies composed of few different materials from a limited number of tomographic projections.

2 - Verification of Exact Solutions in Compressed Sensing with Application to CT

Christian Kruschel, University of Goettingen, Lotzestr. 16-18, Goettingen, 37083, Germany, Christian.Kruschel@mathematik.uni-goettingen.de, Jakob S. Jörgensen, Dirk A. Lorenz

Compressed Sensing techniques are promising for reducing measurements in several applications. However, considering computed tomography, theoretical results, based for example on the restricted isometry property or mutual coherence, deliver bad results for applying compressed sensing. In this talk, we analyze the applicability of compressed sensing to CT via their sufficient (and necessary) conditions. For that purpose we construct uniqueness tests for basis pursuit, anisotropic and isotropic total variation. Further we construct test instances which will be used for Monte Carlo experiments to empirically show that a phase transition in dependency of measurements and sparsity also exists for fan-beam CT applications.

3 - Sparse Signal Recovery from Nonlinear Measurements

Yonina Eldar, Technion, Techion City, Haifa, Israel, yonina@ee.technion.ac.il

We consider an extension of compressed sensing to nonlinear measurements. We present several optimality criteria for sparse recovery from nonlinear measurements and show that they can be used to develop efficient recovery algorithms. A special case that is of large interest in optics is phase retrieval, in which one needs to recover an image given only its Fourier transform magnitude. We consider conditions on the number of measurements needed for stable phase retrieval and show that surprisingly the results coincide with those obtained in the linear measurement setting (up to constants). We demonstrate our algorithms on a variety of problems in optical imaging.

■ ThC09

09- Kings Garden 5

Robust Optimization: Applications to Operations Management

Cluster: Robust Optimization

Invited Session

Chair: Chaithanya Bandi, Assistant Professor, Kellogg School of Management, Northwestern University, 2001 Sheridan Road, 566, Evanston, IL, 60208, United States of America, c-bandi@kellogg.northwestern.edu

1 - Increasing Supply Chain Robustness through Process Flexibility and Inventory

Yehua Wei, Duke University, 100 Fuqua Drive, P.O. Box 90120, Durham, NC, 27713, United States of America, yehua.wei@duke.edu, David Simchi-Levi, He Wang

We study a hybrid strategy that uses both process flexibility and inventory to mitigate risks of plant disruption. In this setting, a firm allocates inventory before disruption while facing demand uncertainties; and schedules its production after demand and disruption are realized. This problem is modeled as a two-stage robust optimization. We show that the robust optimization model can be formulated as a linear program and solved efficiently. Using analytical and numerical analysis, we study the impact of different flexibility designs on the firm's inventory decisions. Our analysis the impact of process flexibility on total inventory level; freedom in inventory placement; inventory allocation strategy.

2 - Simulation Optimization of Stochastic Systems via Robust Optimization

Nataly Youssef, MIT, 20 Palermo Street, Cambridge, MA, 02141, United States of America, youssefn@mit.edu, Dimitris Bertsimas

We propose a tractable approach for simulating and optimizing stochastic systems via robust optimization. Specifically, we model uncertainty via parameterized polyhedral sets inspired by probabilistic limit laws and characterized by variability parameters that control the degree of conservatism of the model. We then cast the fundamental performance analysis and risk minimization problems as robust optimization problems. We demonstrate the tractability and accuracy of our approach via applications from inventory management and portfolio optimization.

3 - Robust All Pay Auctions and Optimal Crowdsourcing

Chaithanya Bandi, Assistant Professor, Kellogg School of Management, Northwestern University, 2001 Sheridan Road, 566, Evanston, IL, 60208, United States of America, c-bandi@kellogg.northwestern.edu

In this talk, we present and analyze a model in which users select among, and subsequently compete in, a collection of contests offering various rewards. The objective is to capture the essential features of a crowdsourcing system, an environment in which diverse tasks are presented to a large community. We answer this question in the setting of incomplete information via All pay auctions and robust optimization.

■ ThC10

10- Kings Terrace

Risk Management Approaches in Engineering Applications

Cluster: Finance and Economics

Invited Session

Chair: Stan Uryasev, University of Florida, Gainesville, FL, 32611, United States of America, uryasev@ufl.edu

1 - Maximization of AUC and Buffered AUC in Classification

Matthew Norton, University of Florida, 2449 NW 93rd st, Gainesville, FL, 32606, United States of America, mdnorton@ufl.edu

We utilize a new concept, called Buffered Probability of Exceedance (bPOE), to introduce an alternative to the Area Under the Receiver Operating Characteristic Curve (AUC) performance metric called Buffered AUC (bAUC). Central is a new technique for optimization of bPOE, reducing it to convex, sometimes even linear, programming. We utilize bPOE to create the bAUC performance metric, showing it to be an intuitive counterpart to AUC that is much easier to optimize than AUC, specifically reducing to convex and linear programming. We use these properties to introduce the bAUC Efficiency Frontier, a concept that serves to partially resolve the ``incoherency" that arises when misclassification costs need be considered.

2 - CVaR Distance between Univariate Probability Distributions and Approximation Problems

Konstantin Pavlikov, University of Florida, 1350 N Poquito Road, Shalimar, FL, United States of America, kpavlikov@ufl.edu, Stan Uryasev

In this talk we define new distances between univariate probability distributions, based on the concept of the CVaR norm. We approximate a discrete distribution by another discrete distribution by minimizing new distances. We find: (i) optimal locations of atoms of the approximating distribution with fixed probabilities and (ii) optimal probabilities with a priori fixed approximating positions of atoms. These two steps are further combined in an iterative procedure for finding both atom locations and their probabilities. Numerical experiments show high efficiency of the proposed approach, solved with convex and linear programming.

3 - Buffered Probability of Exceedance for Multidimensional Random Variables

Alexander Mafusalov, University of Florida, 303 Weil Hall P.O. Box 116595, Gainesville, FL, 32611, United States of America, mafusalov@ufl.edu, Stan Uryasev

This paper introduces a new probabilistic characteristic called buffered probability of exceedance (bPOE). This characteristic is an extension of so-called buffered probability of failure and it is equal to one minus superdistribution function. Paper provides efficient calculation formulas for bPOE. bPOE is proved to be a closed quasi-convex and monotonic function of random variable. Minimization of the bPOE can be reduced to a convex program for a convex feasible region and to LP for a polyhedral feasible region. A family of bPOE minimization problems and family of the corresponding CVaR minimization problems share the same frontier of optimal solutions and optimal values.

■ ThC11

11- Brigade

Independent and Hitting Sets of Rectangles

Cluster: Combinatorial Optimization

Invited Session

Chair: Jose Soto, Assistant Professor, Universidad de Chile, Beauchef 851, Quinto Piso., Santiago, Chile, jsoto@dim.uchile.cl

1 - Approximation Algorithms for Independent Set/Hitting Set of Non-Piercing Rectangles via Local Search

Norbert Bus, PhD Student, Université Paris-Est, 2, Boulevard Blaise Pascal, Noisy-Le-Grand Cedex, 93126, France, busn@esiee.fr, Nabil Mustafa, Shashwat Garg, Saurabh Ray

Local search is a simple and powerful framework in the design of algorithms for combinatorial optimization problems. In this talk we will describe a local-search algorithm for approximating independent/hitting sets of non-piercing rectangles. Using local search Chan and Har-Peled (2009) gave a PTAS for calculating independent set of non-piercing rectangles, Mustafa and Ray (2010) gave the first PTAS for the minimum hitting set problem for disks. Although these techniques give arbitrarily good approximations, their running time is prohibitively large. Recently Bus et al. (2015) improved the method, achieving 8-approximation of independent set of non-piercing rectangles with (3,2)-local search. We describe the key elements of these results.

2 - Decomposition Techniques for Coloring and Independent Set of Rectangles

Parinya Chalermsook, MPII, Campus E1 4, Saarbrucken, 66123, Germany, parinya@mpi-inf.mpg.de

Given a collection of rectangles in the plane, we consider the following two questions: (i) Computing a maximum cardinality subset of pairwise non-overlapping rectangles and (ii) Bounding the chromatic number of a rectangle intersection graph in terms of its clique number. In this talk, I will discuss techniques that decompose any rectangle intersection graph into several “easy” subinstances (those “easy” instances are either perfect or degenerate graph.) This technique has been used in obtaining the following results: An O(log log n) approximation algorithm for the first problem, an O(w log w)-coloring for a broad class of input, and an O(w)-coloring for a relaxed problem where rectangles are allowed to shrink slightly.

3 - Independent and Hitting sets of Rectangles Intersecting a Diagonal Line

Jose Soto, Assistant Professor, Universidad de Chile, Beauchef 851, Quinto Piso., Santiago, Chile, jsoto@dim.uchile.cl, Jose Correa, Pablo Perez-Lantero, Laurent Feuilloley

Wegner conjectured in the 60s that the duality gap between the maximum independent set (MIS) and the minimum hitting set (MHS) of any set of axis-parallel rectangles is bounded by a constant. An interesting special case, that may be useful to tackle the general one, is the diagonal-intersecting case, in which all rectangles are intersected by a diagonal. We show that MIS in diagonal-intersecting sets is NP-complete. Then we derive an O(n^2)-time algorithm for the maximum weight independent set (MWIS) when, in addition the rectangles intersect below the diagonal. This implies a 2-approximation algorithm for MWIS on diagonal-intersecting families. Finally, we prove that for diagonal-intersecting sets the duality gap is between 2 and 4.

■ ThC12

12- Black Diamond

Stochastic Methods for Procurement with Auctions and Contracts

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Chefi Triki, Associate Prof., Sultan Qaboos University, Al Khoud, Muscat, 123, Oman, chefi.triki@unisalento.it

1 - A Solution Approach for WDP in Combinatorial Transportation Procurement Auctions under Uncertainty

Nabila Remli, Cirrelt, 2325 rue de la Terrasse, Quebec, Canada, nabila.remli@gmail.com, Monia Rekik, Issmail Elhallaoui

In combinatorial transportation auctions, shippers act as auctioneers who need to outsource a number of transportation services to external carriers. Carriers compete by submitting bids on packages of shippers’ requests. After receiving all carriers’ bids, the shipper solves the well-known winner determination problem (WDP) in order to determine winning bids. This paper considers the WDP in a context where shipment volumes are not known with certainty. A 2-stage robust formulation is proposed and solved using a constraint generation algorithm. Different accelerating procedures are proposed. Our experimental results show that these accelarting procedures considerably reduce computing times.

2 - Generating Bids in Combinatorial Auctions for the Truckload Procurement

Chefi Triki, Associate Prof., Sultan Qaboos University, Al Khoud, Muscat, 123, Oman, chefi.triki@unisalento.it

Combinatorial Auctions have shown to be very efficient in allocating resources to bidders. Even in the logistics sector several successful experiences of companies that have used CAs in order to procure their transportation needs and achieved remarkable cost savings. Carriers can also take advantage from participating in the e-markets by bidding on loads that reduce the truck empty movements in their transportation networks. The aim of the talk is to define a probabilistic optimization model for the bid generation and evaluation problem that integrates also the routing decision related to the carriers' fleet. Moreover, we develop two heuristic procedures in order to solve the BGP and test their performance on a set of test instances.

■ ThC13

13- Rivers

Mathematical Programming with Equilibrium Constraints

Cluster: Game Theory

Invited Session

Chair: Siddharth Barman, California Institute of Technology, 1200 E. California Blvd., MC 305-16, Pasadena, CA, 91125, United States of America, sid.barman@caltech.edu

1 - Polynomial-Time Complementary Pivot Algorithms for Market Equilibria

Jugal Garg, Max-Planck Institute for Informatics, MPI, Building Campus E1 4, Room 321, Saarbrücken, 66123, Germany, jugal.garg@gmail.com, Milind Sohoni, Ruta Mehta, Nisheeth Vishnoi

We consider the problem of computing market equilibria in the Fisher model for utility functions such as linear, spending constraint and perfect price-discrimination. In each case we start with a convex program that captures market equilibria, and in a systematic way, covert it into a linear complementary problem (LCP) formulation. To obtain a polynomial-time algorithm, we depart from previous approaches of pivoting on a single polyhedron associated with the LCP. Instead, we carefully construct a polynomial-length sequence of polyhedra, one containing the other, such that starting from an optimal solution to one allows us to obtain an optimal solution to the next in the sequence in a polynomial number of complementary pivot steps.

2 - Approximating Sparse Bilinear Programs via an Approximate Version of Caratheodory's Theorem

Siddharth Barman, California Institute of Technology, 1200 E. California Blvd., MC 305-16, Pasadena, CA, 91125, United States of America, sid.barman@caltech.edu

We present novel algorithmic applications of an approximate version of Caratheodory's theorem. This theorem establishes that, given a set of vectors X in R^d, for every vector in the convex hull of X there exists an \epsilon-close (under the p-norm, for 2<= p < \infty) vector that can be expressed as a convex combination of at most b vectors of X, where the bound b is independent of the dimension d. This theorem can be obtained by instantiating Maurey's empirical method (c.f. Pisier 1980/81 and Carl 1985). We use this approximate version of Caratheodory's theorem to develop efficient additive approximation algorithms for (i) sparse bilinear programs over the simplex, and (ii) Nash equilibria in a relevant class of two-player games.

3 - Faster First-Order Methods for Extensive-Form Game Solving

Christian Kroer, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, ckroer@cs.cmu.edu, Tuomas Sandholm, Fatma Kilinc-Karzan, Kevin Waugh

We investigate the application of first-order methods to computing a Nash equilibrium in two-player zero-sum extensive-form games. Many first-order methods rely on a measure of distance over the search space. For our setting, a natural measure is the dilated entropy function. We study this function on treeplexes, which are convex polytopes that encompass the strategy spaces of the players. We develop significantly stronger bounds on the associated strong convexity parameter. In terms of game solving, this considerably improves the convergence rate of several first-order methods. We instantiate both deterministic and stochastic first-order methods using our results, and experimentally show that our algorithms outperform prior algorithms.

■ ThC14

14- Traders

Cryptography, Game Theory and Bounded Rationality

Cluster: Game Theory

Invited Session

Chair: Rafael Pass, Associate Professor, Cornell University, 111 8th Avenue #302, NY, NY, 10011, United States of America, rafael@cs.cornell.edu

1 - The Truth Behind the Myth of the Folk Theorem

Lior Seeman, Cornell University, New York, NY, United States of America, lior.seeman@gmail.com, Rafael Pass

The complexity of finding a Nash equilibrium (NE) is a fundamental question at the interface of game theory and computer science. Our focus in this talk is on the complexity of finding a NE in repeated games. Earlier work by Borgs et al. [2010] suggests that this problem is computationally intractable, even if we only care about finding an ϵ-NE. But, if we take seriously the question of efficiently finding a NE, it must be because we have computationally-bounded players in mind. We show that if players are indeed computationally bounded (polynomial-time Turing machines), and we make some standard cryptographic hardness assumptions (the existence of public-key encryption), then there exists a polynomial-time algorithm for finding an ϵ-NE in repeated games.

2 - Analyzing Cut and Choose Protocols

Abhi Shelat, U of Virginia, 85 Engineer's Way, Charlottesville, VA, 22902, United States of America, abhi@virginia.edu

The technique of cut-and-choose enables constructing cryptographic protocols that are efficient and yet secure against malicious behavior. The basic idea is for one party to prepare a set of "puzzles," a subset of which a verifier audits and the rest of which the verifier requests solutions from the prover. In folklore discussions of this technique, the Prover and Verifier strategies for cut-and-choose are deterministic. In this talk, we use minmax to construct an optimal randomized strategy that leads to both theoretical and practical improvements for many applications such as secure 2-party computation. Joint observation with Y Huang, J Katz, and E Shi.

3 - Reasoning Cryptographically about Knowledge

Rafael Pass, Associate Professor, Cornell University, 111 8th Avenue #302, NY, NY, 10011, United States of America, rafael@cs.cornell.edu

Cryptographic notions of knowledge consider the knowledge obtained, or possessed, by computationally-bounded agents under adversarial conditions. In this talk, we will survey some recent cryptographically-inspired approaches for reasoning about agents' knowledge in the context of mechanism design, voting theory and weather forecasting.

■ ThC15

15- Chartiers

Massive Parallel Implementations of Optimization Software

Cluster: Implementations and Software

Invited Session

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

1 - How to Run a Customized SCIP Solver on Supercomputers with Over 80,000 Cores

Yuji Shinano, Zuse Institute Berlin, Takustr. 7, 14195, Berlin, Germany, shinano@zib.de

SCIP is a framework for Constraint Integer Programming that enables us to develop a customized SCIP solver for a specific combinatorial optimization problem by writing user plugins. ParaSCIP and FiberSCIP are two parallel extensions of SCIP, and their libraries provide us a systematic way to parallelize the customized solver with little effort. Computational results of ParaSCIP for MIP solving show that the parallel version of a customized solver could potentially run on supercomputers with over 80,000 cores. In this talk, we will present a few success stories of obtaining optimal solutions for previously unsolved instances for Steiner Tree Problem and Resource Constrained Project Scheduling Problem.

2 - Advances in the CPLEX Distributed Solver

Laszlo Ladanyi, IBM, 11 Interlaken Rd, Lakeville, CT, United States of America, ladanyi@us.ibm.com, Daniel Junglas

We present some of the new ideas added to CPLEX's distributed solver along with computational analysis of the performance gained compared to the traditional shared memory solver.

3 - A Matrix Scheduling Heuristic to Disaster Restoration of Lifeline Networks

Akifumi Kira, Associate Professor, Institute of Mathematics for Industry, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka city, 819-0395, Japan, kira@imi.kyushu-u.ac.jp, Katsuki Fujisawa, Hidenao Iwane, Hirokazu Anai

The establishment of scheduling techniques, for handling with precedence constraints and synchronized restoration with two or more teams, has become a very important issue. In this talk, we propose an indirect local search method using multiple lists, which succeeds to stamp out the so-called interdependence problem induced by the precedence and synchronization constraints. We have applied parallel computing techniques to this local search method and report numerical results on large-scale SMP servers.

■ ThC16

16- Sterlings 1

Risk Aversion in Routing Games

Cluster: Telecommunications and Networks

Invited Session

Chair: Evdokia Nikolova, University of Texas at Austin, 1616 Guadalupe St, Austin, TX, United States of America, nikolova@austin.utexas.edu

1 - Risk Sensitivity of Price of Anarchy under Uncertainty

Georgios Piliouras, Assistant Professor, Singapore University of Technology and Design, 8 Somapah Road, Singapore, Singapore, georgios.piliouras@gmail.com, Jeff S. Shamma, Evdokia Nikolova

In algorithmic game theory, price of anarchy studies efficiency loss in decentralized environments. Robust optimization explores tradeoffs between optimality and robustness for single agent decision making under uncertainty. We establish connections between the two and prove tight performance guarantees for distributed systems in uncertain environments. We present applications of this framework to novel variants of atomic congestion games with uncertain costs, for which we provide tight performance bounds under a wide range of risk attitudes. Our results establish that the individual's attitude towards uncertainty has a critical effect on system performance and should therefore be a subject of close and systematic investigation.

2 - Improving Selfish Routing for Heterogeneous Risk-Averse Users

Thanasis Lianeas, University of Texas at Austin, 1616 Guadalupe Street, Austin, United States of America, tlianeas@mail.ntua.gr

We investigate how and to which extent one can exploit risk-aversion and modify the perceived latencies of the players so that the Price of Anarchy (PoA) is improved. To provide a simple and general model, we adopt g-modifiable routing games where the perceived cost of edge e for a player of aversion type a_i can increase from l_e(x) to (1+a_i*g_e)l_e(x), for some selected g_e in [0,g]. For g-modifiable games in parallel-links, we show how to (efficiently) compute a set of g-bounded latency modifications so that the PoA of the resulting game improves significantly as g increases. We prove that our PoA analysis is tight. In a generalizing step, we let ||(g_e)_e||_p <= g for any p-norm and provide tight PoA results for the generalized model.

3 - The Burden of Risk Aversion in Mean-Risk Selfish Routing

Evdokia Nikolova, University of Texas at Austin, 1616 Guadalupe St, Austin, TX, United States of America, nikolova@austin.utexas.edu, Nicolas Stier-Moses

Considering congestion games with uncertain delays, we compute the inefficiency introduced in network routing by risk-averse agents. We define the price of risk aversion (PRA) as the worst-case ratio of the social cost at a risk-averse Wardrop equilibrium to that where agents are risk-neutral. For networks with general delay functions and a single source-sink pair, we show that the PRA depends linearly on the agents' risk tolerance and on the degree of variability present in the network. In contrast to the price of anarchy, in general the PRA increases when the network gets larger but it does not depend on the shape of the delay functions.

■ ThC17

17- Sterlings 2

Numerical Methods for Nonlinear Optimization III

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 - A New Fully Polynomial Time Approximation Scheme for Interval Subset Sum Problem

Yu-Hong Dai, Prof., AMSS,Chinese Academy of Sciences, No. 55, ZhongGuanCunDongLu, Beijing, 100190, China, dyh@lsec.cc.ac.cn

The interval subset sum problem (ISSP) is a generalization of the well-known subset sum problem. We show that the ISSP is relatively easy to solve compared to the 0-1 knapsack problem. We also identify several subclasses of the ISSP which are polynomial time solvable (with high probability). Then we propose a new fully polynomial time approximation scheme for solving the general ISSP problem. To the best of our knowledge, the proposed scheme has almost the same time complexity but a significantly lower space complexity compared to the best known scheme. Both the correctness and efficiency of the proposed scheme are validated by numerical simulations. This is a joint work with Rui Diao and Yafeng Liu.

2 - Augmented Lagrangian Methods for Nonlinear Programming with Possible Infeasibility

Jefferson Melo, PhD, Federal University of Goias, Campus Samambaia, Goiania, Go, 74001-970, Brazil, jefferson.ufg@gmail.com, Max Goncalves, Leandro Prudente

We consider a nonlinear programming problem for which the constraint set may be infeasible. We propose an algorithm based on general augmented Lagrangian functions and analyze its convergence properties. We show that, in a finite number of iterations, the algorithm stops detecting the infeasibility of the problem or finds an approximate feasible/optimal solution. We present some numerical experiments showing the applicability of the algorithm.

3 - A Primal-Dual Merit Function with Primal-Proximity Term

Wenwen Zhou, SAS Institute Inc., 100 SAS Campus Drive., Cary, NC, 27513, United States of America, Wenwen.Zhou@sas.com, Joshua Griffin

Classical augmented Lagrangian methods perform line-searches using only the primal variables. The dual variables are subsequently updated, but without a merit function. More recent approaches seek to perform a unified primal-dual line-search by adding a dual proximity term to the merit function, penalizing distance from the primal-multiplier estimates. An unfortunate consequence is that the dual variables necessarily grow large when the problem is infeasible or the overall constraint violation does not decrease proportionally to the penalty parameter. In this talk we show that the addition of a primal-proximity term can counterbalance this effect and additionally greatly improving convergence rates to feasible points.

■ ThC18

18- Sterlings 3

Nonconvex, Non-Lipschitz, and Sparse Optimization III

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 - Regularized Mathematical Programs with Stochastic Equilibrium Constraints: Estimating Demand Models

Hailin Sun, Nanjing University of Science and Technology, School of Economics and Management, Nanjing, 210094, China, hlsun@njust.edu.cn, Xiaojun Chen, Roger Wets

The article considers a particular class of optimization problems involving set-valued stochastic equilibrium constraints. We develop a solution procedure that relies on regularization and sample average approximation scheme for the equilibrium constraints. Convergence is obtained by relying on the graphical convergence of the approximated equilibrium constraints. The problem of estimating the characteristics of a demand model serves both as motivation and illustration of the regularization and sampling procedure.

2 - Distributionally Robust Bidding Model of Power-Controllable Lighting System in Electricity Market

Yanfang Zhang, Minzu University of China,
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This paper investigates a distributionally robust optimization based bidding model for simultaneously participating in day-ahead and real-time electricity markets. The optimal bidding model of LED lighting system is proposed. By the CVaR constraints, the conditional expectation minimization model under the ellipsoidal moment uncertainty is reformulated to be a worst-case expectation minimization problem. Moreover, a solvable semi-definite program (SDP) is presented to relax the moment uncertainty problems and determine the optimal bids. Simulation results illustrate the feasibility and effectiveness of the proposed model and solution method.

3 - Efficient Global or Hybrid Projected Gradient Algorithm for 10 and Convex Constrained Optimization

Fengmin Xu, Associate Professor, Xi'an Jiaotong University,
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fengminxu@mail.xjtu.edu.cn

Sparse optimization has attracted increasing attentions in numerous areas. This paper considers a special class of L_0 constrained optimization, which involves box constraints and a singly linear constraint. An efficient approach is provided for calculating the projection over the feasibility set. Then we present several types of projected gradient methods for the special class of L_0 constrained optimization. Global convergence of the methods are established under suitable assumptions. The implementation on signal recovery and enhanced indexation demonstrate that the proposed projected gradient methods are efficient in terms of both solution quality and speed. A Joint work with Yu-Hong Dai, Zhihua Zhao and Zongben Xu.

■ ThC19

19- Ft. Pitt

Constraint Programming

Cluster: Constraint Programming

Invited Session

Chair: K. Subramani, Professor, West Virginia University, 749 ESB, CSEE,, WVU, Morgantown, WV, 26506, United States of America, k.subramani@mail.wvu.edu

1 - Numerical Methods for Solving Discrete Conditional Moment Problems

Mariya Naumova, Rutgers University, 100 Rockafeller Rd,
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We propose a framework for bounding the expectation of discrete random variables. The bounds are based on the knowledge of some of the power moments as well as conditional moments of the random variables. The discrete conditional moment bounding problems are formulated as LP's with special structures and can be solved using Dantzig-Wolfe decomposition by the used of the Discrete Moment Problem (DMP). We illustrate our method with numerical examples.

2 - Quantifying Linear Programs and Implications

K. Subramani, Professor, West Virginia University, 749 ESB, CSEE,
WVU, Morgantown, WV, 26506, United States of America,
k.subramani@mail.wvu.edu, Pavlos Eirinakis

A Quantified Linear Program (QLP) consists of a set of linear inequalities and a quantifier string, in which each universal variable is bounded. A Quantified Linear Implication (QLI) is an inclusion query over two polyhedral sets with respect to a specified quantifier string. QLPs and QLIs offer a rich modelling language for several important real-life applications, such as reactive systems and real-time schedulers. We provide a brief presentation of applications and recent theoretical developments in the areas of QLPs and QLIs. We discuss the computational complexities of various QLP and QLI classes and show that for each class of the PH, there exists a QLI that is complete for that class.

3 - Solving Large Scale Linear Programming Problems

Parvin Khosravi, Shahed University, Department of Applied
Mathematics, Shahed University, Tehran, Iran,
parvin_khosraviii@yahoo.com, Saeid Akbari

The aim of this paper is to find an exact 2-norm solution to the dual linear programming problem and to generate an exact solution to the primal programming problems. The Newton method is proposed for solving linear programs with 1000000 of variables. We also compare the differences between Goldstein and Wolf conditions in order to find step size in each iterations. We give encouraging comparative test results with MATLAB.

■ ThC20

20- Smithfield

Stochastic Methods

Cluster: Nonsmooth Optimization

Invited Session

Chair: Zhimin Peng, PhD Student, University of California - Los Angeles, Mentone Ave, Apt 212, Los Angeles, CA, 90034, United States of America, zhimin.peng@math.ucla.edu

1 - Randomization in Online Stochastic Gradient-Free Optimization

Ilnura Usmanova, MIPT, Pervomayskaya, 28a, Dolgoprudnii,
141700, Russia, ilnura94@gmail.com, Ekaterina Krymova, Fedor
Fedorenko

We consider the problem of stochastic online optimization with noisy dual-point zero-order oracle in the convex and strongly convex cases. We also show how to choose optimal proximal structure in mirror decent depending on the optimisation set. We establish that the optimal choice of randomization for the estimation of the gradient is a uniform distribution on the unit Euclidean sphere. We also obtain a bound on the noise level, such that pseudo-regret bounds have same forms(up to a factor), as if there wasn't any noise.

2 - Asynchronous Parallel Stochastic Algorithms and Applications

Zhimin Peng, PhD Student, University of California, Los Angeles,
3777 Mentone Ave, Apt 212, Los Angeles, CA, 90034, United
States of America, zhimin.peng@math.ucla.edu, Wotao Yin,
Ming Yan, Yangyang Xu

In this talk, we will give some convergences result on the asynchronous parallel stochastic algorithm with bounded delay to solve fixed point problems. Weak convergence result is provided for alpha-averaged operator, and linear convergence rate is obtained for strongly monotone operator. Special cases of these operators are used to solve problems related to solving linear systems, minimizing convex smooth functions, and minimizing convex nonsmooth functions. We provide some numerical results for these applications.

■ ThC21

21-Birmingham

Recent Advances in Derivative-Free Optimization III: New Algorithms

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: Zaikun Zhang, Dr., F 325, IRIT, 2 rue Camichel, Toulouse, 31071, France, zaikunzhang@gmail.com

1 - Locating All Minima of a Smooth Function without Access to its Derivatives

Jeffrey Larson, Dr., Argonne National Laboratory, 9700 S Cass
Ave, 240-1151, Argonne, IL, United States of America,
jmlarson@anl.gov, Stefan Wild

We present a multistart algorithm for identifying all local minima of a bound-constrained derivative-free optimization problem. With relatively weak assumptions on the function, our method almost surely identifies all local minima while starting only a finite number of local optimization runs. We extend our method by developing rules for pausing local optimization runs, e.g., as they approach previously identified minima or other runs, while ensuring that the initial theoretic underpinnings of the algorithm still hold. We present a parallel implementation of our method that uses concurrent evaluations of the objective functions to more efficiently search the domain.

2 - A New Model-Based Trust-Region Derivative-Free Algorithm for Inequality Constrained Optimization

Mathilde Peyrega, PhD Student, Ecole Polytechnique Montreal,
6-4600 rue saint dominique, Montreal, QC, H2T1T5, Canada,
mathilde.peyrega@polymtl.ca, Sebastien Le Digabel,
Andrew R. Conn, Charles Audet

We present a new model-based trust-region algorithm to treat derivative-free optimization (DFO) problems with bounds and inequality constraints. We consider inequality constraints which can be evaluated at infeasible points, but for which their derivatives are not available. The basic models use interpolation and regression. We discuss the management of sample sets, choice of models and approaches to handling constraints, as well as numerical aspects.

3 - Direct Search based on Probabilistic Descent

Clément Royer, ENSEEIHT-IRIT, 2 rue Charles Camichel, Toulouse CEDEX 7, 31071, France, clement.royer@enseeiht.fr, Serge Gratton, Luis Nunes Vicente, Zaikun Zhang

We propose and analyze a general direct-search framework where the directions are randomly generated so that at least one is descent with a certain probability. We first establish that the algorithm converges almost surely to a first-order stationary point. Compared to the deterministic case, we improve the worst-case complexity bound on the number of function evaluations (now established with overwhelming probability). Finally, we confirm the theoretical findings by showing that this technique significantly reduces the numerical cost of the method.

■ ThC22

22- Heinz

Stability in Structured Optimization: Current Trends and Modern Applications

Cluster: Variational Analysis

Invited Session

Chair: Guoyin Li, University of New South Wales, Department of Applied Mathematics, University of New South Wales,Kensington, Sydney, NS, 2052, Australia, g.li@unsw.edu.au

1 - Symmetry, Invariance and Criticality

Andrew Eberhard, RMIT University, Mathematical and Geospatial Sciences, Melbourne, Australia, andy.eb@rmit.edu.au, V era Roshchina

The aim of this talk is to summarise, relate and generalise a range of results in nonsmooth, and predominantly nonconvex analysis, that exploit the symmetry of underlying problems. Results of this kind date back to the work of Palais on the principle of symmetric criticality but there are more recent results that can be placed in a similar framework that revolves around the application of groups of symmetries. Some new results of this kind will be discussed including one involving monotone operators. We will also discuss some applications.

2 - Uniformly Sequentially Regular Functions with Applications to Semi-Infinite Vector Optimization

Chuong Thai Doan, Dr., University of New South Wales, Sydney NSW 2052, Sydney, Australia, chuongthaidoan@gmail.com, Do Sang Kim

We establish new verifiable conditions for the feasible set of a nonsmooth semi-infinite vector optimization problem in Banach spaces to have the normal regularity (that is, the coincidence of the Fréchet normal cone and the Mordukhovich normal one) at a given point. Also, both the Fréchet normal cone and the Mordukhovich normal one to the considered set are then computed via active constraint multipliers and limiting subdifferentials of the involved constraints. In order to achieve such goals, two classes of nonsmooth functions are introduced and exploited. Finally, the obtained results are applied to provide optimality conditions and study sensitivity analysis in semi-infinite vector optimization problems.

■ ThC23

23- Allegheny

MIP Formulations for Difficult Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Alexander Tesch, Zuse Institute Berlin (ZIB), Takustrafle 7, Berlin, 14195, Germany, tesch@zib.de

1 - A Branch-and-Cut Approach to the General Offset Assignment Problem

Sven Mallach, Universitaet zu Koeln, Albertus-Magnus-Platz, Koeln, 50923, Germany, mallach@informatik.uni-koeln.de

The general offset assignment problem is a hard combinatorial problem that arises in compilers for special-purpose processors, such as, e.g. digital signal processors. It is of crucial importance for the machine code size and execution speed of the resulting programs. The problem can be decomposed into a Hamiltonian cycle and a min-cost flow problem, and with some effort, we obtain a linear integer programming formulation. We present this approach and the corresponding branch-and-cut strategy in order to solve the problem in different variants, together with experimental results that show its practical applicability on real world instances.

2 - Compact MIP Models for the Resource-Constrained Project Scheduling Problem

Alexander Tesch, Zuse Institute Berlin (ZIB), Takustrafle 7, Berlin, 14195, Germany, tesch@zib.de

In the resource-constrained project scheduling problem (RCPSP) a set of jobs is scheduled non-preemptively subject to multidimensional resource constraints and precedence restrictions, whereby the makespan is minimized. Many integer programming models use time-discretization where the number of variables depends on the required time horizon. We consider compact models where the size is polynomial in the number of jobs. For this, we present new models with stronger relaxations compared to recent approaches from the literature. The models are further extended by strong linear lower bounds and cutting plane generation during MIP solving. Computational studies show that our model is very effective on smaller instances of the PSPLIB.

3 - Exact Solutions for the 2D-Bin and Strip Packing Problems using Integer Linear Programming

Nestor Cid-Garcia, Universidad Autónoma de Nuevo León, Av. Universidad SN, Ciudad Universitaria, San Nicolas de los Garza, NL, 66450, Mexico, nxtr.cd@gmail.com, Yasmìn Rios-Solis

We present a novel two-stage approach to obtain exact solutions for the two-dimensional bin and strip packing problems. In the literature, the best resolution methodologies are based on metaheuristics methods, which do not guarantee the solution optimality. Experimental results on literature benchmarks show that with our approach, we can verify that many of the best solutions given by theses metaheuristics are indeed the optimal ones.

■ ThC24

24- Benedum

Tight Relaxations

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Stefan Vigerske, P.O. Box 40 59, Frechen, Germany, stefan@gams.com

1 - Deriving Improved Convex Relaxations from a Representation Result for Mixed-integer Convex Sets

Dennis Michaels, Technische Universitaet Dortmund, Fakultaet fuer Mathematik, Vogelpothsweg 87, Mathematik, TU Dortmund, Dortmund, 44227, Germany, dennis.michaels@math.tu-dortmund.de, Martin Ballerstein, Nick Mertens, Robert Weismantel

In this talk, we present a representation result for mixed-integer convex sets that allows us to describe the convex hull of a vector-valued function by the convex hulls of single real-valued functions. The result can be useful to define improved convex relaxations for mixed-integer nonlinear optimization problems. Some examples are reported showing the usefulness of the presented approach.

2 - Recent Advances in Solving MINLPs with SCIP

Benjamin Mueller, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, benjamin.mueller@zib.de

The constraint integer program framework SCIP solves convex and nonconvex mixed-integer nonlinear programs (MINLPs) to global optimality via spatial branch-and-bound over a linear relaxation. In this talk, we present recent advances and new extensions of SCIP to generate linear underestimators for convex envelopes and for optimality-based domain propagation. We evaluate the performance impact of those new algorithmic ideas on the MINLPLib2 and other public instance libraries.

3 - On Outer-Approximations of Convex Regions

Felipe Serrano, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, serrano@zib.de, Robert Schwarz, Ambros Gleixner

Outer-approximation of the feasible region is a fundamental technique for solving general MINLPs. As expected, this technique is sensitive to the tightness of the outer-approximation. In the convex case, it is standard to generate outer-approximation cuts based on gradient information of the constraints. We show that a naive implementation does not always give a tight approximation and how we can improve it with the help of some basic tools from convex analysis.

ThC25

25- Board Room

Control and Optimization for Power Grids

Cluster: Optimization in Energy Systems

Invited Session

Chair: Pascal Van Hentenryck, NICTA, Australia, pascal.vanhentenryck@nicta.com.au

1 - Vulnerability Analysis of Power Systems

Taedong Kim, University of Wisconsin - Madison, CS Dept., 1210 W. Dayton Street, Madison, WI, 53706, United States of America, tdkim@cs.wisc.edu, Stephen Wright, Daniel Bienstock, Sean Harnett

Potential vulnerabilities in a power grid can be exposed by identifying transmission lines whose degradation causes maximum disruption to the grid. In this study, we model the grid by AC power flow equations, and assume that attacks take the form of increased impedance along transmission lines. We quantify disruption in two ways: (a) overall deviation of the voltages at the buses from 1.0 per unit (p.u.), and (b) the minimal amount of load that must be shed in order to restore the grid to stable operation. We describe optimization formulations of the problem of finding the most disruptive attack and customized algorithms for solving these problems. Experimental results on 118-bus system and 2383-bus system are presented.

2 - Natural Gas System Operations and Expansion Planning with Convex Relaxations

Russell Bent, Los Alamos National Laboratory, DSA-4: Energy & Infrastructure Analysis, Los Alamos, NM, 87545, United States of America, rbent@lanl.gov

The natural gas industry is a capital-intensive sustainable business where the construction and expansion of its infrastructure involves a considerably large amount of capital expenditures. The standard approach for an expansion planning problem typically entails challenging non-linear non-convex feasible operating domains. In this study, we present a mathematical formulation for the expansion and reinforcement of a natural gas transmission network that operates under steady-state conditions. The underlying model captures gas operational constraints, unknown-flow directions and on/off constraints typically required in design and expansion problems. The proposed model, in its original form, takes the form of a mixed-integer non-linear (MINLP) program whose non-convexity and integrality pose a great challenge to scalability and global convergence. Hence, we develop two relaxations as promising alternatives to handle large-scale instances. The first relaxation is based on piecewise linearization (PWL) technique and takes the form of a mixed-integer linear (MILP) program. The second relaxation is based on a second-order cones, which leads to a mixed-integer quadratic program (MIQP). A comprehensive set of computational experiments are conducted to validate and assess the computability of the models on a test bed of complex and large-scale cases that includes existing Belgian and German gas networks. The clear advantages of our approaches reside in their capability of handling cyclic and non-cyclic large network topologies and their robustness and scalability. Joint work with Conrado Borraz-Sanchez, Hassan Hijazi, Pascal van Hentenryck, and Scott Backhaus.

3 - Distributed Optimization Decomposition for Joint Economic Dispatch and Frequency Regulation

Enrique Mallada, Cal Tech, United States of America, mallada@caltech.edu

Economic dispatch and frequency regulation are typically viewed as fundamentally different problems in power systems, and hence are typically studied separately. In this work, we frame and study a joint problem that optimizes both slow timescale economic dispatch resources and fast timescale frequency regulation resources.We provide sufficient conditions under which the joint problem can be decomposed without loss of optimality into slow and fast timescale problems. These slow and fast timescale problems have appealing interpretations as the economic dispatch and frequency regulation problems respectively. Moreover, the fast timescale problem can be solved using a distributed algorithm that preserves the stability of the network during transients. We also apply this optimal decomposition to propose an efficient market mechanism for economic dispatch that coordinates with frequency regulation.

ThC26

26- Forbes Room

Stochastic Optimization in Logistics and Service

Cluster: Stochastic Optimization

Invited Session

Chair: Alexei Gaivoronski, Professor, NTNU, Alfred Geitz vei 3, Trondheim, Norway, Alexei.Gaivoronski@iot.ntnu.no

1 - Lattice-based Methods for Deterministic and Stochastic Resource Constraint Shortest Path Problems

Axel Parmentier, PhD Student, CERMICS - ENPC, 6 et 8 avenue Blaise Pascal, Cite Descartes, Champs sur Marne, 77420, France, axel.parmentier@cermics.enpc.fr

We introduce a lattice ordered monoid framework for the Resource Constrained Shortest Path problem. This lattice ordered framework has two strengths: first, it can handle stochastic resources, probabilistic constraints, and risk measures as cost functions. Second, lattice ordered monoid structure enables to compute tight bounds in polynomial time, and to use these bounds to discard partial paths in an exact label algorithm. The efficiency of the whole approach is proved through extensive numerical experiments.

2 - Stochastic Bilevel Problems with Application to Telecommunications Networks

Alexei Gaivoronski, Professor, NTNU, Alfred Geitz vei 3, Trondheim, Norway, Alexei.Gaivoronski@iot.ntnu.no, Abdel Lisser

We consider several problems that arise in analysis of relationships between different actors providing services in Internet ecosystem. It is shown that these problems can be formalized as bilevel stochastic optimization problems. We study their properties and show how they can be solved with stochastic gradient methods. Interestingly, the stochastic problems of this type possess more regular properties and can be solved more easily than their deterministic counterparts.

ThC27

27- Duquesne Room

Message Passing Algorithms and Statistical Inference

Cluster: Combinatorial Optimization

Invited Session

Chair: Amin Coja-Oghlan, Goethe University, 10 Robert Mayer St, Frankfurt, 60325, Germany, acoghlan@math.uni-frankfurt.de

1 - Concavity of Reweighted Kikuchi Approximation

Po-Ling Loh, The Wharton School of the University of Pennsylvania, loh@wharton.upenn.edu

We analyze a reweighted version of the Kikuchi approximation for estimating the log partition function of a product distribution defined over a region graph. We establish sufficient conditions for the concavity of our reweighted objective function in terms of weight assignments in the Kikuchi expansion, and show that a reweighted version of the sum product algorithm applied to the Kikuchi region graph will produce global optima of the Kikuchi approximation whenever the algorithm converges. When the region graph has two layers, corresponding to a Bethe approximation, we show that our sufficient conditions for concavity are also necessary.

2 - Message-Passing Algorithms in Statistical Learning

Mohsen Bayati, Stanford University, 655 Knight Way, Stanford, CA, United States of America, bayati@stanford.edu

In this talk I will survey some recent results on applications of message-passing algorithm in high-dimensional statistics. In particular, I will describe the state evolution formalism that provides a rigorous framework to study statistical properties of solutions to optimization problems arising in high dimensional data analysis.

3 - Loopy Annealing Belief Propagation for Vertex Covers and Matchings

Marc Lelarge, INRIA-ENS, 23 avenue d'Italie, Paris, 75013, France, marc.lelarge@ens.fr

For the minimum cardinality vertex cover and maximum cardinality matching problems, the max-product form of belief propagation (BP) is known to perform poorly on general graphs. In this paper, we present an iterative loopy annealing BP (LABP) algorithm which is shown to converge and to solve a Linear Programming relaxation of the vertex cover or matching problem on general graphs. LABP finds a minimum half-integral vertex cover (hence provides a 2-approximation) and a maximum fractional matching on any graph. We also show that LABP finds a minimum size vertex cover for any bipartite graph.

■ ThC28

28- Liberty Room

Advances in Theory and Computation of Facility Location and Network Design Problems

Cluster: Telecommunications and Networks

Invited Session

Chair: Manish Bansal, Northwestern University, 2145 Sheridan Road, Department of Industrial Engineering and, Evanston, IL, 60208, United States of America, bansal@tamu.edu

1 - Chance-Constrained Multi-Terminal Network Design Problem

Minjiao Zhang, The University of Alabama, 361 Stadium Dr., Tuscaloosa, AL, 35406, United States of America, mzhang@cba.ua.edu, Yongjia Song

We study a chance-constrained multi-terminal network design problem, which is a stochastic variant of Steiner tree problems. We study formulations using valid inequalities that require different separation efforts. We conduct a computational test to show their performance.

2 - Three-Partition Inequalities for Constant Capacity Capacitated Fixed-Charge Network Flow Problems

Andres Gomez, PhD Student, University of California at Berkeley, Etcheverry Hall, Berkeley, CA, United States of America, a.gomez@berkeley.edu, Simge Kucukyavuz, Alper Atamturk

We give new valid inequalities for the capacitated fixed-charge network flow problem based on a three-partitioning of the nodes. The three-partitioning inequalities are facets for the three-partition polytope and include the flow cover inequalities as a special case. We discuss the constant capacity case and describe a polynomial separation algorithm for the inequalities. Finally, we report our computational results with the new inequalities in networks with different characteristics.

■ ThC29

29- Commonwealth 1

Large-Scale Optimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Angelia Nedich, University of Illinois, 1308 West Main Street, Urbana, IL, 61801, United States of America, angelia@illinois.edu

1 - Decentralized Online Optimization with Global Objectives and Local Communication

Maxim Raginsky, University of Illinois at Urbana-Champaign, 1308 W Main St, UIUC Coordinated Science Lab, Urbana, IL, 61801, United States of America, maxim@illinois.edu, Soomin Lee, Angelia Nedich

We consider a decentralized online convex optimization problem in a static undirected network of agents, where each agent controls only one coordinate of the global decision vector. For such a problem, we propose a decentralized variant of Nesterov's primal-dual algorithm with dual averaging. To mitigate the disagreements on the primal-vector updates, the agents implement a generalization of the local information-exchange dynamics recently proposed by Li and Marden. We show that, when the stepsize is chosen appropriately and the objective functions are Lipschitz with Lipschitz gradients, the resulting regret is sublinear in the time horizon. We also prove an analogous bound on the expected regret for the stochastic variant of the algorithm.

2 - Convergence Rates in Decentralized Optimization

Alexander Olshevsky, University of Illinois, 1308 West Main Street, Urbana, IL, 61801, United States of America, aolshev2@illinois.edu

The widespread availability of copious amounts of data has created a pressing need to develop optimization algorithms which can work in parallel when input data is unavailable at a single place but rather spread throughout multiple locations. In this talk, we consider the problem of optimizing a sum of convex (not necessarily differentiable) functions in a network where each node knows only one of the functions; this is a common model which includes as particular cases a number of distributed regression and classification problems. Our main result is a distributed subgradient method which simultaneously achieves the optimal scalings both with time and the network size for this problem.

3 - Random Block-Coordinate Gradient Projection Algorithms

Angelia Nedich, University of Illinois, 1308 West Main Street, Urbana, IL, 61801, United States of America, angelia@illinois.edu, Chandramani Singh, Rayadurgam Srikant

We discuss gradient projection algorithms based on random partial updates of decision variables. These algorithms generalize random coordinate descent methods. We analyze these algorithms with and without assuming strong convexity of the objective functions. We also present an accelerated version of the algorithm based on Nesterov's two-step gradient method. In each case, we prove convergence and provide a bound on the rate of convergence. We see that the randomized algorithms exhibit similar rates of convergence as their full gradient based deterministic counterparts.

■ ThC30

30- Commonwealth 2

Approximation and Online AlgorithmsI

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Tri-Dung Nguyen, University of Southampton, Mathematical Sciences, Southampton, SO17 3TJ, United Kingdom, T.D.Nguyen@soton.ac.uk

1 - The Online Resource Constrained Project Scheduling Problem with Bounded Multitasking

Carlos Cardonha, Research Staff Member, IBM Research, Rua Tutoia, 1157, São Paulo, Brazil, carlos.cardonha@gmail.com, Victor Cavalcante, Ricardo Herrmann

The Resource Constrained Project Scheduling Problem with Bounded Multitasking (RCPSPBM) is about the assignment of tickets to analysts with varying performance levels and bounded multitasking capacity. An optimal plan minimizes penalties originated from cognitive overheads, which occur whenever analysts work on two or more requests simultaneously, and from due date violations. In this work, we investigate theoretical and practical aspects of O-RCPSPBM, the online version of the problem. Computational experiments based on real-world scenarios show that the algorithm proposed in this work outperforms a greedy method that is typically used in the industry.

2 - Optimizing Prices in Descending Clock Auctions

Tri-Dung Nguyen, University of Southampton, Mathematical Sciences, Southampton, SO17 3TJ, United Kingdom, T.D.Nguyen@soton.ac.uk, Tuomas Sandholm

A descending clock auction (DCA) is a mechanism for buying items from multiple potential sellers where bidder-specific prices are decremented over the course of the auction. DCAs have been proposed as the method for procuring spectrum from existing holders in the FCC imminent incentive auctions so spectrum can be repurposed to higher-value uses. We develop an optimization model and computational methods for setting prices to offer the bidders in each round. We prove attractive properties of this and present experiments on the case of FCC incentive auctions. Extension to the multi-option case is also presented where Markov chains are used to represent the random states of the auctions.

Thursday, 2:45pm - 4:15pm

■ ThD01

01- Grand 1

Complementarity/Variational Inequality V

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Jie Sun, Curtin University, Department of Mathematics and Statistics, Australia, Jie.Sun@curtin.edu.au

1 - Distributed Alternating Direction Method of Multipliers (ADMM): Performance and Network Effects

Ermin Wei, Northwestern University, 2145 Sheridan Rd, Tech L310, Evanston, IL, 60208, United States of America, ermin.wei@northwestern.edu, Asu Özdaglar, Shimrit Shtern

We consider the distributed multi-agent optimization problem: a network of agents is solving a global optimization problem where the objective function is given by the sum of privately known convex, not necessarily smooth, local objective functions and the decision variable is shared among all agents. For this problem, we present a fully distributed Alternating Direction Method of Multipliers (ADMM) based method. We show that this method achieves the best rate of convergence for this general class of distributed convex problems. In particular, the rate guarantee is much faster than the popular (sub)gradient based methods. We further investigate the dependency of algorithm performance bounds on the underlying network structure.

2 - A Bi-Level Model and Solution Techniques for a Demand Response Policy

Yanchao Liu, Senior Analyst, Sears Holdings Corporation, E3-364B, 3333 Beverly Road, Hoffman Estates, IL, 60179, United States of America, yliu@discovery.wisc.edu, Michael Ferris

A bi-level optimization model is proposed for a demand response policy in the energy markets. In this model, the lower level performs the economic dispatch of energy and generates the price and the upper level minimizes the total amount of demand response subject to a net benefit requirement. In the reformulation, the nonconvex complementarity conditions of doubly bounded variables are transformed to SOS2 constraints. For realistic instances, we exploit the fast local solution from a nonlinear programming solver as well as LP-based bound strengthening within a mixed integer/SOS2 formulation. The model is tested against various data cases and settings, and generates useful insight for demand response dispatch operations in practice.

3 - Stochastic Vatiational Inequality – A Risk Measure Point of View

Jie Sun, Curtin University, Department of Mathematics and Statistics, Australia, Jie.Sun@curtin.edu.au

We study a stochastic variational inequality model and its application to multistage stochastic optimization problems. We in particular discuss the impact to theory and computation of introducing risk measures to the stochastic optimization problems.

■ ThD02

02- Grand 2

Optimization of Natural Gas Networks

Cluster: Optimization in Energy Systems

Invited Session

Chair: Alexander Martin, FAU Erlangen-Nürnberg, Department Mathematik, Cauerstr 11, Erlangen, Germany, alexander.martin@math.uni-erlangen.de

1 - Optimum Gas Flows: Exact Results and Efficient Heuristics

Sidhant Misra, Los Alamos National Laboratory, Los Alamos, NM, 87545, United States of America, sidhant172@gmail.com, Marc Vuffray, Michael Chertkov

Natural gas networks transport gas from sources to loads using high pressure pipes. Compressors are installed to compensate for the pressure drop due to the flows. We first consider the problem of minimizing the cost of compression subject to bounds on pressure. For tree networks we show that this transforms into a Geometric Program (GP). For meshed networks we devise a heuristic based on GP and test its performance on real networks. Second, we consider the problem of maximizing the gas transported to loads under pressure bounds. We obtain a mixed integer convex relaxation as well as a heuristic that uses the variational form of the gas flow equations, and validate performance of the algorithms on real gas networks models.

2 - Monotonicity of Dissipative Flow Networks Renders Robust Maximum Throughput Tractable

Marc Vuffray, Postdoctoral Research Associate, Los Alamos National Laboratory, CNLS, MS B258, Los Alamos, NM, 87545, United States of America, vuffray@hotmail.com, Michael Chertkov, Sidhant Misra

We consider flow networks in which flows are related to the drop of a nodal potential. The network contains three sorts of nodes: sources that inject flows, terminals that extract flows and sinks that withdraw an uncertain amount of flows. The objective is to maximize the throughput from sources to terminals such that potentials stay within prescribed bounds. We show that the robust version of this problem with respect to the uncertainty at the sinks is tractable. We first prove that the potential are monotonic functions of the withdrawals. This implies that the infinitely many constraints arising from the robustification can be replaced by only two constraints. We illustrate this general result with the natural gas transmission network.

3 - Computational Challenges in Modeling, Optimization and Control of Natural Gas Networks

Michael Chertkov, Los Alamos National Laboratory, Los Alamos, NM, United States of America, chertkov@lanl.gov, Russell Bent, Scott Backhaus

Challenges in simulation, optimization and control of natural gas transmission systems are reviewed in this presentation of the Grid Science Team @ LANL. We pose and analyze multi-level deterministic and stochastic, robust or distributionally-robust optimization problems. In their most general formulation the constraints includes PDEs that model the physics of gas flows as well as safety, operational and risk margins. We make the problems tractable through novel approximations and relaxations. These include adiabatic approximations and perturbative approximations that replace the PDEs with ODEs. A brief description of our path forward and future plans concludes the presentation.

■ ThD03

03- Grand 3

Algorithms for Network Interdiction

Cluster: Combinatorial Optimization

Invited Session

Chair: S. Thomas McCormick, Professor, Sauder School of Business, UBC, 2053 Main Mall, Vancouver, BC, V7C1Z2, Canada, thomas.mccormick@sauder.ubc.ca

1 - Routing Through A Network with Online Failures

Gianpaolo Oriolo, Professor, University of Rome Tor Vergata, Via del Politecnico, 1, Rome, Italy, oriolo@disp.uniroma2.it

We consider some routing problems where one player aims at routing some commodity from a source S to a sink T through a network G and an adversary removes arc in G. We deal with the setup in which the adversary reveals the identity of the deleted arcs just before the routing player attempts to use them, thus forcing her to rerouting. We consider several problem, such as that of choosing a nominal path as to minimize the worst case arrival time at T, or that of choosing a nominal flow as to maximize the worst case amount of flow sent to T. We solve some models, discuss some game-theoretic extension and leave a few open problems. The talk is based on joint works with David Adjiashvili, Tom McCormick, Jannik Matuschke and Marco Senatore.

2 - Fare Evasion in Transit Networks

Jannik Matuschke, University of Rome Tor Vergata, Via del Politecnico 1, Rome, 00133, Italy, jannik.matuschke@gmail.com, Jose Correa, Vincent Kreuzen, Tobias Harks

We study bilevel programming models for optimizing fare inspection in public transit networks. First, the network operator determines probabilities for inspections at different locations, to which the (fare-evading) passengers respond by optimizing their routes. We study both a non-adaptive variant, in which passengers follow an a priori selected route, and an adaptive variant, in which update their route on the way. For the passengers' subproblem, we design exact and approximate algorithms and prove a tight bound of 3/4 on the ratio of the optimal adaptive and non-adaptive strategy. For the operator's problem, we design an LP-based approximation and a local search procedure and evaluate them in an extensive computational study.

3 - Parametric Network Flows

S. Thomas McCormick, Professor, Sauder School of Business, UBC, 2053 Main Mall, Vancouver, BC, V7C1Z2, Canada, thomas.mccormick@sauder.ubc.ca

We review the parametric optimization framework of Topkis, and how the parametric min cut results of GGT fit into the framework. This framework gives two main results: a Structural Property that min cuts are monotone in the parameter, and an Algorithmic Property, that one can compute all min cuts in the same time as solving the non-parametric problem. We extend these results to parametric capacity and parametric rewards versions of "Max Reward Flow", a "max" version of Min Cost Flow. We prove that the Structural Property again holds, and we adapt the Relax algorithm of Bertsekas to also get the Algorithmic Property. We further indicate how to extend the results to parametric Weighted Abstract Min Cut, and to other problems.

■ ThD04

04- Grand 4

Nonnegative Matrix Factorization and Related Topics II

Cluster: Conic Programming

Invited Session

Chair: Stephen A. Vavasis, University of Waterloo, 200 University Avenue W., Waterloo, ON, N2L 3G1, Canada, vavasis@uwaterloo.ca

Co-Chair: Nicolas Gillis, University of Mons, Rue de Houdain 9, Mons, Ha, 7000, Belgium, nicolas.gillis@umons.ac.be

1 - Learning Overcomplete Latent Variable Models through Tensor Methods

Majid Janzamin, University of California - Irvine, CA, mjanzami@uci.edu, Anima Anandkumar, Rong Ge

We provide guarantees for learning latent variable models emphasizing on the overcomplete regime, where the latent dimensionality exceeds the observed dimensionality. In particular, we consider multiview mixtures, ICA, and sparse coding models. Our main tool is a tensor decomposition algorithm that works in the overcomplete regime. We initialize the method with labels in the semi-supervised setting, and we perform a simple SVD-based initialization in the unsupervised setting. For third order tensors, in the former setting, we establish learning guarantees when the number of components scales as $k=o(d^{1.5})$, where d is the observed dimension. In the latter setting, the guarantees are provided under the stricter condition $k \le O(d)$.

2 - Archetype Pursuit for Archetypal Analysis and Non-negative Matrix Factorization

Yuekai Sun, Stanford University, yuekai@stanford.edu, Anil Damle

Archetypal analysis and non-negative matrix factorization and are staples in a statisticians toolbox for dimension reduction and exploratory data analysis. We describe a unified approach to both NMF and archetypal analysis by reducing both problems to finding extreme points of the data cloud. We develop an approach that requires O(pklog(k)) floating-point operations to find all k extreme points with high probability. We refer to our approach as archetype pursuit. For modern massive datasets that are too large to fit on a single machine and must be stored in a distributed setting, archetype pursuit makes only a small number of passes over the data. In fact, it is possible to perform NMF or archetypal analysis with two passes over the data.

3 - Exact and Heuristic Algorithms for Semi-Nonnegative Matrix Factorization

Nicolas Gillis, University of Mons, Rue de Houdain 9, Mons, Ha, 7000, Belgium, nicolas.gillis@umons.ac.be, Abhishek Kumar

Given a matrix M (not necessarily nonnegative) and a factorization rank r, semi-nonnegative matrix factorization (semi-NMF) looks for a matrix U with r columns and a nonnegative matrix V with r rows such that UV is the best possible approximation of M according to some metric. In this talk, we study the properties of semi-NMF from which we develop exact and heuristic algorithms. In particular, we propose an exact algorithm (that is, an algorithm that finds an optimal solution) for a certain class of matrices which we use as a heuristic for matrices not belonging to that class. Numerical experiments illustrate that this second heuristic performs extremely well, and allows us to compute optimal semi-NMF decompositions in many situations.

■ ThD05

05- Kings Garden 1

Iterative Methods for Inverse Problems

Cluster: Nonlinear Programming

Invited Session

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

1 - A Low-Memory Approach for Best-State Estimation of Hidden Markov Models with Model Error

Mihai Anitescu, Dr., Argonne, anitescu@mcs.anl.gov, Xiaoyan Zeng, Wanting Xu, Emil Constantinescu

We present a low-memory approach for the best-state estimate (data assimilation) of hidden Markov models where model error is considered. In particular, our findings apply to the 4DVar framework. The storage needed by our estimation framework, while including model error, is dramatically reduced from O(number of time steps) to O(1) or O(J) if J checkpointing or multiple shooting segments are used. The reduction device is the restriction of the other states by recursively enforcing the optimality conditions. Our findings are demonstrated by numerical experiments on Burgers' equations.

2 - Optimizing Neural Networks with Kronecker-factored Approximate Curvature

James Martens, PhD Candidate, University of Toronto, 10 King's College Road, Toronto, Canada, jmartens@cs.toronto.edu, Roger Grosse

We propose an efficient method for approximating natural gradient descent in neural networks which we call Kronecker-factored Approximate Curvature (K-FAC). K-FAC is based on an efficiently invertible approximation of a neural network's Fisher information matrix which is neither diagonal nor low-rank, and in some cases is completely non-sparse. It is derived by approximating various large blocks of the Fisher as factoring as Kronecker products between two much smaller matrices. While only several times more expensive to compute than the plain stochastic gradient, the updates produced by K-FAC make much more progress optimizing the objective, which results in an algorithm that can be much faster in practice than SGD with momentum.

3 - Preconditioning Saddle Point Formulation of the Variational Data Assimilation

Selime Gurol, Dr., CERFACS, gurol@cerfacs.fr, Mike Fisher, Serge Gratton

In this talk we will address the numerical solution of the saddle point system arising from four dimensional variational (4D-Var) data assimilation with an emphasis on a study of preconditioning with low-rank updates. These updates can be found by solving two-sided secant equations. The saddle point formulation of 4D-Var allows parallelization in the time dimension. Therefore, it represents a crucial step towards improved parallel scalability of 4D-Var. We will present numerical results obtained from the Object Oriented Prediction System (OOPS) developed by European Centre for Medium-Range Weather Forecasts (ECMWF).

■ ThD06

06- Kings Garden 2

Computational Linear Programming II

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Ambros Gleixner, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, gleixner@zib.de

1 - A Specialized Interior-Point Method for Large-Scale Capacitated Multiperiod Facility Location

Jordi Castro, Prof., Universitat Politecnica de Catalunya, Dept. of Stats. and Operations Research, Barcelona, Spain, jordi.castro@upc.edu, Stefano Nasini, Francisco Saldanha

The capacitated facility location problem is a well known MILP, which has been efficiently solved by cutting plane procedures. We extend this solution procedure for a multiperiod variant of this problem. The resulting linear subproblems, one for time period, exhibit a block-angular structure which can be efficiently solved by a specialized interior-point method. This allows the formulation of world-wide facility location problems, of up to 3 time periods, 200 locations and 1 million customers, resulting in MILPs of 200 binaries and linear subproblems of up to 200 million variables. Those MILP instances are optimally solved in less than one hour of CPU time, while state-of-the-art solvers exhausted the 144 Gigabytes of available memory.

2 - Addressing Degeneracy in the Dual Simplex Algorithm using a Decompositon Approach

Stephen Maher, Zuse Institute Berlin, Takustr. 7, Berlin, Germany, maher@zib.de, Ambros Gleixner, Matthias Miltenberger

The dual simplex algorithm is widely used in mathematical programming and is known as one of the most efficient methods for solving linear programs. However, the presence of dual degeneracy negatively impacts the algorithm efficiency. While many attempts have been made to reduce the impact of dual degeneracy, non-improving pivots still occur. We investigate a decomposition approach to reduce the rows of a linear program to decrease the number of degenerate pivots. The proposed approach forms two problems, which are solved iteratively, aimed at identifying pivots that will provide an objective function improvement. Applying this decomposition aims achieve optimality with a reduced the number of iterations in the dual simplex algorithm.

3 - Glop: An Open-source Linear Programming Solver

Bruno De Backer, Google, 8 rue de Londres, Paris, 75009, France, bdb@google.com, Emmanuel Guéré, Frédéric Didier

We introduce Glop, a new open-source linear programming solver developed at Google. We explain the factors that led to developing (yet) another implementation and the design choices that we made. We present performance results in terms of speed, precision and code size. We conclude with possible future directions for Glop.

■ ThD07

07- Kings Garden 3

Advances in Integer Programming VIII

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 - Non Total-Unimodularity Neutralized Simplicial Complexes

Bala Krishnamoorthy, Washington State University, 14204 NE Salmon Creek Ave, Vancouver, WA, 98686, United States of America, bkrishna@math.wsu.edu, Gavin Smith

We study a class of integer linear programs arising from algebraic topology that have interesting connections to total unimodularity (TU). We define a condition where the constraint matrix is not TU, but integral optimal solutions are guaranteed to exist. Thus the polytope of the LP may not be integral, but an integral optimal vertex exists for every integral right-hand side and every relevant objective function. A preprint is available at http://arxiv.org/abs/1304.4985.

2 - Diverse Vectors Selection: A Novel Approach to Model the Uniform Discrepancy

Giorgio Sartor, SUTD, 8 Somapah Road, Singapore, 487372, Singapore, giorgio_sartor@mymail.sutd.edu.sg, Giacomo Nannicini

In some situations a single solution to a mathematical program might not be sufficient, e.g. the problem cannot be modeled exactly. In these cases, it is better to provide a set of diverse solutions to the decision maker. We study the possibility of using the Uniform Discrepancy as a diversity measure and we propose an MILP model in order to select a set of diverse solutions from a given pool of feasible solutions. We provide preliminary computational evaluation of different diversity measures on a test set, commenting on the results.

3 - Branching as a Ranking and Selection Problem with Multiple Objectives

Jawad El-Omari, Lead Researcher, ORTEC, Houtsingel 5, Zoetermeer, 2719 EA, Netherlands, jawad.elomari@gmail.com

We propose a new branching policy for mixed integer linear programs that relies mainly on statistical methods to understand, and to some extent guide, the growth of a search tree. The policy accounts for: multiple performance measures simultaneously; the mean, variance, and covariance of the branching variables' performance history; and finally, changes in the performance distribution over time. Empirical evaluation against the default branching policy in CPLEX, strong branching, and pseudo-cost branching, showed significant reduction in running time and tree size.

ThD08

08- Kings Garden 4

Convex Optimization and Statistical Learning

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Venkat Chandrasekaran, Cal Tech, 1200 E. California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, venkatc@caltech.edu

1 - Nearly Linear Time Algorithms for Structured Sparsity

Chinmay Hegde, MIT, 32 Vassar St, G564, Cambridge, MA, 02139, United States of America, chinmay@csail.mit.edu

Structured sparsity has been proven beneficial in a number of applications in statistical learning and signal processing. However, these benefits do not come for free: enforcing complex structures in data typically involves cumbersome, computationally intensive algorithms. I will outline a series of new methods for structured sparse modeling that integrate ideas from combinatorial optimization and approximation algorithms. For several structure classes, these methods enjoy a nearly linear time complexity, thereby enabling their application to massive datasets.

2 - The Entropic Barrier: A Simple and Optimal Universal Self-Concordant Barrier

Sebastien Bubeck, Microsoft, Microsoft campus, Redmond, United States of America, sebubeck@microsoft.com, Ronen Eldan

A fundamental result in the theory of Interior Point Methods is Nesterov and Nemirovski's construction of a universal self-concordant barrier. In this talk I will introduce the entropic barrier, a new (and in some sense optimal) universal self-concordant barrier. The entropic barrier connects many topics of interest in Machine Learning: exponential families, convex duality, log-concave distributions, Mirror Descent, and exponential weights.

3 - Convex Regularization with the Diversity Function

Maryam Fazel, Associate Professor, University of Washington, Campus Box 352500, Seattle, WA, 98195, United States of America, mfazel@uw.edu, Amin Jalali, Lin Xiao

We propose a new class of penalties, called diversity functions, that can promote orthogonality among a set of vectors in a vector space, with applications in hierarchical classification, multitask learning, and estimation of vectors with disjoint supports. We give conditions under which the penalties are convex, show how to characterize the subdifferential and compute the proximal operator, and discuss efficient optimization algorithms. Numerical experiments on a hierarchical classification application are presented.

ThD09

09- Kings Garden 5

Robust Optimization and Combinatorial Optimization

Cluster: Robust Optimization

Invited Session

Chair: Jannis Kurtz, Technische Universitaet Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, jannis.kurtz@math.tu-dortmund.de

1 - Uncorrelated Ellipsoidal Uncertainty in Combinatorial Optimization and Markov Decision Processes

Anna Ilyina, TU Dortmund, Vogelpothsweg 87, Dortmund, Germany, anna.ilyina@tu-dortmund.de, Frank Baumann, Christoph Buchheim

In robust binary optimization an uncertain objective function must often be optimized over some combinatorial structure. We present an exact algorithm based on Lagrangean decomposition allowing to separate these two aspects. Particularly in the uncorrelated ellipsoidal uncertainty case our approach is well-suited since the unrestricted case can be solved efficiently. Our approach is also applicable in the area of Markov decision processes with rewards-uncertainty where it is the only algorithm devised so far.

2 - Min-Max-Min Robustness: Combinatorial Optimization under Uncertainty Based on Multiple Solutions

Jannis Kurtz, Technische Universitaet Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, jannis.kurtz@math.tu-dortmund.de, Christoph Buchheim

In the classical min-max approach to robust combinatorial optimization, a feasible solution is computed that optimizes the worst case over a given set of scenarios. As is well known, this approach is very conservative. We present a different approach: the objective is to compute k feasible solutions such that the best of these solutions for each given scenario is worst-case optimal, i.e., we model the problem as a min-max-min problem. Using a polynomial-time oracle algorithm, we show that the problem of choosing k min-max-min optimal solutions is as easy as the underlying combinatorial problem if k is greater or equal to the dimension plus one and if the uncertainty set is convex.

3 - On Robust Solutions to Uncertain Linear Complementarity Problems and their Variants

Yue Xie, Dr Uday Shanbhag, 445 Waupelani Dr, State College, PA, 16801, United States of America, yux111@psu.edu, Uday Shanbhag

Variational inequality and complementarity problems have found utility in modeling a range of optimization and equilibrium problems. Yet, little progress has been seen in the context of obtaining robust solutions for uncertain variational inequality problems in a tractable fashion. In a distribution-free regime, we present an avenue for obtaining robust solutions to uncertain monotone and a subclass of non-monotone linear complementarity problems via a low-dimensional convex program. More generally, robust solutions to uncertain non-monotone LCPs can be provided by customizing an existing global optimization scheme.

ThD10

10- Kings Terrace

Portfolio Allocation and Risk Measures in Optimization

Cluster: Finance and Economics

Invited Session

Chair: Luis Zuluaga, Assistant Professor, 200 West Packer Avenue, Bethlehem, PA, 18015, United States of America, luz212@lehigh.edu

1 - Alternating Direction Methods for Nonconvex Optimization with Applications to Risk Parity/Budgeting

Xi Bai, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, 18015, United States of America, abcbaixi@gmail.com, Reha Tutuncu, Katya Scheinberg

The risk parity portfolio selection problem aims to find such portfolios for which the contributions of risk from all assets are equally weighted. In this talk, we propose a nonconvex least-squares model whose set of optimal solutions includes all risk parity solutions. We generalize the setting further by considering a class of nonlinear, nonconvex functions which admit a (non separable) two-block representation with special structure. We then develop alternating direction and alternating linearization schemes for such functions and analyze their convergence and complexity.

2 - Preference Robust Risk Measures and Optimization

Jonathan Li, Telfer School of Management, University of Ottawa, 55 Laurier Avenue East, Ottawa, Canada, Jonathan.Li@telfer.uottawa.ca, Erick Delage

Popular risk measures such as variance, VaR, or CVaR may not represent the decision maker's true risk attitude. We present a novel preference robust risk minimization framework that provides for the first time the means of identifying and optimizing a risk measure that account precisely for (neither more nor less than) what we know of the risk preferences of a decision maker. We show how this preference robust risk minimization problem can be solved numerically by formulating convex optimization problems of reasonable size. Numerical experiments on a portfolio selection problem, where the problem reduces to a linear program, will illustrate the advantage of accounting for the fact that the information about risk perception is limited.

3 - Multi-Period Portfolio Optimization with Alpha Decay

Kartik Sivaramakrishnan, Axioma, 400 Northridge Road, Suite 800, Atlanta, GA, 30350, United States of America, kksivara@axioma.com, Dieter Vandenbussche, Vishv Jeet

For long-term investors, multi-period optimization offers the opportunity to make "wait-and-see" policy decisions by including approximate forecasts and policy decisions beyond the rebalancing time horizon. We consider portfolio optimization with a composite alpha signal that is composed of a short-term and a long-term alpha signal. The short-term alpha better predicts returns at the end of the rebalancing period but it decays quickly. The long-term alpha has less predictive power but it decays slowly. We develop a "rolling-horizon" two stage multi-period algorithm that incorporates this alpha model and show that it generate portfolios that are likely to have a better realized performance than the traditional single-period MVO algorithm.

■ ThD11

11- Brigade

Trees and Adders in Chip Design

Cluster: Combinatorial Optimization

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 - Two-Level Rectilinear Steiner Trees

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

Given a set P of terminals in the plane and a partition of P into k subsets P_1,..., P_k, a two-level rectilinear Steiner tree consists of a rectilinear Steiner tree T_i connecting the terminals in each set P_i ($i=1,\dots,k$) and a top-level group Steiner tree connecting the trees T_1,..., T_k. The goal is to minimize the total length of all trees. This problem arises naturally in the design of low-power physical implementations of parity functions on a computer chip. We present a polynomial-time 1.63-factor approximation algorithm, as well as a 2.37-factor approximation algorithm with a practical running time of O(|P| log|P|). For fixed k, we develop a polynomial time approximation scheme (PTAS).

2 - Steiner Trees with Bounded RC-Delay

Rudolf Scheifele, Research Institute for Discrete Mathematics, University of Bonn, Lennestr. 2, Bonn, 53113, Germany, scheifele@or.uni-bonn.de

We consider the Minimum Elmore Delay Steiner Tree Problem, which arises as a key problem in VLSI design: Here, we are given a set of pins located on the chip which have to be connected by metal wires in order to make the propagation of electrical signals possible. Challenging timing constraints require that these signals travel as fast as possible. This is modeled as a problem of constructing a Steiner tree minimizing the Elmore delay between a source vertex and a set of sink vertices. The problem is strongly NP-hard even for very restricted special cases, and although it is central in VLSI design, no approximation algorithms were known until today. We give the first constant-factor approximation algorithm and show extensions in practice.

3 - Adder Optimization for Chip Design

Sophie Spirkl, Graduate Student, Princeton University, Fine Hall, Washington Road, Princeton, NJ, 08544, United States of America, sspirkl@princeton.edu, Stephan Held

We consider the problem of constructing adders with prescribed input arrival times. Most previous results implement parallel prefix graphs (e.g. Kogge-Stone) and are designed for uniform input arrival times. We generalize the concept of prefix graphs, which allows us to reduce single-output adder optimization problems to a tree structure, and we allow arbitrary input arrival times. For both single-output and full adders, we present efficient algorithms which construct adders that improve, even for uniform arrival times, upon previous results in the core objectives delay, size and fan-out.

■ ThD12

12- Black Diamond

Network Design

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Olivia Smith, IBM Research - Australia, 204 Lygon St, Carlton, Australia, livsmith@au1.ibm.com

1 - The Coopetition Hub-and-Dpoke Network Design

Cheng-chang Lin, Professor, National Cheng Kung University, 1 University Road, Tainan, 701, Taiwan - ROC, cclin@mail.ncku.edu.tw, Yu-Sing Lai

Carriers in network industries, design hub-and-spoke (H/S) networks and determine operations plans to maximize their respective profits. Shipments are routed and consolidated through a hub network, an economy of scale. The network also allows some of the outlying low-demand centers to be served, an economy of scope. Competitively, carrier may expand its H/S with additional pickup/delivery centers to increase its revenue, or new hubs to reduce operating cost. Cooperatively, carrier may utilize the competitor's carrying capacity with sharing of its revenue. This results a competitive and cooperative game. We modeled it as an integer program and used the less-than-truckload industry in Taiwan for numerical examples.

2 - Exact Algorithms for the Incremental Network Design with Shortest Paths

Olivia Smith, IBM Research - Australia, 204 Lygon St, Carlton, Australia, livsmith@au1.ibm.com, Chaitanya Rao

Incremental Network Design problems are a recently defined class of problems where a network problem must be solved repeatedly during construction of a subset of the network. The optimal order of construction minimises the total cost. Here we present a variety of exact algorithms for this problem with shortest path as the network problem. We demonstrate that non-LP branching algorithms can perform around 100 times faster than standard MIP on difficult instances.

■ ThD13

13- Rivers

Advances and Applications in Conic Optimization Part III

Cluster: Conic Programming

Invited Session

Chair: Masakazu Muramatsu, The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu-shi, Tokyo, Japan, muramatu@cs.uec.ac.jp

Co-Chair: Mituhiro Fukuda, Tokyo Institute of Technology, 2-12-1-W8-41 Oh-okayama, Meguro-ku, Tokyo, 152-8552, Japan, mituhiro@is.titech.ac.jp

1 - Primal-Dual Interior-Point Methods for Hyperbolic Cone Programming and Beyond

Levent Tuncel, Professor, University of Waterloo, 200 University Avenue West, Dept. Combinatorics and Optimization, Waterloo, ON, N2L3G1, Canada, ltuncel@math.uwaterloo.ca, Tor Myklebust

We first discuss some fundamental ingredients of primal-dual interior-point methods for convex optimization. Then, our focus will turn to those convex optimization problems which can be formulated by utilizing convex cones which are hyperbolicity cones of some hyperbolic polynomials. Finally, we will present some interior-point algorithms and their theoretical features including their iteration complexity analysis.

2 - Primal-Dual Path Following Method for Solving Linear Semi-Infinite Semi-Definite Programs

Takayuki Okuno, Department of Management Science, Faculty of Engineering Division I, Tokyo University of Science, Shinjuku 162-8601, Tokyo, Japan, t_okuno@ms.kagu.tus.ac.jp, Masão Fukushima

The semi-infinite program (SIP) is represented with infinitely many inequality constraints, and has been studied extensively so far. Recently, for solving the SIPs with conic constrains such as second-order cone constraints and semi-definite matrix (SDM) constraints, local-reduction SQP-type or exchange-type algorithms has been developed. In this research, we consider the linear SIP involving finitely many SDM constraints (SISDP), and propose a primal-dual path following type algorithm for the SISDP, in which we solve only a certain quadratic program at each iteration unlike the existing methods solving a finitely relaxed SISDP sequentially. We study the global convergence property of the proposed algorithm.

3 - A Relative Interior Seeking Procedure for Second Order Cone Programming and Feasibility Issues

Bruno Lourenco, Tokyo Institute of Technology, 2-12-1-W8-41 Ookayama, Meguro-ku, Tokyo, Japan, flourenco.b.aa@m.titech.ac.jp, Masakazu Muramatsu, Takashi Tsuchiya

In this talk, we discuss a procedure to identify a relative interior point in the feasible region of a second order cone program (SOCP) by solving two optimization problems. This is less than the required for usual approaches based on Facial Reduction. We will also discuss a few subtle feasibility issues arising in SOCP such as weak infeasibility.

ThD14

14- Traders

Price of Anarchy I

Cluster: Game Theory

Invited Session

Chair: Paul Duetting, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom, P.D.Duetting@lse.ac.uk

1 - Barriers to Near-Optimal Equilibria

Tim Roughgarden, Stanford University, 474 Gates, 353 Serra Mall, Stanford, CA, 94305, United States of America, tim@cs.stanford.edu

We explain when and how communication and computational lower bounds for algorithms for an optimization problem translate to lower bounds on the worst-case quality of equilibria in games derived from the problem. The most straightforward use of our lower bound framework is to harness an existing computational or communication lower bound to derive a lower bound on the worst-case price of anarchy (POA) in a class of games. This is a new approach to POA lower bounds, based on reductions in lieu of explicit constructions. Our lower bounds are particularly significant for designing games that have only near-optimal equilibria – ranging from the design of simple combinatorial auctions to the existence of effective tolls for routing networks.

2 - Composable and Efficient Mechanisms

Vasilis Syrgkanis, Microsoft Research, 641 Avenue of the Americas, New York, NY, United States of America, vasy@microsoft.com, Eva Tardos

We initiate the study of efficient mechanism design with guaranteed good properties when players participate in multiple different mechanisms simultaneously or sequentially. We define the class of smooth mechanisms and show that they result in high quality outcome in equilibrium both in the full information and in the Bayesian setting, as well as in learning outcomes. Our main result is to show that such mechanisms compose well: smoothness locally at each mechanism implies efficiency globally.

3 - Price of Anarchy for Auction Revenue

Darrell Hoy, PhD Candidate, Northwestern University, 104A Concord Ave, Somerville, MA, 02143, United States of America, darrell.hoy@gmail.com, Jason Hartline, Sam Taggart

This paper develops tools for welfare and revenue analyses of Bayes-Nash equilibria in asymmetric auctions with single-dimensional agents. We employ these tools to derive price of anarchy results for social welfare and revenue. Our approach separates the standard smoothness framework into two distinct parts, isolating the analysis common to any auction from the analysis specific to a given auction. This approach enables the first known revenue approximation results for the first-price and all-pay auctions in asymmetric settings.

ThD15

15- Chartiers

Rule-Based Optimization

Cluster: Global Optimization

Invited Session

Chair: Zelda Zabinsky, Professor, University of Washington, Industrial and Systems Engineering, Seattle, WA, 98195-2650, United States of America, zelda@u.washington.edu

1 - Tomograph Algorithms for Real-time Generation of Optimal Hybrid Control Models

Wolf Kohn, Professor and Chief Scientist, University of Washington, ISE Dept., Atigeo, LLC, Seattle, WA, 98195-2650, United States of America, wolfk@u.washington.edu, Zelda Zabinsky

Intelligent controllers for enterprise processes require amalgamation of behavioral rules of the dynamic operation to achieve desired performance. We propose a method that hybridizes a-priori knowledge with sensory information to create an active learning based model for the process. Our algorithm implements a data “Tomograph” that extracts a Hamiltonian representing the system. The Hamiltonian is continuously updated (active learning) and is used to derive control laws and strategies. The algorithm is illustrated on a microgrid.

2 - A Model-Based Approach To Multi-Objective Optimization

Joshua Hale, Georgia Institute of Technology, Atlanta, GA, United States of America, jhale32@gatech.edu, Enlu Zhou

We develop a model-based algorithm for the optimization of multiple objective functions that can only be assessed through black-box evaluation. The algorithm iteratively generates candidate solutions from a mixture distribution over the solution space, and updates the mixture distribution based on the sampled solutions’ domination count such that the future search is biased towards the set of Pareto optimal solutions. We demonstrate the performance of the proposed algorithm on several benchmark problems.

3 - Near Optimal Hamiltonian Feedback Control via Chattering

Peeyush Kumar, PhD Student and Intern, University of Washington, Industrial and Systems Engineering, Atigeo, LLC, Seattle, WA, 98195-2650, United States of America, agaron@uw.edu, Wolf Kohn, Zelda Zabinsky

This paper presents a feedback control system implementing an approximation to optimal-measure based control using a chattering approximation. Hamiltonian functions represent the dynamics and criterion of a dynamical system implicitly, and may be estimated from sensory data or behavior rules. The chattering approximation on Hamiltonians leads to a control law realized by an optimization problem with linear constraints. This problem is solved iteratively with a moving window over a finite-horizon, using an open loop feedback strategy.

ThD16

16- Sterlings 1

Risk-Averse Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Darinka Dentcheva, Professor, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, ddentche@stevens.edu

1 - Methods for Risk-Averse Dynamic Programming in Clinical Trial Design

Curtis McGinity, Rutgers University, 100 Rockafeller Rd., Piscataway, NJ, 08854, United States of America, curtis.mcginity@rutgers.edu, Andrzej Ruszczynski, Darinka Dentcheva

We consider the problem of optimal risk-averse design of early stage clinical trials. We formulate the risk-averse Markov decision process, develop dynamic programming equations, and present solution methods over the infinite-dimensional state space. We compare the risk to that of several myopic and look-ahead policies.

2 - Radiation Therapy Design via Stochastic Orders

Constantine Vitt, Rutgers University, 1 Washington Park, Newark, NJ, 07102, United States of America, constantine.vitt@rutgers.edu, Darinka Dentcheva

Radiation therapy design optimizes the radiation dose delivery for the treatment of cancer. We propose a new design approach based on a probabilistic interpretation of the problem. We consider several stochastic orders for expressing the medical requirements regarding the dose distributions. The problem formulation facilitates the application of convex optimization tools and methods while keeping close control on the dose delivery. We propose specialized decomposition methods for solving the resulting optimization problems and report on the numerical results.

3 - Risk Preferences on the Space of Quantile Functions

Darinka Dentcheva, Professor, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, ddentche@stevens.edu, Andrzej Ruszczynski

A novel approach to quantification of law invariant risk preferences is proposed. We consider preference relations on the space of quantile functions defined by several axioms, which impose relations among comonotonic random variables. We infer the existence of a numerical representation of the preference relation in the form of a quantile-based measure of risk. Using conjugate duality theory, we develop a variational representation of the quantile-based measures of risk. Furthermore, we introduce a notion of risk aversion based on quantile functions, which enables us to derive an analogue of Kusuoka representation of coherent law-invariant measures of risk.

ThD17

17- Sterlings 2

Stochastic Optimization for Health Care Applications

Cluster: Life Sciences and Healthcare

Invited Session

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

1 - Vaccine Allocation in a Heterogeneous Population: A Stochastic Programming Approach

Christina Rulon, North Carolina State University, 400 Daniels Hall, Raleigh, NC, 27513, United States of America, cmrulon@ncsu.edu, Osman Ozaltin

Vaccination remains to be one of the most effective interventions for controlling many infectious diseases. In heterogeneous populations, it is important to know what fraction of each subgroup should be covered with a vaccine having certain characteristics to eliminate the infectious disease from the whole population. We propose a stochastic programming model based on a threshold surface characterization of critical vaccine allocation fractions. These fractions can provide epidemiologists with information about the best deployment of limited quantities of vaccine to contain the infectious disease.

2 - A Column Generation Approach for Stochastic Operating Room Scheduling

Zheng Zhang, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48105, United States of America, zhazheng@umich.edu, Brian Denton, Xiaolan Xie

This study considers a chance constrained version of the stochastic extensible bin packing problem with applications to operating room (OR) scheduling. Surgeries are subject to random duration and surgery-to-OR allocation decisions are made to minimize the expected cost of overtime subject to probabilistic constraints on completion time that vary by OR. We describe a column generation approach tailored to this problem and we describe results based on instances of the problem for a large hospital-based surgical practice.

3 - Chance-constrained Surgery Planning under Uncertain or Ambiguous Surgery Durations

Yan Deng, University of Michigan, Ann Arbor, MI, 48109, United States of America, yandeng@umich.edu, Siqian Shen, Brian Denton

We study surgery planning problems with uncertain surgery durations and probabilistic constraints restricting risk of delays and overtime. We develop cutting-plane algorithms exploiting decomposable problem structure, and study distributionally robust model variants by assuming ambiguous distributional information. Computational experiments on real data reveal insights in surgery planning under data uncertainty/ambiguity.

ThD18

18- Sterlings 3

Nonconvex, Non-Lipschitz, and Sparse Optimization IV

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 - Recovery of Sparse Vectors and Low-Rank Matrices via Partial Regularization

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

We propose a model for recovering sparse vectors and low-rank matrices via partial regularization that alleviates the bias of some nonzero components of sparse vector or nonzero singular values of low-rank matrices. We derive the null space and RIP recovery conditions that are weaker than those for the models using full regularization. Also, we propose a proximal gradient method to solve this model whose subproblem generally has a closed-form solution and can be efficiently solved. The global convergence of this method is also established. Numerical experiments show that the proposed approach is capable of recovering some sparse vectors and low-rank matrices that fail to be recovered by the existing models using full regularization.

2 - Composite L_q Minimization over Polyhedron

Ya-Feng Liu, Assistant Professor, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No. 55, ZhongGuanCun DongLu, Beijing, Beijing,100190, China, yafliu@lsec.cc.ac.cn, Shiqian Ma, Yu-Hong Dai, Shuzhong Zhang

The composite L_q minimization problem over a general polyhedron with q less than one has received various applications in machine learning, wireless communications, image restoration, signal reconstruction, etc. In this talk, we shall present a theoretical study on this problem. In particular, we shall study the computational complexity of the problem, derive the Karush-Kuhn-Tucker (KKT) optimality conditions for local minimizers of the problem, propose a smoothing sequential quadratic programming framework for solving the problem, and analyze the worst-case iteration complexity of the proposed framework.This is a joint work with Shiqian Ma, Yu-Hong Dai, and Shuzhong Zhang.

3 - A Structured Low Rank Matrix Penalty Method and Applications to Sensor Network

Tianxiang Liu, Chinese Academy of Sciences, No.55 East Zhongguancun Road, Haidian District, Beijing, China, liutx@lsec.cc.ac.cn, Zhaosong Lu, Xiaojun Chen, Yu-Hong Dai

This paper considers a matrix optimization problem where the objective function is continuously differentiable and the constraints involve a box constraint and a rank constraint. We penalize the rank constraint by a non-Lipschitz function and give sufficient conditions for the existence of exact penalty parameters regarding local minimizers and global minimizers. Moreover, we propose an efficient algorithm to solve the penalized problem and prove the convergence of the algorithm to a stationary point.

ThD19

19- Ft. Pitt

Combinatorial Optimization for Big Data Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Anand Srivastav, Professor, Kiel University / Department of Computer Science, Christian-Albrechts-Platz 4, Kiel, 24118, Germany, asr@numerik.uni-kiel.de

1 - Parallel Evolutionary Algorithms for Large Problems: Parameter Optimization and Hypergraph Coloring

Volkmar Sauerland, Research Associate, Kiel University / Department of Computer Science, Christian-Albrechts-Platz 4, Kiel, 24118, Germany, vsa@informatik.uni-kiel.de

We present a framework for parallel Estimation of Distribution Algorithms to tackle two applications. The first one is the estimation of the production of marine carbon dioxide in order to more precisely predict climate effects. The second one is the (practical) solution of a hypergraph coloring problem, which has been open for 20 years. We show with methods from Algorithm Engineering the experimental and also theoretical and partially also theoretical foundation of our Algorithms.

2 - External Memory Graph Algorithms

Ulrich Meyer, Professor, Goethe University Frankfurt am Main / Institute of Computer Science, Robert-Mayer-Strafle 11-15, Frankfurt am Main, 60325, Germany, umeyer@ae.cs.uni-frankfurt.de

Large graphs arise naturally in many real world applications. The actual performance of simple RAM model algorithms for traversing these graphs (stored in external memory) deviates significantly from their linear or near-linear predicted performance because of the large number of I/Os they incur. In order to alleviate the I/O bottleneck, many external memory graph traversal algorithms have been designed with provable worst-case guarantees. In the talk I highlight some techniques used in the design and engineering of such algorithms and survey the state-of-the-art in I/O-efficient graph traversal algorithms.

3 - Parallel Graph Partitioning for Complex Networks

Christian Schulz, Postdoctoral Researcher, Karlsruhe Institute of Technology (KIT) / Institute of Theoretical Informatics, Am Fasanengarten 5, Karlsruhe, 76131, Germany, christian.schulz@kit.edu, Henning Meyerhenke, Peter Sanders

To do parallel graph processing of social networks, we need to partition them into equally sized pieces. Previous parallel graph partitioners do not work well for these networks. We address this problem by parallelizing and adapting the label propagation technique developed for graph clustering. By introducing size constraints, label propagation becomes applicable for coarsening and refinement of multilevel partitioning. We obtain a high quality system that is also more scalable than state-of-the-art systems like ParMetis or PT-Scotch. On large networks the performance differences are very big. For example our algorithm partitions a web graph with 3.3G edges in 16 seconds using 512 cores of a HPC cluster producing a high quality partition.

■ ThD20

20- Smithfield

Recent Advances in Constrained Convex Minimization

Cluster: Nonsmooth Optimization

Invited Session

Chair: Volkan Cevher, Laboratory for Information and Inference Systems (LIONS), EPFL, Switzerland, EPFL STI IEL LIONS, ELE 233 (B,timent ELE) Station 11, Lausanne, 1015, Switzerland, volkan.cevher@epfl.ch

1 - Solving Convex Constrained Problems using Random Distributed Algorithms

Jean-Christophe Pesquet, University of Paris-Est, 5, Boulevard Descartes, Champs sur Marne, Marne la Vallee Cedex 2, 77454, France, jean-christophe.pesquet@u-pem.fr, Emilie Chouzenoux, Audrey Repetti

Relying on random block-coordinate primal-dual methods, we designe distributed algorithms for minimizing a sum of (non-)smooth convex functions involving linear operators. Distributed methods have the ability to deal with multi-agent problems where the performed updates are limited to a neighborhood of a small number of agents, the set of active agents being selected according to an arbitrary random rule. We prove the almost sure convergence of the iterates to a solution of the considered problem. When the non-smooth functions are chosen as indicator functions of convex sets, the proposed algorithms can be viewed as distributed versions of alternating projections onto convex sets techniques to solve constrained optimization problems.

2 - Solving Constrained and Non-Smooth Problems with Efficient Dual Techniques

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

Proximal methods are a recent trend in optimization. Of course, a major issue arises when it is not possible to compute the proximity operator efficiently. This happens in situations such as (1) composition with a linear operator, and/or (2) using a scaled metric, such as in a Newton or quasi-Newton method. We go over the solution proposed by TFOCS, which is to use the proximal point method and solve the dual. We also present recent work (joint with J. Fadili) on an alternative method to solve the prox, which can be used instead of, or in conjunction with, TFOCS. For some carefully designed quasi-Newton methods, the prox update can be done for essentially no extra cost over the gradient-descent case.

3 - Universal Primal-Dual Proximal-Gradient Methods

Alp Yurtsever, (LIONS), EPFL, Switzerland, Laboratory for Information and Inference, ELD 244 (B,timent ELD) Station 11, Lausanne, 1015, Switzerland, alp.yurtsever@epfl.ch, Quoc Tran-Dinh, Volkan Cevher

We propose a primal-dual algorithmic framework for a prototypical constrained convex minimization problem. The new framework aims to trade-off the computational difficulty between the primal and the dual subproblems. We achieve this in our setting by replacing the standard proximal mapping computations with linear minimization oracles in the primal space, which has been the hallmark of the scalable Frank-Wolfe type algorithms. Our analysis extends Nesterov's universal gradient methods to the primal-dual setting in a nontrivial fashion, and provides optimal convergence guarantees for the objective residual as well as the feasibility gap without having to know the smoothness structures of the problem.

■ ThD21

21-Birmingham

Stochastic and Nonsmooth Derivative-Free Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

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

1 - Trust Region-Based Optimization over Stochastic Simulations

Satyajith Amaran, Senior Engineer, The Dow Chemical Company, 2301 N Brazosport Blvd, Freeport, TX, 77541, United States of America, SAmaran@dow.com, Nikolaos Sahinidis

Simulation optimization involves the optimization over stochastic simulations such as discrete-event simulations and stochastic differential equation systems. We develop a provably convergent trust region-based method for continuous simulation optimization. In addition to providing formal convergence proofs, we demonstrate the practical use of the method through the description of an implementation, its success on a large test bed and two important applications, namely inventory optimization in chemical supply chains and optimal sizing of obstructions for DNA separation.

2 - Derivative-Free Optimization of Costly Simulators Taking Uncertain Values

Benoit Pauwels, PhD Student, IFP Energies Nouvelles and Université de Toulouse 3, 1&4 avenue de Bois-Préau, Rueil-Malmaison, France, Benoit.Pauwels@ifpen.fr, Serge Gratton, Frédéric Delbos

We consider the derivative-free optimization of costly simulators whose return values are uncertain. This uncertainty may result from noisy measures or ill-known model parameters in the definition of the objective function. We investigate methods taking into account stochastic uncertainty or subjective knowledge on the uncertainty. These have several applications in the energy industry such as oil wells placement or wind turbine design.

3 - Model-based Approaches for Nonsmooth Greybox Optimization

Stefan Wild, Argonne National Laboratory, 9700 S Cass Ave, 240-1151, Argonne, IL, 60439, United States of America, wild@anl.gov, Jeffrey Larson, Aswin Kannan, Matt Menickelly

We consider settings where an objective function is a nonsmooth function of simulation outputs, which are characterized by having smooth, but unavailable derivatives. We survey and propose a number of techniques based on forming smooth models of the simulation output, with each technique differing in its treatment of the nonsmoothness. Our analysis focuses on special cases, while our numerical study illustrates when these techniques are beneficial in practice.

■ ThD22

22- Heinz

Recent Enhancements in Solving Nonsmooth Optimization Problems

Cluster: Variational Analysis

Invited Session

Chair: Sandra Santos, University of Campinas, Rua Sergio Buarque de Holanda, 651,, Campinas, SP, Brazil, sandra@ime.unicamp.br

1 - Epsilon-Subgradient Algorithms for Bilevel Convex Optimization

Elias Helou, Professor, University of São Paulo, Avenida Trabalhador Sancarlense, 400, São Carlos, SP, 13562-180, Brazil, elias@icmc.usp.br, Lucas Simoes

We introduce and study the convergence properties of a new class of explicit epsilon-subgradient methods for the task of minimizing a convex function over the set of convexly-constrained minimizers of another convex function. The general algorithm specializes to some important cases, such as first-order methods applied to a varying objective function, which have computationally cheap iterations. We present numerical experimentation for certain cases where the theoretical framework encompasses efficient algorithmic techniques, with application of the resulting methods to very large practical problems arising in tomographic image reconstruction.

2 - Advantages of using Nonmonotone Line Search on Gradient Sampling with Adaptivity and LBFGS Technique

Lucas Simoes, State University of São Paulo, Rua Sèrgio Buarque de Holanda, Campinas, Brazil, simoes.lea@gmail.com, Sandra Santos, Elias Helou

The gradient sampling method has been gaining attention from the scientific community, mostly because of its intuitive ideas, associated with its good performance in challenging problems. Hence, many variations of the original method have been developed in the last decade, being the adaptive gradient sampling method with LBFGS approach an example. However, some issues involving the practical algorithms have not been solved yet. This study has the aim to supress the differentiability test in each iteration and to introduce a nonmonotone line search to avoid tiny step sizes during the execution of the algorithms. We also present some numerical results that corroborate the new procedures.

3 - String-Averaging of Subgradients: a New Method for Nonsmooth Constrained Convex Optimization

Rafael Oliveira, PhD Student, University of São Paulo, Avenida Trabalhador São-carlense, 400, São Carlos, SP, 13566-590, Brazil, rafaelzane@hotmail.com, Eduardo Costa, Elias Helou

We present a method for non-smooth convex minimization which is based on subgradient directions and string-averaging techniques. In this approach, the set of available data is split into sequences (strings) and a given iterate is processed independently along each string, possibly in parallel, by an incremental subgradient method (ISM). The end-points of all strings are averaged to form the next iterate. The method is useful to solve sparse and large-scale non-smooth convex optimization problems, such as those arising in tomographic imaging. A convergence analysis is provided and the numerical tests show good performance for the convergence speed when measured as the ratio of objective function decrease, in comparison to classical ISM.

ThD23

23- Allegheny

Combinatorial Optimization

Cluster: Combinatorial Optimization
Invited Session

Chair: Vincent Kreuzen, Maastricht University, Tongersestraat 53, Maastricht, Netherlands, v.kreuzen@maastrichtuniversity.nl

1 - Heuristics for the Stochastic Single-machine Problem with E/T Costs

Débora Ronconi, University of São Paulo, Av. Prof. Almeida Prado, 128, São Paulo, SP, 05017020, Brazil, dronconi@usp.br, Rafael Lemos

This paper addresses the problem of concurrent due-date assignment and sequencing of jobs on a stochastic single-machine environment with distinct job earliness and tardiness penalty costs. It is assumed that the jobs processing times are statistically independent and follow a normal distribution whose mean and variance are provided. Two insertion-based constructive heuristics are proposed to minimize the E/T costs. Numerical experiments were performed and, in the majority of the cases, the solutions found by the proposed heuristics had better costs than the solutions described in the literature. An extension of the problem with processing times modeled as lognormal random variables was also investigated and solved with good results.

2 - The Oil Tanker Problem

Vincent Kreuzen, Maastricht University, Tongersestraat 53, Maastricht, Netherlands, v.kreuzen@maastrichtuniversity.nl, Tim Oosterwijk, Alexander Grigoriev, MichaÎl Gabay

We study a variant of the single machine capacitated lot-sizing problem with sequence-dependent setup costs and product-dependent inventory costs. Given a single platform and a set of tankers associated with shore stations, each tanker is associated with a constant demand rate, maximum loading rate and holding costs per time unit. Docking and undocking incurs sequencing costs based on the types of tankers. We prove a number of structural properties for optimal schedules for the problem and present an algorithm which approximates the optimal solution.

3 - Total Dual Integrality of the Linear Complementarity Problem

Hanna Sumita, University of Tokyo, 7-3-1 Hongo Bunkyo-ku, Tokyo, 113-8656, Japan, Hanna_Sumita@mist.i.u-tokyo.ac.jp, Naonori Kakimura, Kazuhisa Makino

In this talk, we introduce total dual integrality of the linear complementarity problem (LCP) by analogy with the linear programming problem. The main idea of defining the notion is to propose the LCP with orientation, a variant of the LCP whose feasible complementary cones are specified by an additional input vector. This allows us to define naturally its dual problem and the total dual integrality of the LCP. We show that if the LCP is totally dual integral, then all basic solutions are integral. If the input matrix is sufficient or rank-symmetric, then this implies that the LCP always has an integral solution whenever it has a solution.

ThD24

24- Benedum

Theory and Computing for Mixed–Integer Nonlinear Optimization

Cluster: Mixed-Integer Nonlinear Programming
Invited Session

Chair: Ashutosh Mahajan, Assistant Professor, IIT Bombay, Powai, Mumbai, 400076, India, amahajan@iitb.ac.in

1 - Local Polyhedral Property of some Integer Hulls

Vishnu Narayanan, Assistant Professor, Indian Institute of Technology Bombay, Industrial Eng. and Operations Research, IIT Bombay, Powai, Mumbai, MH, 400 076, India, vishnu@iitb.ac.in, Umakanta Pattanayak

We study properties of convex hulls of integer points in the following classes of convex sets: nonrational polyhedra and strictly convex sets. Moussafir (2003) showed that for a class of nonrational polyhedra, the convex hull of integer points is locally polyhedral. We extend this result to a larger class, and give examples of nonrational polyhedra whose integer hulls are not locally polyhedral. We give sufficient conditions for strictly convex sets to have locally polyhedral integer hulls.

2 - MINLPLib 2.0

Stefan Vigerske, GAMS, P.O. Box 40 59, Frechen, 50216, Germany, svigerske@gams.com

Since 2001, the Mixed-Integer Nonlinear Programming Library (MINLPLib) and the GLOBAL Library (GLOBALLib) have provided algorithm developers with a varied set of both theoretical and practical (MI)NLP test models. In this presentation, we report on recent progress on extending, updating, and categorizing MINLPLib and GLOBALLib. We hope that the updated library can be a starting point to define a widely accepted test set to evaluate the performance of NLP and MINLP solving software.

3 - New Developments in Minotaur Toolkit

Ashutosh Mahajan, Assistant Professor, IIT Bombay, Powai, Mumbai, 400076, India, amahajan@iitb.ac.in

Minotaur is an open-source toolkit for implementing algorithms for solving MINLPs. Different components of this object oriented modular framework can be combined together to create fast solvers. We describe the latest developments in the toolkit. These include a faster LP-NLP algorithm for convex MINLPs, a multistart heuristic for global optimization and other improvements in interfaces and features.

ThD25

25- Board Room

Optmization in Energy Systems

Cluster: Optimization in Energy Systems
Invited Session

Chair: Siew Fang Woon, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Sintok, Malaysia, woonsiewfang@yahoo.com

1 - AC Power Grid Design by Integer Linear Programming

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

As the AC power flow is given by nonconvex, nonlinear equations, designing a power grid implies either the solving of a mixed integer nonlinear optimization problem or refraining from optimality. Instead of the linear DC model, we study in this talk a Taylor-based linearization that also considers reactive flows. We derive valid inequalities, present computations, and show the superiority of this linearization for the power grid design problem, when considering AC feasibility.

2 - A MIP Framework for Non-Convex Uniform Price (European) Day-Ahead Electricity Auctions

Mehdi Madani, Louvain School of Management (Catholic University of Louvain), Place des Doyens 1 bte L2.01.01, Louvain-la-Neuve, 1348, Belgium, mehdi.madani@uclouvain.be, Mathieu Van Vyve

A new 'primal-dual framework' is provided (involving prices and quantities), which allow to consider algorithmic and economic issues of interest for European electricity market stakeholders, avoiding any auxiliary binary variables. Main characteristics of coupled European day-ahead markets are presented. We show how to use the framework to give an exact linearization of a non-convex 'minimum income condition' for producers, still without any auxiliary variables, or to minimize opportunity costs of so-called paradoxically rejected block bids.

3 - Chance Constrained Optimal Power Flow with Renewable Energy and Energy Storage

Jianqiang Cheng, Sandia National Laboratories, Quantitative Modeling & Analysis Dept, Sandia National Labs, 7011 East Avenue, Livermore, CA, United States of America, jianqiang.cheng@gmail.com, Habib Najm, Ali Pinar, Cosmin Safta, Jean-Paul Watson, Richard Chen

We consider a chance constrained optimal power flow (CCOPF) problem that integrates energy storage and uncertainty in renewable energy output and demand. Specifically, it is required that the probability that both supply-demand and the energy storage physical constraints are satisfied is close to 1. To solve this problem, an efficient partial sample average approximation (PSAA) is put forward. We will present computational results performed on IEEE test systems and how they compare to other methods.

■ ThD26

26- Forbes Room

MISP at ISMP: Mixed-Integer Stochastic Programming

Cluster: Stochastic Optimization

Invited Session

Chair: Maarten van der Vlerk, University of Groningen, Dept. of Operations, P.O. Box 800, Groningen, Netherlands, m.h.van.der.vlerk@rug.nl

1 - A Convex Approximation for Two-Stage Mixed-Integer Recourse Models

Ward Romeijnders, University of Groningen, Dept. of Operations, P.O. Box 800, Groningen, 9700AV, Netherlands, w.romeijnders@rug.nl, Ruediger Schultz, Maarten van der Vlerk, Wim Klein Haneveld

We derive a convex approximation for two-stage mixed-integer recourse models and we show that the error of this approximation vanishes as all total variations of the probability density functions of the random variables in the model decrease to zero. To prove this result we use asymptotic periodicity of the mixed-integer value function and error bounds on the expectation of periodic functions.

2 - Computational Considerations for Mixed Integer Variables in Both Stages

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

Mixed integer variables arise in both stages of many SMIP applications. These include two stage location-allocation, location-sizing-allocation, and many other classes. Unfortunately, standard Benders' decomposition does not apply here, and as a result, researchers often try to solve the deterministic equivalent formulation (DEF) using standard off-the-shelf MIP solvers. This approach is inadequate to the task when scenarios grow. In this presentation we give computational evidence that combining polyhedral combinatorics with SP decomposition provides the necessary tools for computations as well as mathematical convergence. Using desktops, we report optimal solutions for instances whose DEF contain millions of mixed-integer variables.

3 - Totally Unimodular Multistage Stochastic Programs

Ruichen Richard Sun, PhD Student, Univeirsity of Pittsburgh, 1048 Benedum Hall, 3700 O'Hara Street, Pittsburgh, PA, 15261, United States of America, rus19@pitt.edu, Andrew J. Schaefer, Oleg V. Shylo

We consider totally unimodular multistage stochastic programs, that is, multistage stochastic programs whose extensive-form constraint matrices are totally unimodular. We establish several sufficient conditions and identify examples that have arisen in the literature.

ThD27

27- Duquesne Room

Network Design III

Cluster: Combinatorial Optimization

Invited Session

Chair: Laszlo Vegh, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom, L.Vegh@lse.ac.uk

1 - On Approximate Precedence Constrained Deadline Scheduling & Network Diffusion

Jochen Koenemann, University of Waterloo, 200 University Avenue West, Waterloo, ON, Canada, jochen@uwaterloo.ca

We consider the classic problem of scheduling a set of n jobs non-preemptively on a single machine. Each job j has non-negative processing time, weight, and deadline, and a feasible schedule needs to be consistent with chain-like precedence constraints. The goal is to compute a feasible schedule that minimizes the sum of penalties of late jobs. Lenstra and Rinnoy Kan [Annals of Disc. Math., 1977] showed that the above problem is NP-hard. To the best of our knowledge, we are the first to study the approximability of this problem. We present an O(log k)-approximation for instances with k distinct job deadlines. We also show a nice connection of this problem to technology diffusion processes in networks.

2 - On Survivable Set Connectivity

Fabrizio Grandoni, Prof., IDSIA, Galleria 1, Manno, 6928, Switzerland, fabrizio@idsia.ch, Bundit Laekhanukit, Parinya Chalermsook

In the Survivable Set Connectivity problem (SSC) we are given an n-node edge-weighted undirected graph and a collection of h set pairs (S_i,T_i), where S_i and T_i are subsets of nodes. Each pair i has an integer connectivity requirement k_i>=1. Our goal is to compute a min-cost subgraph H so that there are at least k_i edge-disjoint paths in H between S_i and T_i for all i. We show that there is no poly-logarithmic approximation for SSC unless NP has a quasi-polynomial time algorithm. Furthermore, we present a bicriteria approximation algorithm for SSC that computes a solution H of cost at most poly-logarithmically larger than the optimal cost and provides a connectivity at least Omega(k_i/log n) for each set pair i.

3 - Degree-bounded Network Design with Node Connectivity Requirements

Alina Ene, Assistant Professor, University of Warwick, Department of Computer Science, Coventry, CV4 7AL, United Kingdom, A.Ene@warwick.ac.uk, Ali Vakilian

We consider degree bounded network design problems with element and vertex connectivity requirements. The input is an undirected graph G with weights on the edges and degree bounds b(v) on the vertices, and connectivity requirements for each pair of vertices. The goal is to select a minimum-weight subgraph of G that meets the connectivity requirements and it satisfies the degree bounds on the vertices. We give the first (O(1), O(1) b(v)) bicriteria approximation algorithms for the degree-bounded survivable network design problem with element connectivity requirements and for several problems with vertex connectivity requirements.

■ ThD28

28- Liberty Room

Interdiction Models in Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Juan Sebastian Borrero, University of Pittsburgh, 1048 Benedum Hall, PIttsburgh, PA, 15261, United States of America, jsb81@pitt.edu

1 - Critical Nodes in Network Cohesion

Alexander Veremyev, University of Florida, 303 Weil Hall, Gainesville, FL, United States of America, averemyev@ufl.edu, Oleg Prokopyev, Eduardo Pasiliao

In this talk we consider a class of critical nodes detection problems that involves minimization of the cohesiveness (communication efficiency) of a given unweighted graph via the removal of a subset of nodes subject to a budgetary constraint. The communication efficiency of a graph is assumed to be a general distance-based metric (e.g., graph efficiency or harmonic average geodesic distance, Harary index, characteristic path length, communication utility) that depends on the actual pairwise distances between nodes in the remaining graph. We derive linear integer programming (IP) formulations along with additional enhancements, and develop an exact iterative algorithm aimed at improving the performance of standard solvers.

2 - Detecting Critical Vertex Structures on Graphs: A Mathematical Programming Approach

Jose Walteros, Assistant Professor, University at Buffalo, 413 Bell Hall, Buffalo, NY, 14260, United States of America, josewalt@buffalo.edu, Alexander Veremyev, Eduardo Pasiliao, Panos Pardalos

We consider the problem of detecting a collection of critical vertex structures of a graph, whose deletion optimally deteriorates the connectivity of the graph. The principal objective of the proposed approach is to generalize other models existing in the literature, whose scope is restricted to removing individual and unrelated vertices. We focus our attention on the cases where the vertex structures form cliques or stars, albeit the proposed technique is general enough to be easily extended for detecting other kinds of critical structures.

3 - Sequential Shortest Path Network Interdiction with Incomplete Information

Juan Sebastian Borrero, University of Pittsburgh, 1048 Benedum Hall, PIttsburgh, PA, 15261, United States of America, jsb81@pitt.edu, Oleg Prokopyev, Denis Saure

We study sequential interdiction of evaders on a network when the interdictor has partial initial information about the network structure and costs. In each period, the interdictor removes up to k arcs from the network, after which an evader travels a shortest path. By observing the evaders' actions the interdictor learns about the arcs and costs of the network and adjusts its actions accordingly. We analyze a class of policies that remove a set of k-most vital arcs of the observed network, and assess its optimality.

■ ThD29

29- Commonwealth 1

New Trends in First Order Methods for Non-smooth Optimization

Cluster: Nonsmooth Optimization

Invited Session

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

1 - iPiano: Inertial Proximal Algorithm for Nonconvex Optimization

Peter Ochs, University of Freiburg, ochs@cs.uni-freiburg.de, Yunjin Chen, Thomas Brox, Thomas Pock

We study an algorithm for solving a minimization problem composed of a differentiable (possibly nonconvex) and a simple (possibly nondifferentiable and nonconex) function. The algorithm iPiano combines forward-backward splitting with an inertial force. It can be seen as a nonsmooth split version of the Heavy-ball method from Polyak. A rigorous analysis of the algorithm for the proposed class of problems yields global convergence of the function values and the arguments. This makes the algorithm robust for usage on nonconvex problems. The convergence result is obtained based on the Kurdyka-Lojasiewicz inequality.

2 - Extensions of the PDHGM

Tuomo Valkonen, DAMTP, University of Cambridge, Wilberforce Road, Cambridge, CB3 0WA, United Kingdom, tjmv3@cam.ac.uk

The Chambolle-Pock method or PDHGM (primal-dual hybrid gradient method, modified) has been very succesfull in image processing. It has recently been extended, by the speaker and others, from its original convex optimisation setting also to non-convex problems, such as inverse problems involving non-linear forward operators. In this talk, I will speak about these algorithms, and how their analysis helps to further study the original method, and to possibly derive improved acceleration schemes.

3 - On the Convergence of the Iterates of Accelerated Descent Methods

Antonin Chambolle, Prof., CMAP, Ecole Polytechnique & CNRS, Ecole Polytechnique, Palaiseau, 91128, France, antonin.chambolle@cmap.polytechnique.fr

Based on the standard convergence theory for over-relaxed and inertial descent algorithms, we are able to show that a slight modification of the "FISTA" descent rule (Beck and Teboulle, 2008) yields a converging sequence of iterates, without changing the overall accelerated rate of decay of the energy (only the constant is slightly affected). This is a joint work with Charles Dossal from Univ. Bordeaux-1.

■ ThD30

30- Commonwealth 2

Approximation and Online Algorithms XI

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Dorit S. Hochbaum, Professor, University of California, Berkeley, Etcheverry Hall, Berkeley, CA, 94720, United States of America, hochbaum@ieor.berkeley.edu

1 - Online Submodular Welfare Maximization: Greedy Beats 1/2

Morteza Zadimoghaddam, Research Scientist, Google Research, 76 9th Ave, New York, NY, 10011, United States of America, zadim@google.com, Vahab Mirrokni, Nitish Korula

In the Online Submodular Welfare Maximization (SWM) problem, the input consists of a stream of n items arriving one at a time. The algorithm must make an irrevocable decision about which of the m agents to assign the just arrived item to before seeing the subsequent items. Each agent has a monotone submodular valuation function for the set of items she receives. The goal is to assign items while maximizing the social welfare, defined as the sum of valuations of all agents. We prove that a simple greedy algorithm is (1/2+Omega(1))-competitive if the items arrive in a random order. We also formulate a natural conjecture which, if true, would improve the competitive ratio of the greedy algorithm to at least 0.567.

2 - The Submodular Joint Replenishment Problem

Adam Elmachtoub, IBM Research, 1101 Kitchawan Rd., Yorktown Heights, NY, United States of America, adam@ieor.columbia.edu, Retsef Levi, Maurice Cheung, David Shmoys

The joint replenishment problem (JRP) is a multi-item inventory model that captures the tradeoff between replenishing inventory frequently versus holding lots of inventory to satisfy time-dependent, deterministic demands. Moreover, the JRP captures the economies of scale in replenishing multiple item types simultaneously. Historically, the joint replenishment cost has a simple additive structure. We generalize the joint replenishment cost to be a submodular function over the item types, and provide approximation algorithms under various settings.

3 - Approximation Algorithms for Submodular Minimization Problems

Dorit S. Hochbaum, Professor, University of California, Berkeley, Etcheverry Hall, Berkeley, CA, 94720, United States of America, hochbaum@ieor.berkeley.edu

We show that submodular minimization (SM) problems subject to constraints containing up to two variables per inequality are 2-approximable in polynomial time. When the coefficients of the two variables in each constraint are of opposite signs (monotone constraints) then the SM minimization or supermodular maximization is polynomial time solvable. The 2-approximable problems include: SM-vertex cover; SM-2SAT: SM-min satisfiability; SM-edge deletion for clique, SM-node deletion for biclique and others. These 2-approximations are best possible unless NP=P. We show that SM minimization on totally unimodular constraints is an NP-hard problem, but SM minimization over monotone constraints is solved in polynomial time.

Thursday, 4:35pm - 5:25pm

■ ThE01

01- Grand 1

On Mathematical Programming with Indicator Constraints

Cluster: Plenary

Invited Session

Chair: Egon Balas, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA 15213, United States of America, eb17@andrew.cmu.edu

1 - On Mathematical Programming with Indicator Constraints

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

In this paper we review the relevant literature on mathematical optimization with logical implications, i.e., where constraints can be either active or disabled depending on logical conditions to hold. In the case of convex functions, the theory of disjunctive programming allows one to formulate these logical implications as convex nonlinear programming problems in a space of variables lifted with respect to its original dimension. We concentrate on the attempt of avoiding the issue of dealing with large NLPs. In particular, we review some existing results that allow to work in the original space of variables for two relevant special cases where the disjunctions corresponding to the logical

implications have two terms. Then, we significantly extend these special cases in two different directions, one involving more general convex sets and the other with disjunctions involving three terms. Computational experiments comparing disjunctive programming formulations in the original space of variables with straightforward bigM ones show that the former are computationally viable and promising. (Joint work with Pierre Bonami, Andrea Tramontani and Sven Wiese).

■ ThE02

02- Grand 2

Quasi-Monte Carlo Methods for Linear Two-Stage Stochastic Programming Problems

Cluster: Plenary

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 - Quasi-Monte Carlo Methods for Linear Two-Stage Stochastic Programming Problems

Werner Roemisch, Humboldt University, Berlin, Germany, romisch@math.hu-berlin.de

Quasi-Monte Carlo algorithms are studied for generating scenarios to solve two-stage linear stochastic programming problems. Their integrands are piecewise linear-quadratic, but do not belong to the function spaces considered for QMC error analysis. We show that under some weak geometric condition on the two-stage model all terms of their ANOVA decomposition, except the one of highest order, are continuously differentiable and second order mixed derivatives exist almost everywhere and belong to L_{2}. This implies that randomly shifted lattice rules may achieve the optimal rate of convergence $O(n^{-1+\delta})$ with $\delta\in(0,\frac{1}{2})$ and a constant not depending on the dimension if the effective superposition dimension is less than or equal to two. The geometric condition is shown to be satisfied for almost all covariance matrices if the underlying probability distribution is normal. We discuss effective dimensions and techniques for dimension reduction. Numerical experiments for a production planning model with normal inputs show that indeed convergence rates close to the optimal rate are achieved when using randomly shifted lattice rules or scrambled Sobol' point sets accompanied with principal component analysis for dimension reduction.

Thursday, 5:30pm - 7:00pm

■ ThF01

01- Grand 1

Complementarity/Variational Inequality VI

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Todd Munson, Argonne National Laboratory, Argonne, IL, 60439, United States of America, tmunson@mcs.anl.gov

1 - Complementarity Models for Traffic Equilibrium with Ridesharing

Huayu (Cathy) Xu, PhD, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089, United States of America, huayuxu@usc.edu, Jong Shi Pang, Fernando Ordòñez, Maged Dessouky

Ridesharing is an efficient way to utilize unused vehicle capacity and reduce traffic congestion, and it has recently become popular due to new communication technologies. The objective of this paper is to analyze how ridesharing impacts traffic congestion and how people can be motivated to participate in ridesharing, and conversely, how congestion influences ridesharing activities. We propose a new traffic equilibrium model with ridesharing, and formulate it as a mixed complementarity problem (MiCP). It is proved under meaningful conditions on the model parameters that there exists one and only one solution to this model. The KNITRO solver is adopted to solve the MiCP and the computational results are promising.

2 - Pricing Schemes for Two-Stage Market Clearing Model in Electricity Markets

Jinye Zhao, ISO New England, One Sullivan Rd, Holyoke, MA, 01040, United States of America, JZhao@iso-ne.com

To keep up with the growth of renewable resources, alternative dispatch mechanisms based on two-stage models, such as stochastic programming and look-ahead problems, have been extensively explored in electricity markets. However, little attention has been paid to the pricing issue. In this talk, two alternative pricing schemes are proposed for two-stage models. Under the first scheme, the 1st-stage decision is settled at a marginal clearing price which contains all future information while the 2nd-stage decision is compensated in the pay-as-bid fashion. Under the second scheme, both the 1st and 2nd stage decisions are settled at marginal prices which reflect partial future information. The pros and cons of both schemes are discussed.

3 - Phase Retrieval and Nash Games

Todd Munson, Argonne National Laboratory, Argonne, IL, 60439, United States of America, tmunson@mcs.anl.gov, Stefan Wild, Ashish Tripathi, Sven Leyffer

Coherent x-ray diffractive imaging is a technique that utilizes phase retrieval and nonlinear optimization to image matter at nanometer scales. Algorithms for the nonconvex phase retrieval problem can be written as a two player Nash game where the players choose the variables inside and outside the support, respectively. A Gauss-Jacobi algorithm for solving the game is discussed where each player chooses a descent direction for their individual optimization problem and then a two-variable complementarity problem is solved to obtain the step lengths. Numerical results for this algorithm on phase retrieval problems are provided.

■ ThF02

02- Grand 2

Conic Optimization: From Fundamental Limitations to Algorithmic Developments

Cluster: Conic Programming

Invited Session

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

Co-Chair: Hamza Fawzi, MIT, hfawzi@mit.edu

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

1 - Equivariant Semidefinite Lifts and Sum-of-Squares Hierarchies

Hamza Fawzi, MIT, hfawzi@mit.edu, James Saunderson, Pablo Parrilo

A positive semidefinite lift (psd lift) of a polytope P is a representation of P as the projection of an affine slice of the positive semidefinite cone. In this work we consider equivariant psd lifts, which are psd lifts that respect the symmetries of a polytope P. We present a representation-theoretic framework to study equivariant psd lifts of a certain class of symmetric polytopes known as regular orbitopes. Our main result is a structure theorem that establishes a connection between equivariant psd lifts and sum-of-squares lifts. We apply our framework to get lower bounds as well as constructions of equivariant psd lifts for certain well-known symmetric polytopes such as regular polygons, parity polytopes and cut polytopes.

2 - PSD Minimality and Polytope Ideals

Joào Gouveia, University of Coimbra, Apartado 3008 EC Santa Cruz, Coimbra, 3001-501, Portugal, jgouveia@mat.uc.pt, Kanstantsin Pashkovich, Richard Robinson, Rekha Thomas

A d-polytope is said to be psd minimal if it can be written as a projection of a slice of the cone of d+1 by d+1 positive semidefinite matrices, the smallest possible size for which this may happen. In this talk, we will introduce the concept of polytope ideal, an algebraic object that codifies the geometry of a polytope, and use it to derive obstructions and sufficient conditions for psd minimality. These will allow us to complete the classification of psd minimal 4-polytopes, providing examples that settle some open questions.

3 - A Polynomial-Time Affine-Scaling Method for Semidefinite and Hyperbolic Programming

Mutiara Sondjaja, New York University, 251 Mercer St., New York, NY, 10012, United States of America, sondjaja@cims.nyu.edu, James Renegar

We develop a natural variant of Dikin's affine-scaling method, first for semidefinite programming and then for hyperbolic programming in general. We match the best complexity bounds known for interior-point methods. All previous polynomial-time affine-scaling algorithms have been for conic optimization problems in which the underlying cone is symmetric. Hyperbolicity cones, however, need not be symmetric. Our algorithm is the first polynomial-time affine-scaling method not relying on symmetry.

■ ThF03

03- Grand 3

Strengths and Limits of Linear Programming Formulations

Cluster: Combinatorial Optimization

Invited Session

Chair: Yuri Faenza, EPFL SB MATH AA MA C1 573 Station 8 CH-1, Station 8, Lausanne, Switzerland, yuri.faenza@epfl.ch

1 - Effectiveness of Sparse Cutting-planes for Integer Programs with Sparse Constraints

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

Many practical integer programming instances have sparse constraints. Consequently, many effective cutting-plane classes are sparse. State-of-the-art IP solvers prefer use of sparse cutting-planes due to performance of LP solvers. Motivated by these considerations, we theoretically study the strength of cutting-planes whose support is restricted to the support of the constraints in the constraint matrix. Additionally, this study helps in developing new approximation algorithms with better performance guarantees for some classes of stochastic IPs.

2 - Extended Formulation Lower Bounds via Hypergraph Coloring?

Stavros Kolliopoulos, Professor, Department of Informatics and Telecommunications, University of Athens, Panepistimiopolis, Panepistimiopolis, Ilissia, Athens, 157 84, Greece, sgk@di.uoa.gr, Yannis Moysoglou

We propose a framework for proving lower bounds on the size of extended formulations. We do so by introducing a specific type of extended relaxations that we call product relaxations and is motivated by the study of the Sherali-Adams hierarchy. We show that for every approximate relaxation of a zero-one polytope P, there is a product relaxation that has the same size and is at least as strong. We provide a methodology for proving lower bounds on the size of approximate product relaxations by lower bounding the chromatic number of an underlying hypergraph, whose vertices correspond to gap-inducing vectors. An application of the method to the capacitated facility location polytope is presented.

3 - Extended Formulations Based on Composition Rules

Kanstantsin Pashkovich, University of Waterloo, Waterloo, Canada, kanstantsin.pashkovich@gmail.com, Michele Conforti

This talk is dedicated to extended formulations of combinatorial polytopes which arise from “smaller” polytopes via some composition rule. We present known extended formulations of this type. In particular, we describe the framework developed by Margot (1994) for iterative construction of extended formulations and establish connections to other existing frameworks for constructing extended formulations. We also study the properties of polytopes, which are compatible with the framework of Margot.

■ ThF04

04- Grand 4

Conic Programming Algorithms and Applications

Cluster: Conic Programming

Invited Session

Chair: Kim-Chuan Toh, Professor, National University of Singapore, Department of Mathematics, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, mattohkc@nus.edu.sg

1 - A Numerical Study on the SOS Relaxation for a Lagrangian Relaxation of QOPs with Binary Variables

Sunyoung Kim, Professor, Ewha W. University, 11-1 Dahyun-dong, Sudaemoongu, Seoul, 120-750, Korea, Republic of, skim@ewha.ac.kr, Masakazu Kojima

We consider a Lagrangian relaxation of the QOPs whose convergence depends on a single Lagrangian parameter, and then studies its sum-of-squares (SOS) relaxation using numerical experiments. We show that the SOS relaxation attains the same optimal value as the Lagrangian relaxation for randomly generated QOPs. We also discuss a special class of QOPs whose optimal values cannot be obtained by the SOS relaxation.

2 - An Inexact Majorized Multi-block ADMM for a Class of Large-scale Convex Composite Programming

Kim-Chuan Toh, Professor, National University of Singapore, Department of Mathematics, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, mattohkc@nus.edu.sg

We design an inexact ADMM-type method for solving a class of large-scale linearly constrained multi-block convex composite minimization problems. We design majorized convex functions with appropriate proximal terms to construct subproblems that can be solved by a recently proposed symmetric block Gauss-Seidel (SBGS) technique, and some implementable inexact minimization criteria for solving the subproblems within the SBGS iterations. We establish the global convergence as well as some iteration-complexity results for the proposed method where the step-length can be chosen up to 1.618. Numerical results on a variety of high-dimensional quadratic SDP problems are also provided to show the efficiency of the proposed method.

3 - Unified Binary Classification Algorithm based on Practical Accelerated Proximal Gradient Methods

Naoki Ito, PhD Student, Keio University, Department of Administration Engineering, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama, 223-8522, Japan, pico@keio.jp, Akiko Takeda, Kim-Chuan Toh

Binary classification is the problem of predicting the class a given sample belongs to. It is important to find suitable classification models for given datasets in order to achieve good prediction performances. We design an efficient algorithm for solving a unified problem for various classification models, which speeds up the process of finding the best model. It is based on an accelerated proximal gradient method and performs better than specialized lgorithms designed for specific models.

■ ThF05

05- Kings Garden 1

Nonconvex, Non-Lipschitz, and Sparse Optimization V

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 - An Improved Algorithm for the L2-Lp Minimization Problem

Simai He, Professor, Shanghai University of Finance and Economics, School of Information Mgt and Eng, Wudong Road, 100, Yangpu District, Shanghai, China, simaihe@mail.shufe.edu.cn, Dongdong Ge, Rongchuan He

In this work, we propose an iterative algorithm that finds approximate KKT point within polynomial time, for a class of non-Lipschitz and non-convex minimization problems. Same results are also generalized to problems with general linear constraints under mild conditions.

2 - Efficient Smoothing Method for Box Constrained Nonsmooth Nonconvex Optimization

Chao Zhang, Dr., Beijing Jiaotong University, Department of Applied Mathematics, Beijing, 100044, China, zc.njtu@163.com, Xiaojun Chen

In this paper, we develop efficient smoothing method to solve box constrained nonsmooth nonconvex minimization problems, which is flexible to enroll various existing algorithms for smooth optimization. We show the convergence of our method to stationary point under mild conditions. Numerical experiments are given to illustrate the efficiency of our smoothing method for solving nonsmooth nonconvex box constrained minimization problems of large size.

3 - Optimal Beamformer Design in Reverberant Environment

Zhibao Li, Post Doc, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No. 55, ZhongGuanCun East Road, Beijing, China, zbli0307@163.com, Yu-Hong Dai

In this paper, we consider the optimal beamformer design problem, i.e., the joint group delay and beamformer design problem. We introduce a new variable to represent the group delay and formulate the joint group delay and beamformer design problem as a structured constrained convex optimization (SCCO) problem. Moreover, we exploit the separable structures of the SCCO problem and propose to use the alternating direction method of multipliers (ADMM) to solve it. Numerical simulation results show the effectiveness of the proposed method in the reverberant environment by comparing it with the LCMV method.

ThF06

06- Kings Garden 2

Advances in Integer Programming IX

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 - Faster Solution of Semidefinite Relaxations for Non-Convex Quadratic Integer Programs

Maribel Montenegro, Technische Universitaet Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, maribel.montenegro@math.tu-dortmund.de, Angelika Wiegele, Christoph Buchheim

We discuss different techniques for improving Q-MIST, a branch-and-bound approach for solving non-convex quadratic integer optimization problems. Q-MIST uses an interior point method at each node of the B&B tree to solve the semidefinite programming relaxations of such problems. We present two alternative methods that both try to exploit the specific problem structure, namely a small total number of active constraints and very sparse constraint matrices. In the first approach, we reformulate the semidefinite problem as a quadratic problem through low-rank factorization. The second approach works on the dual of the semidefinite relaxation, we solve it using a coordinate descent method with exact line search in order to compute dual bounds.

2 - Deciding Emptiness of the Gomory-Chvatal Closure is NP-Complete

Yanjun Li, Professor, Purdue University, 403 West State Street, West Lafayette, IN, 47907, United States of America, li14@purdue.edu, Gerard Cornuejols

The Gomory-Chvatal cuts are a prominent class of cutting planes for integer programs. The Gomory-Chvatal closure of a polyhedron is the intersection of all half spaces defined by its Gomory-Chvatal cuts. We show that it is NP-complete to decide whether the Gomory-Chvatal closure of a polyhedron is empty.

3 - A Linear Programming Approach to Inverse Mixed-Integer Programming

Jourdain Lamperski, Researcher, University Of Pittsburgh, 3700 O'Hara St., Pittsburgh, PA, 15261, United States of America, jbl22@pitt.edu, Andrew J. Schaefer

Given a feasible solution and "target objective" to a mixed-integer program (MIP), the inverse MIP problem is to find an objective such that the given feasible solution is optimal, and the distance from the target objective is minimized. Algorithms for solving inverse MIPs are known, but the structure of the problem remains an open question. By using the superadditive dual of the MIP, we formulate the inverse MIP problem as an exponentially large linear program.

ThF07

07- Kings Garden 3

Dealing with Nonlinearities using the Example of Gas Networks

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Alexander Martin, FAU Erlangen-Nürnberg, Department Mathematik, Cauerstr 11, Erlangen, Germany, alexander.martin@math.uni-erlangen.de

1 - Network Flow Theory for Natural Gas Transportation

Martin Grofl, TU Berlin, Strafle des 17. Juni 136, Fak. II, Mathematik, Sekr. MA 5-2, Berlin, 10623, Germany, gross@math.tu-berlin.de, Martin Skutella, Marc Pfetsch

We study the use of network flow theory for natural gas networks. Natural gas is an important energy source and is being used for over 20% of the world's electricity generation. Transportation requires the use of pipeline networks, which incorporate several types of control mechanisms in order to adapt to different usage scenarios. Tasks here include identifying feasible usage scenarios and finding control settings for their realization. We discuss a model that adapts classical network flow theory for this purpose. This requires handling binary decisions for controls, and the non-linear dependencies of flow on pressure.

2 - Optimal Layout of Gas Pipeline Networks

Robert Schwarz, Zuse Institute Berlin, Takustrafle 7, Berlin, Germany, schwarz@zib.de

We consider the problem of designing a network of pipelines to transport gas from multiple sources to sinks. It can be shown that cost-minimal networks do not contain cycles. We therefore restrict our search to Steiner trees. In addition to the topology, we also need to choose positions for the Steiner nodes and diameters on the pipeline segments. This is formulated as non-convex MINLP model, with a convex reformulation for any fixed topology.

3 - Computational Comparison of MIP and MINLP Models for Compressor Stations

Tom Walther, Konrad Zuse Institute, Takustrasse 7, Berlin, 14195, Germany, walther@zib.de, Benjamin Hiller

Compressor stations are the most complex parts of gas transmission networks. Proper modelling of their technical capabilities is crucial for efficiently running and planning gas networks. Mathematically, they are also a source of hard MINLP models since the operating range of a single compressor is a nonconvex set and several compressors may be used together in many combinatorial ways. We study models for complex compressor stations based on several models for a single compressor that have been proposed in the literature. We perform a computational comparison of those models, investigating their runtime/accuracy tradeoff.

ThF08

08- Kings Garden 4

Large-Scale First-Order Optimization Methods

Cluster: Sparse Optimization and Applications

Invited Session

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

1 - Communication-Efficient Distributed Dual Coordinate Ascent

Martin Jaggi, ETH Zürich, Universitaetsstr 6, Zürich, 8092, Switzerland, m.jaggi@gmail.com, Virginia Smith, Martin Takac, Jonathan Terhorst, Sanjay Krishnan, Thomas Hofmann, Michael I Jordan

Communication remains the most significant bottleneck in the performance of distributed optimization algorithms for large-scale machine learning. We propose a communication-efficient framework, COCOA, that uses local computation in a primal-dual setting to dramatically reduce the amount of necessary communication. We provide a strong convergence rate analysis for this class of algorithms, as well as experiments on real-world distributed datasets with implementations in Spark. In our experiments, we find that as compared to state-of-the-art mini-batch versions of SGD and SDCA algorithms, COCOA converges to the same .001-accurate solution quality on average 25x as quickly.

2 - Accelerated Communication-Efficient Distributed Dual Coordinate Ascent

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

We explore Nesterov acceleration techniques in distributed settings. We partition the data describing objective function across K nodes (computers) and on each of them we define a local optimization problem. We assume that the local problem is solved by any optimization method which can deliver some prescribed accuracy. In each iteration the approximate solutions are aggregated and a new iterate is obtained. We provide the iteration complexity of given framework and also discuss the computation vs. communication trade-off.

3 - Learning Sparsely used Overcomplete Dictionaries

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

We consider the problem of learning sparsely used overcomplete dictionaries, where each observation consists of a sparse combination of the mutually incoherent dictionary elements. Our method consists of a clustering-based initialization step that gives a reasonably accurate initial estimate of the true dictionary. This estimate is further improved via an iterative algorithm which alternates between estimating the dictionary and coefficients. We establish that, under a set of sufficient conditions, our method converges at a linear rate to the true dictionary as well as the true coefficients for each observation. [[Joint work with Anima Anandkumar, Prateek Jain, Praneeth Netrapalli and Rashish Tandon]].

■ ThF09

09- Kings Garden 5

Applications of Robust Optimization

Cluster: Robust Optimization

Invited Session

Chair: Chrysanthos Gounaris, Assistant Professor, Carnegie Mellon University, DH3107, 5000, Forbes Ave., Pittsburgh, PA, 15213, United States of America, gounaris@cmu.edu

1 - Stochastic Robust Multi-Echelon Inventory Control based on Data Analytics

Cong Cheng, Institute of Industrial Engineering and Logistics Optimization, Northeastern University, Shenyang, 110819, China, chc_5588@163.com, Lixin Tang

In this paper, we address the multi echelon inventory problem based on the data analytics. The muiti-echelon inventory extracted from practical iron and steel enterprises has many features: logistics delay, stochastic demand, and the production process is a gray box, which are hard to represent by the traditional model, but one has plenty historical data. The probabilistic arguments for this problem relyed on historical data are provided. The stochastic robust model is build and a new trust region algorithm based on data is proposed to handle this problem, where each subproblem is reduced to a conic program.

2 - Robust Geometry Optimization in Elastodynamics with Time-Dependent Uncertainties

Philip Kolvenbach, Technische Universitaet Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, kolvenbach@mathematik.tu-darmstadt.de, Stefan Ulbrich

We consider the robust geometry optimization of load-carrying structures that are governed by the wave equation of elastodynamics and are subject to uncertain time-dependent parameters. We use a first-order approximation for the worst-case functions and assume the perturbations are restricted to an ellipsoidal or cylinder-like uncertainty set. The FEM-discretized geometry is subdivided such that the geometry transformation is piecewise affine and the system matrices can be assembled and differentiated efficiently. We present numerical results.

3 - Adjustable Robust Optimization of Process Scheduling under Uncertainty

Chrysanthos Gounaris, Assistant Professor, Carnegie Mellon University, DH3107, 5000, Forbes Ave., Pittsburgh, PA, 15213, United States of America, gounaris@cmu.edu, Nikolaos Lappas

We develop an Adjustable Robust Optimization (ARO) framework to address uncertainty in the parameters of Process Scheduling models. Unlike the traditional RO approach, which results in a static, “here-and-now” solution, ARO results in a solution policy that is a function of parameter realizations. We discuss the derivation of the ARO counterpart in this context, and we propose decision-dependent uncertainty sets to enforce that the policy depends only on observable realizations. Our results show that the ARO approach provides robust solutions that are considerably less conservative. In addition, we show that ARO can provide feasible solutions to instances with “zero-wait” task restrictions for which a traditional approach inherently cannot.

■ ThF10

10- Kings Terrace

Real-Time Optimization and Predictive Control II

Cluster: Nonlinear Programming

Invited Session

Chair: Lorenz T. Biegler, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, lb01@andrew.cmu.edu

1 - Parallel Cyclic Reduction Strategies for Dynamic Optimization

Bethany Nicholson, Carnegie Mellon University, United States of America, blnichol@andrew.cmu.edu, Lorenz Biegler, Shivakumar Kameswaran

Direct Transcription is a well-established method to solve dynamic optimization / optimal control problems efficiently. However, for problems with thousands of state variables and discretization points, the linear systems resulting from the Newton step comprise the dominant computational cost and become prohibitively expensive to solve. In this talk we discuss ways to exploit the inherent structure and sparsity of these linear systems, and employ parallel cyclic reduction strategies to solve them efficiently.

2 - An Interior-Point Decomposition Strategy for Parallel Solution of Dynamic Optimization Problems

Carl Laird, School of Chemical Engineering, Purdue University, 480 Stadium Mall Drive, West Lafayette, IN, United States of America, lairdc@purdue.edu, Yankai Cao, Jose Santiago Rodriguez

An efficient strategy for solution of DAE constrained optimization problems is to apply a direct transcription approach and solve the resulting large-scale nonlinear program. Here, we present a parallel decomposition strategy for these problems based on decomposition of the KKT system arising in nonlinear interior-point methods. This approach shows speedups of over 50 times on some problems.

3 - Robust NLP Formulations for Nonlinear Model Predictive Control (NMPC)

Devin Griffith, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, dwgriffi@andrew.cmu.edu, Xue Yang, Lorenz Biegler

Modern NLP solvers enable fast NMPC strategies for control of challenging nonlinear processes. However, dynamic systems have been reported where standard NMPC strategies have zero robustness. Guided by well-known sufficient KKT conditions and constraint qualifications, we develop and reformulate ideal, advanced step and advanced multi-step NMPC strategies that guarantee robust stability properties for general dynamic systems. We also demonstrate how these formulations overcome robustness limitations on three pathological examples from the literature.

■ ThF11

11- Brigade

Network Flows

Cluster: Combinatorial Optimization

Invited Session

Chair: Andreas Karrenbauer, Max Planck Institute for Informatics, Campus E1 4, Saarbruecken, 66123, Germany, andreas.karrenbauer@mpi-inf.mpg.de

1 - A Simple Efficient Interior Point Method for Min-Cost Flow

Ruben Becker, Max Planck Institute for Informatics, Campus E 1.4, Saarbruecken, 66123, Germany, ruben.becker@mpi-inf.mpg.de, Andreas Karrenbauer

In recent years, methods for computing network flows at the same time became asymptotically faster and also more and more involved. Since the underlying ideas of the new techniques originate from convex optimization (most notably interior point methods), rather than from discrete mathematics, their combinatorial interpretation stayed vague. We propose a novel and much simpler algorithm for the min-cost flow problem with a runtime of ~O(m^{3/2}). We consider the simplicity of the method, and the fact that the combinatorial interpretation of all its steps becomes explicit, to be our main contributions. The three algorithmic parts of our method are of independent interest and might be useful as subroutines in other approaches as well.

2 - Cut-Approximators, Approximating Undirected Max Flows, and Recursion

Richard Peng, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E18-378, Cambridge, MA, 02139, United States of America, rpeng@mit.edu

We show a closer algorithmic connection between constructing cut-approximating hierarchical tree decompositions and computing approximate maximum flows in undirected graphs. Our approach is based on invoking known algorithms for these problems recursively, while reducing problem sizes using ultra-sparsifiers. This leads to the first O(m polylog(n)) time algorithms for both problems.

3 - Near-Optimal Distributed Maximum Flow

Christoph Lenzen, MPI for Informatics, Campus E1 4, Saarbrücken, Germany, christoph.lenzen@mpi-inf.mpg.de, Mohsen Ghaffari, Fabian Kuhn, Boaz Patt-Shamir, Andreas Karrenbauer

We present a distributed (1+o(1))-approximation of max flow in undirected weighted networks with diameter D running in nearly D + sqrt(n) communication rounds of the CONGEST model. In this model, each node of the network hosts its own computing device, and in each communication round, a node can send O(log n) bits to each neighbor. This is the first improvement over the trivial quadratic bound, and the running time is optimal up to factor n^o(1). Along the way, we establish two results of independent interest: Fast distributed constructions of low average stretch spanning trees and a congestion approximator consisting of the cuts induced by O(log n) virtual trees. All our algorithms are randomized and succeed with high probability.

■ ThF13

13- Rivers

Convex Conic Optimization: Models, Properties, and Algorithms III

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 - A Branch and Bound Approach to the Minimum k-enclosing Ball Problem

Marta Cavaleiro, PhD Student, Rutgers University, RUTCOR, 100 Rockafeller, Piscataway, NJ, United States of America, marta.cavaleiro@rutgers.edu, Farid Alizadeh

The minimum k-enclosing ball problem seeks the ball with smallest radius that contains at least k of n given points. This problem is NP-hard. The minimum enclosing ball problem (requiring the ball to contain all points) can be formulated as an SOCP (in fact a QP) and solved in polynomial time, however primal and dual iterative algorithms, similar to the simplex method for LP, have also been developed. We incorporate these methods into a branch and bound search to solve the minimum k-enclosing ball problem. Additionally we use problem relaxations, using both QP and SOCP, as lower bounds in some nodes of the tree to speed up the search. Some computational results will be presented.

2 - Unifying Nesterov's Method and Nonlinear Conjugate Gradient

Stephen A. Vavasis, University of Waterloo, 200 University Avenue W., Waterloo, ON, N2L 3G1, Canada, vavasis@uwaterloo.ca, Sahar Karimi

We present a variant of nonlinear conjugate gradient method that, when applied to strongly convex functions, achieves the optimal complexity bound as Nesterov's method using a similar analysis. However, unlike Nesterov's method, the proposed method is optimal in the traditional sense of conjugate gradient when applied to convex quadratic objective functions.

3 - Solving Semi-Infinite Programs using Rational Function Approximations and Semidefinite Programming

David Papp, Assistant Professor, North Carolina State University, Department of Mathematics, 3222 SAS Hall / Campus Box 8205, Raleigh, NC, 27695, United States of America, dpapp@ncsu.edu

In the most common formulation of semi-infinite programs, the infinite constraint set is a requirement that a function parametrized by the decision variables is nonnegative over an interval. If this function is sufficiently closely approximable by a polynomial, the semi-infinite program can be reformulated as an equivalent semidefinite program. Solving this semidefinite program is challenging if the polynomials involved are of high degree. We combine rational function approximation techniques and polynomial programming to overcome the numerical difficulties that arise in the solution of these problems. Motivating applications come from statistics.

■ ThF14

14- Traders

Mechanism Design and Optimization

Cluster: Game Theory

Invited Session

Chair: Yang Cai, McGill University, 3480 University, MC 324, Montreal, QC, Canada, cai@cs.mcgill.ca

1 - Convex Optimization and Bayesian Mechanism Design I: Basic Settings and Revenue Maximization

Yang Cai, McGill University, 3480 University, MC 324, Montreal, QC, Canada, cai@cs.mcgill.ca, Constantinos Daskalakis, Seth Matthew Weinberg

In his seminal paper, Myerson [1981] provides a revenue-optimal auction for a seller who is looking to sell a single item to multiple bidders. Extending this auction to simultaneously selling multiple heterogeneous items has been one of the central problems in Mathematical Economics. By borrowing techniques from Convex Optimization, we provide such an extension that is also computationally efficient. Our auction also preserves the simple structure of Myerson's. While Myerson's auction always chooses the allocation that maximizes the virtual welfare, our allocation rule is a distribution of virtual welfare maximizers.

2 - Convex Optimization and Bayesian Mechanism Design II: Algorithms for Strategic Agents

Seth Matthew Weinberg, Princeton University, 35 Olden St, Princeton, NJ, 08540, United States of America, sethmw@cs.princeton.edu, Constantinos Daskalakis, Yang Cai

This talk will further investigate tools developed in part I to address the following question. In traditional algorithm design, no incentives come into play: the input is given and your algorithm must produce a correct output. How much harder is it to solve the same problem when the input is not given directly, but instead reported by strategic agents with interests of their own? We develop a new algorithmic framework with which to study such problems, building upon the tools developed in part I of this session. We provide a computationally efficient black-box reduction from solving any optimization problem on strategic input to solving a perturbed version of that same optimization problem when the input is directly given.

3 - Bandit in a Network

L. Elisa Celis, EPFL, Ecole Polytechnique Federale de Lausanne, Lausanne, 1015, Switzerland, elisa.celis@epfl.ch, Farnood Salehi

In many optimization settings, agents are required to make sequential decisions with limited information, and traditionally base decisions on past experience. However, agents are often also privy to the experience of others. Thus, a natural question arises: how much can one gain (individually or as a whole) from this shared knowledge? We introduce a model that captures this setting in which a network of agents play against one multi-armed bandit; each player observes her neighbor's actions and rewards in addition to her own. This naturally interpolates between the classic multi-armed bandit setting and the full-information setting from online learning. We examine this problem from both an optimization and game theoretic point of view.

■ ThF15

15- Chartiers

Synergies Between Optimization and Robust Control

Cluster: Global Optimization

Invited Session

Chair: Venkat Chandrasekaran, Caltech, 1200 E. California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, venkatc@caltech.edu

1 - Robust to Dynamics Optimization (RDO)

Amir Ali Ahmadi, Princeton University, a_a_a@princeton.edu, Oktay Gunluk

We introduce a new type of robust optimization problems that we call "robust to dynamics optimization" (RDO). The input to an RDO problem is twofold: (i) a mathematical program (e.g., an LP, SDP, IP), and (ii) a dynamical system (e.g., a linear, nonlinear, discrete, or continuous dynamics). The objective is to maximize over the set of initial conditions that forever remain feasible under the dynamics. We initiate an algorithmic study of RDO and demonstrate tractability of some important cases.

2 - Regularization for Design

Nikolai Matni, California Institute of Technology, 1200 E California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, nmatni@caltech.edu, Venkat Chandrasekaran

When designing controllers for large-scale systems, designing the controller architecture, i.e., placing sensors and actuators as well as the communication links between them, is as important as the design of the control laws themselves. We show that the architecture design task can be framed as one of seeking structured solutions to linear inverse problems. We use this observation to formulate the Regularization for Design framework, in which we augment variational formulations of controller synthesis problems with convex penalty functions that induce a desired controller architecture. We further show that the resulting convex optimization problems identify optimally structured controllers under a signal-to-noise ratio type condition.

3 - Analysis and Design of Optimization Algorithms using Robust Control

Benjamin Recht, UC Berkeley, 465 Soda Hall, MC 1776, Berkeley, CA, 94720, United States of America, brecht@berkeley.edu

I will present a method to analyze and design optimization algorithms built on the framework of Integral Quadratic Constraints (IQC) from robust control theory. IQCs provide conditions for ensuring the stability of complicated interconnected systems and can be checked via semidefinite programming. I will discuss how to adapt IQC theory to study optimization algorithms, deriving upper bounds on convergence rates for many popular optimization methods. I will close with a discussion of how these techniques can be used to search for optimization algorithms with desired performance characteristics, establishing a new methodology for algorithm design. This is joint work with Laurent Lessard and Andrew Packard.

■ ThF16

16- Sterlings 1

Risk-Averse Control of Markov Systems

Cluster: Stochastic Optimization

Invited Session

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

1 - Risk-Averse Optimization of Discrete-Time Markov Systems

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

First, we shall briefly review basic ideas of modeling risk in optimization problems, in particular, the use of measures of risk. Then we shall focus on modeling risk in dynamical systems and discuss the property of time consistency and the resulting interchangeability in optimal control models. Special attention will be paid to discrete-time Markov systems. We shall refine the concept of time consistency of risk measures for such systems, introducing conditional stochastic time consistency. We shall also introduce the concept of Markovian risk measures and derive their structure. This will allow us to derive a risk-averse counterpart of dynamic programming equations. Finally, we shall discuss solution methods.

2 - Dynamic Risk Measures for Finite-State Partially Observable Markov Decision Problems

Jingnan Fan, Instructor, Rutgers University, 100 Rockefeller Road, Piscataway, NJ, 08854, United States of America, jingnan.fan@rutgers.edu

We provide a theory of time-consistent dynamic risk measures for finite-state partially observable Markov decision problems. By employing our new concept of stochastic conditional time consistency, we show that such dynamic risk measures have a special structure, given by transition risk mappings as risk measures on the space of functionals on the observable state space only. Moreover, these mappings enjoy a strong law invariance property.

3 - Risk-averse Hamilton-Jacobi-Bellman Equation

Jianing Yao, PhD Student, Rutgers University, 100 Rockefeller Road, Piscataway, NJ, 08854, United States of America, jy346@scarletmail.rutgers.edu

In this paper, we study the risk-averse control problem in continuous-time setting. We make use of forward backward stochastic differential equation (FBSDE) system to evaluate fixed policy and formulate the optimal control problem. Weak formulation is established to facilitate the derivation of the risk-averse dynamic programming equation (DPE). We also prove the value function of risk-averse control problem is a viscosity solution of generalized Hamilton-Jacobian-Bellman (HJB) equation. On the other hand, verification theorem is proved when the classical solution of HJB exists.

■ ThF17

17- Sterlings 2

Optimization in Healthcare Delivery

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Rema Padman, Professor of Mgmt. Sci & Healthcare Informatics, Carnegie Mellon University, The H. John Heinz III College, Pittsburgh, PA, 15213, United States of America, rpadman@cmu.edu

1 - The Impact of Optimization on The Allocation of Livers for Organ Transplantation

Mustafa Akan, Carnegie Mellon University, akan@cmu.edu, Heidi Yeh, James Markmann, Sridhar Tayur, Zachary Leung

Patients on the waitlist for liver transplantation are prioritized according to their MELD scores, which reflects the severity of each patient's liver disease. Recent studies have shown that hepatocellular carcinoma (HCC) patients have significantly higher liver transplant rates than non-HCC patients. We recommend a family of alternative MELD score policies based on a fluid model approximation of the queueing system and an optimization model that achieves an optimal balance between efficiency and equity.

2 - Electronic Health Records For Decision Support – Meaningful Use of Complex Medical Data

Fan Yuan, Georgia Tech, Atlanta, GA, United States of America, Eva Lee

This work is joint with Grady Memorial Hospital and the Children's Healthcare of Atlanta. We focus on identifying reasons behind the recurrence of patient admissions, and designing classification models to predict potential readmissions. Large scale data analysis and results will be presented. This is critical given the Affordable Care Act is beginning to implement readmission penalties. The algorithmic approach could detect readmission triggers without human monitoring.

3 - Optimizing Order Sets for Computerized Provider Order Entry: A Mathematical Programming Approach

Daniel Gartner, Carnegie Mellon University, The H. John Heinz III College, 5000 Forbes Ave, Pittsburgh, PA, 15213-3890, United States of America, dgartner@andrew.cmu.edu, Rema Padman, Yiye Zhang

Order sets improve care delivery by allowing faster and easier physician order entry, but creating usable and relevant time-interval-clustered order sets is challenging. We formulate and solve exact and heuristic approaches to minimize physical and cognitive workloads associated with assigning order sets/a-la-carte orders to patients and selecting/deselecting appropriate orders. Dominance properties and symmetry breaking constraints boost computation speed. Using real patient data from a major pediatric hospital, we demonstrate the effectiveness of our methods.

■ ThF18

18- Sterlings 3

Large-Scale Optimization and Its Applications

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 - Structured Optimization with Applications in Health Care

Yueling Loh, Johns Hopkins University, 3400 North Charles Street, Baltimore, MD, 21218, United States of America, yueling.loh@gmail.com, Suchi Saria, Daniel P. Robinson

Common regularizers do not adequately account for the complex cost structures that exist in some modern applications. We present a new structured regularizer that captures these complicated cost structures and present an efficient algorithm for predictive learning that uses these regularizers. We will provide numerical results on a particular application in health care, namely the prediction of sepsis in Intensive Care Unit patients. We incorporate this regularizer into a framework that takes into account the underlying structure of patient profiles while predicting their risk of septic shock, allowing us to identify different groups of patients in order to generate tailored sets of tests and treatments.

2 - A Shifted Interior-Point Algorithm for Nonlinear Optimization

Vyacheslav Kungurtsev, Czech Technical University, Karlovo namesti 9, Prague, Czech Republic, slavakung2@gmail.com, Daniel P. Robinson, Philip E. Gill

Interior methods provide an effective approach for the treatment of inequality constraints in nonlinearly constrained optimization. A new primal-dual interior method is proposed that has favorable global convergence properties, yet, under suitable assumptions, is equivalent to the conventional path-following interior method in the neighborhood of a solution. The method may be combined with a primal-dual shifted penalty function for the treatment of equality constraints to provide a method for general optimization problems with a mixture of equality and inequality constraints.

■ ThF19

19- Ft. Pitt

Game Theoretic Aspects of Social Choice

Cluster: Game Theory

Invited Session

Chair: Lirong Xia, RPI, 110 8th Street, Computer Science Department, Troy, NY, 12180, United States of America, xial@cs.rpi.edu

1 - An Algorithmic Framework for Strategic Fair Division

Ariel Procaccia, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, United States of America, arielpro@cs.cmu.edu, David Kurokawa, Ioannis Caragiannis, Simina Branzei

Classic cake cutting protocols are susceptible to manipulation. Do their strategic outcomes still guarantee fairness? To address this question we adopt a novel algorithmic approach, proposing a concrete computational model and reasoning about the game-theoretic properties of algorithms that operate in this model. Specifically, we show that each protocol in the class of generalized cut and choose (GCC) protocols is guaranteed to have approximate subgame perfect Nash equilibria, or even exact equilibria if the protocol's tie-breaking rule is flexible. We further observe that the (approximate) equilibria of proportional protocols must be (approximately) proportional, thereby answering the above question in the positive.

2 - A Local-Dominance Theory of Voting Equilibria

Reshef Meir, reshef24@gmail.com

We suggest a new model for strategic voting based on local dominance, where voters consider a set of possible outcomes without assigning probabilities to them. We prove that local dominance-based dynamics quickly converge to an equilibrium (and in particular that an equilibrium exists). Using extensive simulations of strategic voting, we show that emerging equilibria replicate known patterns of human voting behavior such as Duverger's law, and usually yield a better winner than truthful Plurality.

3 - Price of Anarchy, Price of Stability, and the Condorcet Jury Theorem

Lirong Xia, RPI, 110 8th Street, Computer Science Department, Troy, NY, 12180, United States of America, xial@cs.rpi.edu

We initiate the study of price of anarchy (PoA) and price of stability (PoS) for social choice mechanisms in Bayesian games motivated by the Condorcet Jury Theorem, where strategic agents receive noisy signals about the ground truth. The social welfare and agents' utility are defined by the probability for the mechanism to reveal the ground truth. We characterize the PoA and PoS of the common interest social choice game for two types of mechanisms: (1) The mode mechanism, which chooses an alternative that receives most votes uniformly at random. (2) All mechanisms that satisfy three axiomatic properties: anonymity, neutrality, and strategy-proofness for all distance-based models.

■ ThF20

20- Smithfield

Coordinate Descent Methods for Sparse Optimization Problems II

Cluster: Nonsmooth Optimization

Invited Session

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

1 - An Alternating Minimization Method for A Class of Rank Constrained Problems

Yuan Shen, Assistant professor, Nanjing University of Finance & Economics, School of Applied Mathematics, No 3, Wenyuan Road, Qixia District, Nanjing, 210023, China, ocsiban@126.com, Yin Zhang, Zaiwen Wen, Xin Liu

In this paper, we focus on solving a class of rank constrained optimizations which arises from many applications in the fields of information theory, statistics, engineering, etc. However, the inherent nonconvexity of this type of optimization makes it difficult to handle. Traditional approach uses a nuclear norm term to replace the rank constraints. The yielded model is convex, and can be solved by a bunch of existing algorithms. However, these algorithms need to compute Singular Value Decomposition which is expensive. We retains the rank constraints in the optimization model, and propose an alternating minimization method. The yielded algorithm shows satisfactory speed performance, and its theoretical property is also analyzed.

2 - On The Global Optimality For Linear Constrained Rank Minimization Problems

Hong Wang, Mr., The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, hong.wang@connect.polyu.hk, Xiaojun Chen, Ya-xiang Yuan, Xin Liu

In this paper, we first focus on exploring the theoretical properties of the factorization model for rank minimization problems with linear constraints. And then based on such properties, we propose an algorithm framework which returns the global solution of the linear constrained rank minimization problem. We also show the relationship between the factorization model and the corresponding rank constrained linear least squares model. Finally, we put forward a conjecture that the reduction between the global minima of problems with consecutive ranks is monotonically decreasing with the increasing of the rank.

3 - A Parallel Line Search Subspace Correction Method for Composite Convex Optimization

Qian Dong, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, No.55, ZhongGuanCun DongLu, P.O.Box 2719, Beijing, 100190, China, dongqian@lsec.cc.ac.cn, Zaiwen Wen, Ya-xiang Yuan, Xin Liu

We investigate a parallel subspace correction framework for composite convex optimization based domain decomposition method. At each iteration, the algorithms solve subproblems on subspaces simultaneously to construct a search direction and take the Armijo line search to find a new point. They are called PSCLN and PSCLO, respectively, depending on whether there are overlapping variables. Their convergence is established under mild assumptions. We compare them with state-of-the-art algorithms for solving LASSO problems, which shows that PSCLN and PSCLO can run fast and return solutions no worse than those from the others. It is also observed that the overlapping scheme is helpful for the structured-data problem.

■ ThF21

21-Birmingham

Software Tools for Optimization

Cluster: Implementations and Software

Invited Session

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

1 - Benchmarks of Distributed Solvers for Mixed-Integer Linear Programs on a High Performance Computer

Thorsten Ederer, TU Darmstadt, Magdalenenstr. 4, Darmstadt, 64289, Germany, ederer@mathematik.tu-darmstadt.de, Thomas Opfer

MILP algorithms usually run on a single compute node and utilize threads in a shared-memory context. Recent versions of leading solvers introduced a feature to distribute the Branch-and-Bound tree over multiple machines. We compare these parallel capabilities using the Lichtenberg High Performance Computer of TU Darmstadt. Promising initial tests with the MIPLIB benchmark test set have been conducted on up to 32 Haswell nodes with up to 24 cores and a FDR-14 Infiniband interconnect.

2 - COIN-OR at 15: Open Source Tools for Operations Research

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

The COIN-OR initiative was inaugurated at ISMP 2000 in Atlanta. We report on the progress and impact of COIN-OR over the past fifteen years, the state of the initiative today, currently available tools, and how new developers and users can get involved.

3 - Revisiting Expression Representations and Automatic Differentiation for Nonlinear AMPL Models

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

Currently the AMPL/Solver interface library uses "executable" expression graphs to represent nonlinear objectives and constraint bodies; each node points to a little function implementing the operation represented by the node. Each node also stores partial derivatives for use in computing derivatives. This makes the graphs nonreentrant. To permit several threads to evaluate the same expression at different points without having separate copies of the expression graphs, such details as variable values and partial derivatives must be stored in thread-specific arrays. We describe and compare some possible alternative representations for use in function and gradient evaluations.

■ ThF22

22- Heinz

Inventory and Supply Chain Applications

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Eneko Malatsetxebarria, Research Engineer, ArcelorMittal, Global R&D Asturias P.O. Box 90, Aviles, 33400, Spain, eneko.malatsetxebarria@arcelormittal.com

1 - Lifecycle Pricing and Inventory Optimization in an Omni-channel Retail Environment

Pavithra Harsha, IBM Research, 1101 Kitchawan Road, Room 34-225, Yorktown Heights, NY, 10598, United States of America, pharsha@us.ibm.com, Markus Ettl, Shiva Subramanian, Joline Uichanco

Lifecycle pricing is traditionally done for a single sales channel where inventory is exogenous. However, this ignores customers channel-switching due to differences in prices in different channels and cross-channel fulfillments such as buy online pickup in store and ship-from-store where inventory is not exclusive to one channel. We develop an optimization model for joint price and inventory management in an omni-channel retail environment that accounts for the current drawbacks and present results on real data.

2 - A Particle Swarm Optimization Approach to the Part-Supplying Problem at Assembly Lines

Dalila Fontes, Professor, Universidade do Porto, Faculdade de Economia and LIAAD - INESC, Universidade do Porto, Porto, 4200 - 464, Portugal, fontes@fep.up.pt, Masood Fathi

The Assembly Line Part-Supplying Problem concerns the delivery of parts to the workstations in a mixed-model assembly line. Here, we consider the problem of delivering the parts from a decentralized logistics area, through round trips. In order to provide the workstations with the needed parts, one has to decide which parts and respective amounts to load on each tour, while minimizing both the number of tours and the part inventories at the workstations. Limits are imposed on tour capacity and on storage capacity at the workstations. We propose a Particle Swarm Optimization algorithm to address this problem with a tour time additional constraint. The results obtained have shown the method to be efficient and effective.

3 - Robust Optimization of a Raw Materials Distribution Problem through Pessimization

Eneko Malatsetxebarria, Research Engineer, ArcelorMittal, Global R&D Asturias P.O. Box 90, Aviles, 33400, Spain, eneko.malatsetxebarria@arcelormittal.com, Diego Diaz, Pablo Valledor, Tatiana Manso

The robust optimization of large-scale logistics problems with uncertainties in transport durations and many integer variables can be difficult to tackle. In order to circumvent this, we show a real case application of a worst-case analysis by using a pessimizing oracle. This is done for an inventory control problem with fixed demand but uncertain bulk arrivals of multiple products with linked consumption, where the pessimizing oracle considers inventory levels and stock rupture events.

■ ThF23

23- Allegheny

Discrete Convex Analysis II

Cluster: Combinatorial Optimization

Invited Session

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

1 - L-natural-convexity And Its Applications In Operations Models

Xin Chen, University of Illinois, UIUC, xinchen@illinois.edu

L-Natural-convexity, an important concept from discrete convex analysis, provides a powerful tool to derive structural results of optimal policies in a variety of operations models. In this talk, I will illustrate how it can be used, by developing new preservation properties, to establish monotone comparative statics in several challenging applications including perishable inventory models, dual sourcing models with uncertain supply capacities, and joint inventory and transshipment control models.

2 - Exact Bounds For Steepest Descent Algorithms of L-convex Function Minimization

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

We analyze minimization algorithms for L-convex functions in discrete convex analysis, and establish exact bounds for the number of iterations required by the steepest descent algorithm and its variants. We also mention the implication of our results to the research areas such as discrete optimization, computer vision, and iterative auction.

3 - Multi-Unit Trading Networks with Discrete Concave Utility Functions

Yosuke Sekiguchi, Keio University, Hiyoshi, Kohoku-ku, Yokohama, 223-8522, Japan, sekiguchi@math.keio.ac.jp, Akihisa Tamura, Yoshiko Ikebe, Akiyoshi Shioura

We propose a model of trading networks in which multiple units of contracts are allowed. We assume that valuation functions of all agents are twisted M#-concave functions, which play a central role in our model. We show that competitive equilibria always exist and the set of competitive equilibrium price vectors forms a lattice in this setting. Furthermore, we consider the connection between competitive equilibria and stable outcomes in the model.

■ ThF24

24- Benedum

Algorithms for Problems with Combinatorial Structure

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

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

1 - A New Exact Solution Approach for the Quadratic Matching Problem

Lena Hupp, FAU Erlangen-Nuernberg, Cauerstrafle 11, Erlangen, Germany, Lena.Hupp@math.uni-erlangen.de, Laura Klein, Frauke Liers

The quadratic matching problem (QMP) generalizes the quadratic assignment problem. The QMP asks for a matching in a graph that optimizes a quadratic objective in the edge variables. In our approach the linearized IP-formulation is strengthened by facets of the corresponding problem where the objective contains only one quadratic term. We present methods to generalize them in order to design cutting planes for QMP. We develop an exact branch-and-cut approach and report computational results.

2 - Lift-and-Convexification Approach for Quadratic Programming with Semi-Continuous Variables

Baiyi Wu, The Chinese University of Hong Kong, Room 609, William M. W. Mong Engineering, Building, CUHK, Hong Kong, Hong Kong, Hong Kong - PRC, baiyiwu@gmail.com, Duan Li, Xiaojin Zheng

We propose a lift-and-convexification approach to derive an equivalent linearly constrained mixed-integer reformulation for quadratic programming problems with semi-continuous variables. It improves the performance of branch-and-bound algorithms by providing the same tightness at the root node as the state-of-the-art perspective reformulation and much faster child-node processing time. Furthermore, quadratic convex reformulation technique can be applied to our new reformulation to obtain an even tighter bound. Promising computational results verify the benefits of our new reformulations.

3 - Polyhedral Study of Linearizations of Polynomial Matroid Optimisation Problems

Anja Fischer, TU Dortmund, Department of Mathematics, Vogelpothsweg 87, Dortmund, Germany, anja.fischer@mathematik.tu-dortmund.de, Frank Fischer, S. Thomas McCormick

We consider polynomial matroid optimization problems with some non-linear monomial in the objective function. The monomials are linearized and we study the corresponding polytopes. Extending results of Edmonds we present complete descriptions for the linearized polytopes given a set of nested monomials and given a set of monomials fulfilling certain up- and downward completeness conditions. Indeed, apart from the standard linearization in these cases one needs appropriately strengthened rank inequalities. The separation problems of these constraints reduce to submodular function minimization problems. In the case of exactly one non-linear monomial we even completely characterize the facetial structure of the associated polytope.

■ ThF25

25- Board Room

Stochastic Aspects of Energy Management I

Cluster: Optimization in Energy Systems

Invited Session

Chair: Wim van Ackooij, EDF R&D, 1 Avenue du Général de Gaulle, Clamart, 92141, France, wim.van.ackooij@gmail.com

1 - Modeling Demand Response Resources in Large-Scale Unit Commitment Models

Elaine Hale, Senior Engineer, National Renewable Energy Laboratory, 15013 Denver West Parkway, MS RSF300, Golden, CO, 80401, United States of America, elaine.hale@nrel.gov

Integrating large proportions of renewable, variable generation into power systems requires increased system flexibility. One possible source of flexibility is demand response, in which a load's power draw is adjusted or on standby to help achieve power system balance and reliability. Mathematically, demand response is not yet integrated into standard grid modeling tools. This talk will describe how such resources can be modeled, both from an optimization problem formulation perspective, and within existing tools. Computational results and performance are presented and discussed.

2 - Robust Control Command Strategies in a Contract-Based Collaboration Framework

Rosa de Figueiredo, LIA, UAPV, Agroparc, Avignon, France, rosamaria.figueiredo@gmail.com, Antoine Jouglet, David Savourey

We consider two entities that are both producer and consumer of a same kind of energy resource and have to collaborate to balance their consumption and production over a given time horizon. We tackle the problem from a real time viewpoint by modeling the decisions that must be taken every delta units of time. Moreover, we assume that the production is uncertain. Our resulting robust optimization model must determine an optimal (according to the cost) contract subscription from the client to the partner in such a way that there exists a robust real time command strategy which satisfies consumer demands of the client subsystems over the time horizon and in such a way that each commitment taken by the client with the partner is honored.

3 - A Dynamic Programming Approach for a Class of Robust Optimization Problems

Michael Poss, LIRMM, 161 rue Ada, Montpellier, 34392, France, michael.poss@lirmm.fr, Marcio Costa Santos, Agostinho Agra, Dritan Nace

Common approaches to solve a robust optimization problem decompose the problem into a master problem (MP) and adversarial separation problems (APs). MP contains the original robust constraints, however written only for finite numbers of scenarios. Additional scenarios are generated on the fly by solving the APs. We consider in this work the budgeted uncertainty polytope and propose new dynamic programming algorithms to solve the APs that are based on the maximum number of deviations allowed and on the size of the deviations. Our algorithms can be applied to robust constraints that occur in various applications such as lot-sizing and TSP with time-windows, among many others. We assess numerically our approach on a lot-sizing problem.

■ ThF26

26- Forbes Room

Stochastic Convex Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Umit Tursun, Postdoctoral Research Associate, University of Illinois at Urbana-Champaign, 117 Transportation Bldg., 104 S. Mathews, Room 214, Urbana, IL, 61801, United States of America, utursu2@illinois.edu

1 - Optimal Dividend Payment under Time of Ruin Constraint: Exponential Case

Camilo Hernandez, Universidad de los Andes, Cra 1 N∫ 18A- 12 Dep. de Matematicas, Bogota, Colombia, mc.hernandez131@uniandes.edu.co, Mauricio Junca

We consider the classical optimal dividend payments problem under the Cram\'er-Lundberg model with exponential claim sizes subject to a constraint on the time of ruin P1. We use the Lagrangian dual function which leads to an auxiliary problem P2. For this problem, given a multiplier Λ, we prove the uniqueness of the optimal barrier strategy and we also obtain its value function. Finally, we prove that the optimal value function of P1 is obtained as the point-wise infimum over Λ of all value functions of problems P2. We also present a series of numerical examples.

2 - Stochastic Online Optimization with Noisy First Order Oracle

Daniil Merkulov, MIPT, Bulvar Svobodi, 3-19, Sergiyev Posad, Russia, bratishka.mipt@gmail.com

We consider the stochastic online optimization problem. We assume that only noisy stochastic gradients can be obtained from the oracle. We use two assumptions about noise, which goes back to the Juditski-Nemirovski'11 and to the Devolder-Gellineur-Nesterov'11. We demonstrate how to generalize this concept in online context. Additionally, we investigate corresponding theorem about mirror descent convergence in stochastic online context with inexact oracle. All estimations are unimprovable up to a logarithmic factor. We also consider applications to the contextual bandits and SLT.

3 - Stochastic Convex Minimization: Random Projection Algorithms in the Presence of Noise

Umit Tursun, Postdoctoral Research Associate, University of Illinois at Urbana-Champaign, 117 Transportation Bldg., 104 S. Mathews, Room 214, Urbana, IL, 61801, United States of America, utursu2@illinois.edu

The focus of this work is stochastic convex minimization problems with uncertain objectives over arbitrary family of convex sets. Constraint sets are not known in advance yet revealed one by one or chosen randomly at each algorithm iteration. We consider a two step random projection algorithm. First step is a stochastic gradient projection. Gradient for this step carries stochastic error with centered and bounded deterministic variance. The feasibility violation of the intermittent point with respect to the revealed/chosen constraint set is mitigated at second step of algorithm The proposed algorithm can handle finitely many number of convex constraint sets as well as infinite number of them by proceeding through a random subset of them.

■ ThF27

27- Duquesne Room

Stable Matching Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Rakesh Vohra, University of Pennsylvania, 3718 Locust Walk, Philadelphia, PA, United States of America, rvohra@seas.upenn.edu

1 - On Weighted Kernels of Two Posets

Tamas Fleiner, Budapest University of Technology and Economics, Dept of Comp Sci and Information Theory, Magyar Tudòsok Köerútja 2., Budapest, H-1117, Hungary, fleiner@cs.elte.hu, Zsuzsanna Jankó

A recent result of Aharoni Berger and Gorelik is a weighted generalization of the well-known theorem of Sands Sauer and Woodrow on monochromatic paths. The authors prove the existence of a so called weighted kernel for any pair of weighted posets on the same ground set. In this work, we point out that this result is closely related to the stable marriage theorem of Gale and Shapley, and we generalize Blair's theorem by showing that weighted kernels form a lattice under a certain natural order. To illustrate the applicability of our approach, we prove further weighted generalizations of the Sands Sauer Woodrow result.

2 - Matching with Externalities

Bumin Yenmez, Carnegie-Mellon University, Tepper School of Business, 5000 Forbes Av., Pittsburgh, PA, 15217, United States of America, byenmez@cmu.edu, Kyle Woodward

We incorporate externalities into the stable matching theory of two-sided markets. To this end, we establish the existence of stable matchings provided that externalities are positive and agents' preferences satisfy substitutability, and we show that the standard insights of matching theory—-e.g. the existence of side optimal stable matchings and the rural hospital theorem—-remain valid despite the presence of externalities. Furthermore, we establish novel comparative statics on externalities.

3 - Near Feasible Stable Matchings with Complementarities

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

The National Resident Matching program strives for a stable matching of medical Students to teaching hospitals. With the presence of couples, stable matchings need not exist. For any Student preferences, we show that each instance of a stable matching problem has a `nearby' instance with a stable matching. The nearby instance is obtained by perturbing the capacities of the hospitals. Our approach is general and applies to other type of complementarities, as well as matchings with side constraints and contracts.

■ ThF28

28- Liberty Room

Complex Networks Analysis and Design under Uncertainty

Cluster: Telecommunications and Networks

Invited Session

Chair: Alexander Veremyev, University of Florida, 303 Weil Hall, Gainesville, FL, United States of America, averemyev@ufl.edu

1 - Finding Groups with the Largest Betweenness Centrality

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, Alexander Veremyev, Eduardo Pasiliao

The betweeness centrality metric captures significance of a given node to the network structure under the assumption that all nodes exchange information along shortest paths. The concept of the betweenness centrality can be naturally generalized to a group of nodes and/or edges. In this talk we consider solution approaches (based on integer programming techniques) for finding a cluster of graph elements (possibly, with some conditions on inter-relationships within the cluster) with the largest betweenness centrality (or, one of its variations). We conduct extensive computational experiments with real-life and randomly generated instances that reveal interesting insights and demonstrate the advantages and limitations of our approaches.

2 - Nonzero-Sum Nonlinear Network Path Interdiction

Noam Goldberg, Bar-Ilan University, Max ve-Anna Webb St., Ramat Gan, 5290002, Israel, noam.goldberg@gmail.com

A novel nonzero-sum game is presented for a variant of a classical network interdiction problem. In this model an interdictor (e.g. an enforcement agent) decides how much of an inspection resource to spend along each arc in the network in order to capture the evader (e.g. a smuggler). The evader selects a probability distribution on paths from source nodes to destinations. The evasion probabilities nonlinearly decrease in the inspection resources spent. We show that under reasonable assumptions, with respect to the evasion probability functions, Nash equilibria of this game can be determined (approximately) in polynomial time. Stronger results are also presented in the special case of exponential functions.

3 - Achieving the Spatial Connectivity of Parcels in the Dynamic Reserve Network Design Problem

Nahid Jafari, University of Georgia, nahid.jafari@uga.edu, Clinton Moore

The conservation (reserve) network design problem is challenging to solve because of the spatial and temporal nature of the problem, uncertainties in the decision process, and possibly alternative conservation actions for any given land parcel. We propose a Mixed Integer Programming model that guarantees the fully connected budget-constrained selection of sites for conservation of species. It maximizes conservation measure at the end of the planning horizon under stochastic costs and uncertain land use change.

■ ThF29

29- Commonwealth 1

Computational Integer Programming

Cluster: Implementations and Software

Invited Session

Chair: Daniel Steffy, steffy@oakland.edu

1 - Facets for the Master Knapsack Polytope

Daniel Steffy, steffy@oakland.edu, Sangho Shim, Sunil Chopra

Through the use of shooting experiments and worst case analysis Shim, Cao and Chopra have demonstrated the strength of 1/k-facets for the master knapsack polytope. The 1/k-facets are facets whose coefficients are multiples of 1/k, and they are particularly strong for smaller values of k. For the general integer knapsack problem, or knapsack sub-problem, with l variables, the number of 1/k-facets is O(l^(k/2)). We describe algorithms for separating 1/k-facets for the general integer knapsack problem for some small values of k. Additionally, we draw new insights from additional shooting experiments, including the observation that facets arising from Gomory's homomorphic lifting are strong.

2 - An Extended Formulation of the Convex Recoloring Problem on a Tree

Sangho Shim, Kellogg School of Management, 2001 Sheridan Road Suite 548, Kellogg School of Management, Evanston, IL, 60208, United States of America, shim@kellogg.northwestern.edu, Minseok Ryu, Kangbok Lee, Sunil Chopra

We introduce a strong extended formulation of the convex recoloring problem on a tree, which has an application in analyzing a phylogenetic tree. The extended formulation has only polynomial number of constraints, but dominates the conventional formulation and the exponentially many previously known valid inequalities. We show that the valid inequalities can be derived from the extended formulation. The extended formulation solves the problems on the phylogenetic trees given by treeBASE.org at the root node of the branch-and-bound tree without branching. The solution time using the extended formulation is much faster than any other known algorithm.

3 - Some More Ways to use Dual Information in MILP

Imre Polik, SAS Institute, 500 SAS Campus Dr, Cary, NC, 27513, United States of America, imre@polik.net, Philipp Christophel, Menal Güzelsoy, Amar Narisetty, Yan Xu

Building on the concept of a dual information cache we talked about earlier, we are presenting some more ways to use this information.

■ ThF30

30- Commonwealth 2

Approximation and Online Algorithms XII

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Kunal Talwar, Google, 1600 Amphitheater Parkway, Mountain View, CA, 94043, United States of America, kunal@kunaltalwar.org

1 - Constant Factor Approximation for Balanced Cut in the PIE Model

Konstantin Makarychev, Researcher, Microsoft Research, One Microsoft Drive, Redmond, WA, 98052, United States of America, kmakaryc@cs.princeton.edu, Yury Makarychev, Aravindan Vijayaraghavan

We propose and study a new semi-random model for Balanced Cut, a planted model with permutation-invariant random edges (PIE). Our model is much more general than planted models considered previously. Consider a set of vertices V partitioned into two clusters L and R of equal size. Let G be an arbitrary graph on V with no edges between L and R. Let E_Random be a set of edges sampled from an arbitrary permutation-invariant distribution (a distribution that is invariant under permutation of vertices in L and in R). We say that G+E_Random is a graph from the PIE model. We present a constant factor approximation algorithm for the Balanced Cut problem in the PIE model for graphs with the size of the cut between L and R at least n poly-log n.

2 - Approximating Hereditary Discrepancy via Small Width Ellipsoids

Kunal Talwar, Google, 1600 Amphitheater Parkway, Mountain View, CA, 94043, United States of America, kunal@kunaltalwar.org, Aleksandar Nikolov

The Discrepancy of a hypergraph is the minimum attainable value, over two-colorings of its vertices, of the maximum absolute imbalance of any hyperedge. The Hereditary Discrepancy (HerDisc) of a hypergraph, defined as the maximum discrepancy of a restriction of the hypergraph to a subset of its vertices, is a measure of its complexity. Lovasz, Spencer and Vesztergombi (1986) related the natural extension of this quantity to matrices, to rounding algorithms for linear programs. In this work, we give a O(log^1.5 n)-approximation algorithm for HerDisc. We show that a factorization norm γ_2 studied in functional analysis, and can be computed as an optimum of a natural convex program gives a good approximation to HerDisc.

3 - An Experimental Analysis of Karp-Karmarkar One-Dimensional Bin Packing Algorithm

Otavio Silva,Centro de Informatica, Av. Jornalista Anibal Fernandes, s/n - C, Recife, Brazil, olas@cin.ufpe.br, David Johnson, Ricardo Silva

In this work, we present an experimental analysis and validation of the theoretical results about the three polynomial-time approximation algorithms for the one-dimensional bin-packing problem, designed by Karp and Karmarkar in the work entitled "An efficient aproximation scheme for the one-dimensional bin-packing problem", published in proceedings of the 23rd Annual Symposium on Foundations of Computer Science sponsored by IEEE Computer Society in 1982, pages 312-320.

Friday, 9:00am - 9:50am

■ FA01

01- Grand 1

Laplacian Matrices of Graphs: Algorithms and Applications

Cluster: Plenary

Invited Session

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

1 - Laplacian Matrices of Graphs: Algorithms and Applications

Daniel Spielman, Yale University, New Haven, CT, United States of America, spielman@cs.yale.edu

The problem of solving systems of linear equations in the Laplacian matrices of graphs arises in many fields including Optimization, Machine Learning, Computer Vision, and of course Computational Science. We will explain what these matrices are and why they arise in so many applications. We then will survey recently developed algorithms that allow us to solve such systems of