Friday, 10:00am - 11:30am

■ FA01

Marriott - Chicago A

Approximation Algorithms III

Cluster: Approximation Algorithms
Invited Session

Chair: Cliff Stein, Columbia University, 326 S W Mudd Building, 500 W. 120th Street, New York, NY, 10027, cliff@ieor.columbia.edu

1 - Differentially Private Approximation Algorithms

Kunal Talwar, Microsoft Research, Silicon Valley Campus, 1065 La Avenida, Mountain View, CA, 94043, United States of America, kunal@microsoft.com, Frank McSherry, Anupam Gupta, Katrina Ligett, Aaron Roth

We initiate a systematic study of algorithms for optimization problems in the framework of differential privacy, which formalizes the idea of protecting the privacy of individual input elements. We study the problems of vertex and set cover, min-cut, k-median, facility location, Steiner tree, and the recently introduced submodular maximization problem, Combinatorial Public Projects. For all these problems we give information theoretic lower bounds, and matching or nearly matching upper bounds.

2 - Unsplittable Flow in Paths and Trees and Column-Restricted Packing Integer Programs

Chandra Chekuri, University of Illinois at Urbana-Champaign, Dept of Computer Science, 201 N Goodwin Ave, Urbana, IL, 61801, United States of America, chekuri@cs.uiuc.edu

We consider the unsplittable flow problem (UFP). Most previous work on UFP has focused on the case where the maximum demand of the requests is no larger than the smallest edge capacity - referred to as the “no-bottleneck” assumption. We give a simple $O(\log^{2n})$ approximation for UFP on trees. Using our insights, we develop an LP relaxation for UFP on paths that has an integrality gap of $O(\log^{2n})$. We also discuss related problems on column-restricted packing integer programs (CPIPs)

3 - Multi-armed Bandits with Side Constraints

Kamesh Mungala, Assistant Professor, Duke University, Box 90129, Durham, NC, 27708, United States of America, kamesh@gmail.com, Sudipto Guha, Peng Shi

The stochastic multi-armed bandit (MAB) problem models the exploration exploitation tradeoff. For this problem, traditional index policies become sub-optimal in the presence of side-constraints, such as costs of switching between arms. In this talk, we will present a novel, simple, and general algorithmic technique for handling side-constraints, which yields policies that are not only constant factor approximations, but are also computationally just as efficient as index policies.

■ FA02

Marriott - Chicago B

Matrix Classes in LCP and Semidefinite LCP

Cluster: Complementarity Problems and Variational Inequalities
Invited Session

Chair: A Chandrashekaran, CSIR-SRF, Indian Institute of Technology Madras, Department of Mathematics, IIT”Madras, Chennai, TN, 600036, India, chandru1782@gmail.com

1 - New Characterizations of Row Sufficient Matrices

Richard Cottle, Professor Emeritus, Stanford University, Department of Mgt. Sci. & Engr., 380 Panama Mall, Stanford, CA, 94305, United States of America, rwc@stanford.edu, Sushil Verma, Ilan Adler

Using structural properties of certain matrix classes, we give new characterizations of RSU, the class of row sufficient matrices. We show that such matrices belong to Eaves’s class L. Asking what must be true of row sufficient L-matrices, we establish three new characterizations of RSU expressed in terms of the matrix classes L, E0, Q0, and the structural properties of sign-change invariance, completeness, and fullness. When coupled with the structural property of reflectiveness, these results give new characterizations of the class of sufficient matrices.

2 - P-matrix Generalized Linear Complementarity Problems with Matrices That Are Not Hidden K-matrices

Walter Morris, George Mason University, 4400 University Drive, Fairfax, VA, 22030, United States of America, wmorris@gmu.edu, Bernd Gaertner, Leo Ruest, Rahul Savani

The complexity analysis of some simple principal pivot algorithms for the (generalized) LCP (G,q) with a (vertical block) P-matrix G depends on the acyclicity of a certain directed graph associated with G and q. This graph is acyclic if the matrix G is a hidden K-matrix. We show that if G has 3 columns, there exists a vector q so that the digraph for LCP (G,q) contains a directed cycle iff G is in the interior of the set of (vertical block) matrices that are not hidden K-matrices.

3 - Some New Results in Semidefinite Linear Complementarity Problems

A Chandrashekaran, CSIR-SRF, Indian Institute of Technology Madras, Department of Mathematics, IIT Madras, Chennai, TN, 600036, India, chandru1782@gmail.com, T Parthasarathy, V Vetrivel

In this article we study the semimonotone type properties in the Semidefinite Linear Complementarity Problems(SDLCP’s) motivated by the semimonotone property in the Linear Complementarity problems(LCP’s). We introduce and prove some results on a semimonotone type property called P’_2 - property for SDLCP’s, similar to the already existing results in the LCP theory. Then we prove the equivalence of the P’_2 and P_2 - property for the Lyapunov and the double sided multiplicative transformations. We also study the implications of P’_2 properties on the P and Q - properties for the Lyapunov, Stein and double sided multiplicative transformations.

■ FA03

Marriott - Chicago C

Electricity Markets II

Cluster: Optimization in Energy Systems
Invited Session

Chair: Andres Ramos, Professor, Universidad Pontificia Comillas, Alberto Aguilera 23, Madrid, 28015, Spain, andres.ramos@upcomillas.es

1 - Formulation of the Economic Dispatch with a Complete and Novel Modeling of Technical Characteristics

Juan Carlos Morales, XM Expertos en Mercados, Calle 12 Sur # 18-168, Medellin, Colombia, jcmorales@XM.com.co, Carlos Mario Correa, Oscar Mauricio Carreão, Pablo Corredor

This article presents in detail a practical, efficient and novel Mixed Integer Linear Programming approach (MILP) to model a complete Unit Commitment (UC) problem with network linear constraints. In this paper the authors show a practical and efficient UC problem integrating into a mathematical model the technical characteristics of the power plants, the frequency reserve and the network constraints, with the primary objective of minimizing the operational costs of the system.

2 - Stochastic Dual Dynamic Programming Applied to Nonlinear Hydrothermal Models

Santiago Cerisola, Researcher, Universidad Pontificia Comillas, Alberto Aguilera 23, Madrid, 28015, Spain, santiago.cerisola@upcomillas.es, Jesus M. Latorre, Andres Ramos

We apply the SDDP decomposition to a nonlinear stochastic hydrothermal model where we model nonlinear water head effects and the nonlinear dependence between the reservoir head and the reservoir volume. We use the McCormick envelopes to approximate the nonlinear constraints that model the efficiency of the plant. We divide these constraints into smaller regions and use the McCormick envelopes for each region. Binary variables are used for this disjunctive programming approach which complicates the application of the decomposition method. We use a variant of the L-shaped method that enables the inclusion of binary variables into the subproblem and perform the stochastic decomposition method. A realistic large-scale case study is presented.

3 - Stochastic Programming Models for Optimal Bid Strategies in the Iberian Electricity Market

F.-Javier Heredia, Professor, Universitat Politècnica de Catalunya, North Campus-C5, Office 206, Jordi Girona, 1-3, Barcelona, 08034, Spain, f.javier.heredia@upc.edu, Cristina Corchero

The day-ahead market is not only the main physical energy market of Portugal and Spain in terms of the amount of traded energy, but also the mechanism through which other energy products, as bilateral (BC) and physical futures (FC) contracts, are integrated into the Iberian Electricity Market (MIBEL) energy production system. We propose stochastic programming models that give both the optimal bidding and BC and FC nomination strategy for a price-taker generation company in the MIBEL. Implementation details and some first computational experiences for small real cases are presented.

FA04

Marriott - Denver

Combinatorial Optimization I

Contributed Session

Chair: Quentin Botton, PhD, Universite Catholique de Louvain - Louvain School of Management, Place des Doyens, 1, Louvain-la-Neuve, 1348, Belgium, quentin.botton@uclouvain.be

1 - Matching Structure of Symmetric Bipartite Graphs and a Generalization of Polya's Problem

Naonori Kakimura, University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo, 1138656, Japan, kakimura@mist.i.u-tokyo.ac.jp

A bipartite graph is called symmetric if it has symmetry of reflecting two vertex sets. This talk discusses matching structure of symmetric bipartite graphs. We first apply the Dulmage-Mendelsohn decomposition to symmetric bipartite graphs. The resulting components, which are matching-covered, turn out to have symmetry. We then decompose a matching-covered symmetric bipartite graph via an ear decomposition. We show an ear decomposition can retain symmetry by adding at most two paths. As an application of these decompositions to combinatorial matrix theory, we introduce a generalization of Polya's problem to rectangular matrices. We show this problem can be solved in polynomial time, and give a characterization in terms of excluded minors.

2 - On a Minimal Linear Description of the Stable Set Polytope of Quasi-line Graphs

Gianpaolo Oriolo, Università degli studi di Roma Tor Vergata, Via del Politecnico 1, Roma, Italy, oriolo@disp.uniroma2.it, Gautier Stauffer

A linear description of the stable set polytope STAB(G) of quasi-line graphs was recently given by Eisenbrand, Oriolo, Stauffer and Ventura. Quasi-line graphs generalize line-graphs and so their stable set polytope is a generalization of the matching polytope. In the talk we address the question of a (minimal) linear description of STAB(G) for quasi-line graphs. Recall that a minimal set of inequalities describing the matching polytope is a celebrated result by Edmonds and Pulleyblank.

3 - Properties of a Layered Extended Graph Formulation for Designing K-Edge(Arc) Disjoint L-paths

Quentin Botton, PhD, Universite Catholique de Louvain - Louvain School of Management, Place des Doyens, 1, Louvain-la-Neuve, 1348, Belgium, quentin.botton@uclouvain.be, Luis Gouveia, Bernard Fortz

In this paper, we propose an extended formulation for the K-Arc(Edge)-Disjoint Hop-Constrained Network Design Problem in the single commodity case. We formulate some interesting properties and we prove that our formulation provides a complete description of the polyhedron when L<=3 and for any value of K for the Arc-Disjoint case. We propose some new valid inequalities for the Edge-Disjoint case and we illustrate the quality of the lower bound when L>3 through some numerical results.

FA06

Marriott - Kansas City

Theory and Applications of Conic Programming Problems

Cluster: Conic Programming

Invited Session

Chair: Hayato Waki, The University of Electro-Communications, Chofu-gaoka 1-5-1 West Building 4, 311, Chofu-shi, Tokyo, Japan, Tokyo, 182-8585, Japan, hayato.waki@jsb.cs.uec.ac.jp

1 - ESDP Relaxation of Sensor Network Localization: Analysis, Extensions and Algorithm

Ting Kei Pong, Graduate Student, University of Washington, Department of Mathematics, Box 354350, Seattle, United States of America, tkpong@math.washington.edu, Paul Tseng

Recently Wang, Zheng, Boyd, and Ye proposed an edge-based SDP (ESDP) as a further relaxation of the SDP relaxation of the sensor network localization problem. We show that zero trace necessarily certifies position accuracy in ESDP interior solutions, provided that measured distances are noiseless. We then propose a robust version of ESDP to handle noise and a fast distributed algorithm for its solution.

2 - Facial Reduction Algorithm and Conic Expansion Algorithm

Masakazu Muramatsu, The University of Electro-Communications, Chofu-gaoka 1-5-1 West Building 4, 311, Chofu-shi, Tokyo, Japan, Tokyo, Japan, muramatu@cs.uec.ac.jp, Hayato Waki

We first propose a facial reduction algorithm (FRA) for general conic linear programming, and prove some useful properties of the algorithm. Then we establish relationships between FRA and conic expansion algorithm (CEA, a.k.a. the dual regularization approach) by Luo, Sturm, and Zhang. In fact, CEA can be regarded as a dual of special case of FRA. We give some examples that FRA can provide finer sequence of regularizations than CEA.

3 - A Facial Reduction Algorithm for Semedefinite Programming Problems in Polynomial Optimization

Hayato Waki, The University of Electro-Communications, Chofu-gaoka 1-5-1 West Building 4, 311, Chofu-shi, Tokyo, Japan, Tokyo, 182-8585, Japan, hayato.waki@jsb.cs.uec.ac.jp, Masakazu Muramatsu

Kojima et al. (2005) proposed a method that eliminates redundant monomials for all SOS representations of a given polynomial. In this talk, we reveal a relationship between the elimination method and Facial Reduction Algorithm (FRA) proposed by Bowrein and Wolkowicz (1980), and show that the elimination method not only reduces the size of the SDP problem of finding an SOS representation of the given polynomial but also improves the numerical stability. We also present some examples that the elimination method performs well.

FA07

Marriott - Chicago D

Integer and Mixed Integer Programming J

Contributed Session

Chair: Illya Hicks, Associate Professor, Rice University, 6100 Main St. - MS 134, Houston, TX, 77005-1892, United States of America, ivhicks@rice.edu

1 - Experiments with Two-row Cuts

Pierre Bonami, CNRS, Aix Marseille Université, 163 Avenue de Luminy, Marseille, France, pierre.bonami@lif.univ-mrs.fr, Gerard Cornuejols, Francois Margot, Amitabh Basu

Most of the cutting plane algorithms implemented in current state of the art solvers rely on cuts that can be derived from a single equation. A natural idea to build more efficient cutting plane algorithms is to use cuts which need more than one equation to be derived. Recently there has been a lot of interest in cutting planes generated from two rows of the optimal simplex tableau. For example, it has been shown that there exist examples of integer programs for which a single cut generated from two rows can dominates the split closure by an arbitrary amount. Motivated by these theoretical results, we study computationaly the effect of adding these cutting planes on a set of problems from the MIPLIB library.

2 - Fast Lower Bounds for the Capacitated Arc Routing Problem

Rafael Martinelli, Pontificia Universidade Catolica do Rio de Janeiro, Rua Marques de Sao Vicente, 225 - RDC, Departamento de Informatica, Gavea, Rio de Janeiro, 22453-900, Brazil, rmartinelli@inf.puc-rio.br, Marcus Poggi

We devise a dual ascent algorithm for the Capacitated Arc Routing Problem (CARP) based on the formulation proposed by Belenguer and Benavent. Although this approach may not yield the best possible bounds, it allows a very fast computation. The main difficulty is to select active primal cuts, associated to dual variables, that allow reaching high quality dual bounds. We discuss how to find these cuts and show that the resulting algorithm consistently finds strong lower bounds.

3 - Integer Programming Techniques for General Branchwidth

Illya Hicks, Associate Professor, Rice University, 6100 Main St. - MS 134, Houston, TX, 77005-1892, United States of America, ivhicks@rice.edu

In this talk, we consider the problem of computing the branchwidth and optimal branch decomposition of a symmetric submodular function, the general branchwidth problem. General branchwidth encompasses graphic, hypergraphic, and matroidal branchwidth, as well as carvingwidth and rankwidth. We present the first integer programming model for this general branchwidth problem and offer preliminary computational results for solving our model.

■ FA08

Marriott - Chicago E

Trends in Mixed Integer Programming X

Cluster: Integer and Mixed Integer Programming
Invited Session

Chair: Robert Weismantel, Professor, Otto-von-Guericke University Magdeburg, Institute for Mathematical Optimization, Universitaetsplatz 2, Magdeburg, 39106, Germany, weismant@mail.math.uni-magdeburg.de

Co-Chair: Andrea Lodi, DEIS, University of Bologna, Viale Risorgimento, 2, Bologna, 40136, Italy, andrea.lodi@unibo.it

1 - Properties of Integer Feasibility on a Simplex

Karen Aardal, Professor, Delft University of Technology, Mekelweg 4, Delft, 2628 CD, Netherlands, Karen.Aardal@cwi.nl, Laurence Wolsey

We give a non-trivial upper bound on the number of nodes needed to solve the integer feasibility problem on a simplex after it has been reformulated using the Aardal-Hurkens-Lenstra lattice reformulation.

2 - Revival of Vertex Enumeration

Leen Stougie, Professor Doctor, Vrije Universiteit & CWI Amsterdam, De Boelelaan 1105, Amsterdam, 1085HV, Netherlands, lstougie@feweb.vu.nl, Vicente Acuna

The complexity of enumerating vertices of bounded polyhedra is a long standing open problem. Khachiyan et al. (2005) give a negative answer for (unbounded) polyhedra. Research in this field is attracting new attention by the study of metabolic networks. Our new results are a) it is NP-hard to decide if a vertex exists with 2 prespecified coordinates in its support, b) enumerating vertices having 1 specific coordinate in their support cannot be done with polynomial delay unless P=NP.

3 - Smallest Compact Formulation for the Permutahedron

Michel Goemans, MIT, Department of Mathematics, Cambridge, MA, 02139, United States of America, goemans@math.mit.edu

We give an extended formulation of the permutahedron (convex hull of all permutations on n elements) with O(n log(n)) variables and O(n log (n)) constraints. We also show that no smaller compact formulation exists (up to constant factors). This answers a question of Alberto Caprara. The results easily generalize to variants of the permutahedron.

■ FA09

Marriott - Chicago F

Branch-and-Price III

Cluster: Integer and Mixed Integer Programming
Invited Session

Chair: Marco Luebbecke, TU Berlin, Institute of mathematics, Strasse des 17. Juni 136, Berlin, 10623, Germany, m.luebbecke@math.tu-berlin.de

1 - The Column Generation Improvement Heuristic (CGI) and its Consequences

Marcus Poggi, Pontificia Universidade Catolica do Rio de Janeiro, Rua Marques de Sao Vicente, 225 - RDC, Departamento de Informatica, Gavea, Rio de Janeiro, 22451-900, Brazil, poggi@inf.puc-rio.br

One may propose column generation formulations for combinatorial problems where the pricing subproblem turns out to be another, although identical sometimes, instance of the original problem. When it is not, we point out that finding a profitable new solution for the subproblem implies an improvement on the current (LP) solution. We discuss this instance repetition behavior over applications of CGI to routing problems (TSP, TDTSP) and nonlinear 0-1 programs (UBQP, MAX-CUT, MAX-CLIQUE). We explore the consequences of this embedded instance transformation in branch-and-price approaches where problem solutions are associated to single columns. Uniting implications on variables coming from different related instances is the current challenge.

2 - An All-integer Column Generation Methodology for Set Partitioning Problems

Elina Ronnberg, Linkoping University, Department of Mathematics, Division of Optimization, Linkoping, SE-58183, Sweden, elron@mai.liu.se, Torbjorn Larsson

The set partitioning polytope has the quasi-integrality property, that enables the use of simplex pivot based methods for moving between integer solutions associated with linear programming bases. In our methodology each intermediate solution to a restricted master problem is feasible, integer, and associated with simplex multipliers. A subproblem is designed to produce columns that maintain integrality when pivoted into the basis. Criteria for verifying optimality are presented.

3 - Cutting in Branch-and-cut-and-price Algorithms

Simon Spoorendonk, DTU Management Engineering, Produktionstorvet, Building 426, Kgs. Lyngby, 2800, Denmark, spoo@man.dtu.dk, Guy Desaulniers, Jacques Desrosiers

Given a Dantzig-Wolfe decomposition of an integer program, this talk presents a general framework for formulating, on the original formulation, valid inequalities derived on an equivalent master problem. It is possible to model these inequalities by adding new variables and constraints to the original formulation. We show how the additional inequalities may give rise to an augmented sub-problem. Examples on how to apply this framework are given for the vehicle routing problem with time windows.

■ FA10

Marriott - Chicago G

Global Optimization of Differential Equations

Cluster: Global Optimization
Invited Session

Chair: Paul Barton, Lammot du Pont Professor, MIT, Room 66-464, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, pib@mit.edu

1 - Global Optimization of Nonlinear Programs with Partial Differential Equations Embedded

Alexander Mitsos, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Department of Mechanical Engineering, Cambridge, MA, 02139, mitsos@mit.edu

A methodology for global optimization with algorithms embedded is summarized [1]. It relies on McCormick relaxations [2] and their subgradient propagation. Algorithms with a fixed number of iterations are considered. Parameter estimation problems with ordinary and partial differential equations are presented. The approach proposed has drastically smaller number of optimization variables in the lower bounding scheme compared to existing global optimization methods. Reference: [1] A. Mitsos, B. Chachuat and P. I. Barton. McCormick-Based Relaxations of Algorithms. SIOPT, in press. [2] G. P. McCormick. Computability of global solutions to factorable nonconvex programs: Part I. Convex underestimating problems. Math. Progr., 10(2):147-175, 1976.

2 - A Discretize-then-relax Approach for Convex/Concave Relaxation of the Solutions of Parametric ODEs

Benoit Chachuat, Assistant Professor, McMaster University, Department of Chemical Engineering, 1280 Main Street West, Hamilton, ON, L8S 4L7, Canada, benoit@mcmaster.ca, Ali M. Sahlodin

The ability to construct tight convex and concave relaxations for the solutions of parametric ODEs is pivotal to deterministic global optimization methods for nonconvex dynamic optimization. The emphasis so far has been on constructing an auxiliary system of ODEs that describes convex/concave bounds of the parametric solutions, pointwise in the independent variable, thereby following a relax-then-discretize approach. This paper presents a novel discretize-then-relax approach to construct tight convex/concave bounds that are guaranteed to enclose the parametric solutions. Our procedure builds upon interval-based techniques implemented in state-of-the-art validated ODE solvers such as VNODE-LP, and applies to a wide class of parametric ODEs.

3 - Bounding Trajectories for Nonlinear ODEs: Application to Global Optimization

Mark Stadtherr, University of Notre Dame, Department of Chem. & Biomolecular Eng., 182 Fitzpatrick Hall, Notre Dame, IN, 46556, markst@nd.edu, Yao Zhao, Youdong Lin

Recent developments in the solution of interval-valued initial value problems for systems of nonlinear ordinary differential equations are reviewed. These techniques provide mathematically and computationally guaranteed bounds on the state trajectories. Applications to global optimization problems involving nonlinear dynamic systems are described.

■ FA11

Marriott - Chicago H

Robust Optimization A

Contributed Session

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

1 - Linear Recovery Robust Programs

Sebastian Stiller, MATHEON, Institut für Mathematik, TU Berlin, Berlin, 10623, Germany, stiller@math.tu-berlin.de

The concept of recoverable robustness has been invented to overcome the conservatism of robust optimization. We treat the case of linear recovery which is similar to a 2-stage stochastic program, where the second stage cost is the maximum over a restricted scenario set. We give efficient algorithms and a tight polyhedral analysis of coincidental covering, i.e., that solutions are recoverable also for scenarios outside the given scenario set. The method is superior to classical approaches in particular for disturbed right-hand side vectors and in case many or all rows are affected by disturbances. In a study on delay resistant train platforming with real-world data this general method has outperformed special purpose methods by 25%.

2 - Robust Estimation: Case of Regression by Minimum Sum of Absolute Errors

John F Wellington, Indiana University Kokomo, 2300 S. Washington Street, P. O. Box 9003, Kokomo, IN, 46904, United States of America, jfwellin@iuk.edu, Stephen A. Lewis

We look upon estimation of the parameters of the single equation multiple linear regression model as an optimization problem and address its solution under the criterion of minimum sum of absolute errors (MSAE). We report a post-optimality analysis that allows evaluation of the sensitivity of the MSAE solution to simultaneous variations in the technical or left-hand side (LHS) coefficients of the linear programming formulation of the MSAE problem.

3 - Robust Optimization with Uncertainty Regions Based on Phi-divergence

Dick den Hertog, Tilburg University, P.O. Box 90153, Tilburg, Netherlands, D.denHertog@uvt.nl, Aharon Ben-Tal, Anja De Waegenaere, Bertrand Melenberg

We focus on robust linear optimization with uncertainty regions defined by phi-divergence distance measures (e.g. chi-squared, Hellinger). Such uncertainty arise in a natural way if the uncertain parameters depend on an unknown probability distribution and goodness-of-fit tests are used. We show that the robust counterpart of a linear optimization problem with "phi-divergence" uncertainty is tractable. We also apply the theory to expected utility functions; in particular to the newsboy problem.

■ FA12

Marriott - Los Angeles

Industrial Applications of PDE-Constrained Optimization

Cluster: PDE-constrained Optimization

Invited Session

Chair: Amr El-Bakry, ExxonMobil Research & Engineering Company, 1545 Route 22 East, Annandale, NJ, 08801, United States of America, amr.s.el-bakry@exxonmobil.com

1 - A Multi-model Approach to Simulation Based Optimization

Natalia Alexandrov, NASA Langley Research Center, Mail Stop 442, Hampton, VA, 22681-2199, United States of America, n.alexandrov@nasa.gov

We examine an approach to the design of complex systems governed by computationally intensive simulations. The problem may be viewed in terms of a multilevel formulation or a multilevel solution algorithm. The term multi-model refers to the use of several layers of models in representing a particular simulation at various stages of design or for the purposes of tractability. We investigate analytical and computational properties of the approach and examine a numerical demonstration.

2 - Adjoint Based Numerical Optimization of a Reservoir Waterflooding Problem

Klaus Wiegand, Senior Engineering Associate, ExxonMobil Upstream Research, Mercer Street, Houston, United States of America, klaus.d.wiegand@exxonmobil.com, Matthias Heinkenschloss, Amr El-Bakry

We present numerical algorithms to find optimal well rates for a reservoir waterflooding problem. First and second order optimality conditions are derived based on the Adjoint method. Results are presented for a shallow oil-water system that is simulated using two popular time discretization schemes.

3 - Dynamic Optimization for Plastic Sheet Production

Antonio Flores-Tlacuahuac, Professor, Universidad Iberoamericana, Prolongacion Paseo de la Reforma 880, Mexico df, 01219, Mexico, antonio.flores@uia.mx

The dynamic optimization of a heating and polymerization reaction process for plastic sheet production in a forced-circulated warm air reactor is addressed. The mathematical model is cast as a time dependent Partial Differential Equation system (PDEs). Our aim is to compute the warming air temperature as time function so to drive the plastic sheet temperature to its desired profile as soon as possible while meeting a set of process constraints.

■ FA14

Marriott - Scottsdale

PDE-constrained Optimization A

Contributed Session

Chair: Christian Brandenburg, TU Darmstadt, Schlossgartenstr. 7, Darmstadt, Germany, brandenburg@mathematik.tu-darmstadt.de

1 - Adaptive Multilevel SQP-Methods for PDE-constrained Optimization with Control Constraints

J. Carsten Ziems, Technische Universitaet Darmstadt, Schlossgartenstr. 7, Darmstadt, 64289, Germany, ziems@mathematik.tu-darmstadt.de, Stefan Ulbrich

We present an adaptive multilevel SQP-method for opt. problems governed by nonlinear PDEs with control constraints. Starting with a coarse discretization of the problem we combine a trust-region SQP-method with an implementable adaptive refinement strategy based on error estimators and a criticality measure. In the presence of parabolic PDE constraints the alg. also supports the use of independent discretizations for state and adjoint PDE. We prove global convergence and show numerical results.

2 - Discrete Adjoint Techniques for Flow Optimization Based on Parallel Large Eddy Simulation

Rolf Roth, Technische Universität Darmstadt, Schlossgartenstr. 7, Darmstadt, 64289, Germany, rroth@mathematik.tu-darmstadt.de, Stefan Ulbrich

We describe a systematic way to generate adjoint code by applying an efficient sparsity exploiting forward mode of AD to the original code. The result is a linear system for the adjoint that can be solved by taking advantage of the original code and the existing structure for multicore and multigrid. We applied this procedure to the parallel, block-structured, multigrid flow solver FASTEST, which uses LES and is written in Fortran. Numerical results of engineering applications will be presented.

3 - Shape Optimization for the Instationary Navier-Stokes Equations with Goal-oriented Adaptivity

Christian Brandenburg, TU Darmstadt, Schlossgartenstr. 7, Darmstadt, Germany, brandenburg@mathematik.tu-darmstadt.de, Florian Lindemann, Michael Ulbrich, Stefan Ulbrich

We present an adjoint approach for shape optimization in function spaces which is conveniently implementable in that it allows for the use of existing state and adjoint solvers on the current computational domain to obtain exact gradients. This approach is applied to the incompressible instationary Navier-Stokes equations in 2 and 3 space dimensions. Multilevel techniques are realized by using goal-oriented adaptivity w.r.t. to the drag objective functional. Numerical results will be given.

■ FA15

Gleacher Center - 100

Applications of Stochastic Complementarity Programs

Cluster: Stochastic Optimization

Invited Session

Chair: Asgeir Tomasgard, NTNU, Alfred Getz vei 3, Trondheim, 7491, Norway, Asgeir.Tomasgard@sintef.no

1 - Resale in Vertically Separated Markets: Profit and Consumer Surplus Implications

Adrian Werner, SINTEF, S.P. Andersens vei 5, Trondheim, 7491, Norway, AdrianTobias.Werner@sintef.no, Qiong Wang

Liberalizing industries with natural monopoly characteristics often leads to vertical separation. With high investment costs the upstream market remains monopolistic. Entrants purchase the upstream component for downstream resale. This potential competition may even help the incumbent's downstream subsidiary to improve profit but may raise end-user costs. We focus on two aspects: market power and demand uncertainty. Utilizing two-stage SMPECs, we discuss a case for natural gas transport.

2 - Capacity Booking in a Transportation Network with Stochastic Demand

Asgeir Tomasgard, NTNU, Alfred Getz vei 3, Trondheim, 7491, Norway, Asgeir.Tomasgard@sintef.no, Mette Bjorndal, Yves Smeers, Kjetil Midthun

We present an equilibrium model for transport booking in a gas transportation network. The booking regime is similar to the regime implemented in the North-Sea. The model looks at the challenges faced by the network operator in regulating such a system. There are some privileged players in the network, with access to a primary market for transportation capacity. The demand for capacity is stochastic when the booking in the primary market is done. There is also an open secondary market for transportation capacity where all players participate including a competitive fringe. This is modelled as a Generalized Nash Equilibrium using a stochastic complementarity problem.

3 - A Benders Decomposition Method for Discretely-Constrained MPEC

Yohan Shim, University of Maryland, College Park, 1173 Martin Hall, College Park, MD, 20742, United States of America, yshim@umd.edu, Marte Fodstad, Asgeir Tomasgard, Steve Gabriel

We present a new variant of Benders method combined with a domain decomposition heuristic to solve discretely-constrained mathematical programs with equilibrium constraints. These bi-level, integer-constrained problems are important for a variety of areas involving infrastructure planning (e.g., energy) although they are computationally challenging. We apply the proposed new method in the natural gas investment decisions under competitive operations and stochastic markets.

■ FA16

Gleacher Center - 200

Stochastic Optimization G

Contributed Session

Chair: Michael Chen, Post Doctoral Fellow, IBM, TJ Watson Research Center, York Town, NY, vancouver.michael@gmail.com

1 - Monte Carlo Methods for Risk Minimization Problems

Dali Zhang, PhD Student, University of Southampton, School of Mathematics, Southampton, SO17 1BJ, United Kingdom, zhangdl@soton.ac.uk, Huifu Xu

In the paper we consider a stochastic optimization model where the objective function is the variance of a random function and the constraint function is the expected value. Instead of using popular scenario tree methods, we apply the sample average approximation method to solve it. Under some mild conditions, we show that the statistical estimator of the optimal solution converges at an exponential rate. We apply the proposed model and the method to a portfolio management problem.

2 - Sparse Grid Scenario Generation and its Rate of Convergence

Michael Chen, Post Doctoral Fellow, IBM, TJ Watson Research Center, York Town, NY, United States of America, vancouver.michael@gmail.com, Sanjay Mehrotra

We adapt the sparse grid integration method for scenario generation in stochastic optimization. For problems with sufficient differntiability numerical results show that this method outperforms Monte-Carlo and QMC methods and it remains competetive for two-stage stochastic program. We present a rate of convergence analysis for this method.

3 - An Inexact Bundle Method for Two-stage Stochastic Linear Programming

Welington Oliveira, Federal University of Rio de Janeiro, P.O. Box 68511, Rio de Janeiro, 21941-972, Brazil, wlo@cos.ufrj.br, Claudia Sagastizabal, Susana Scheimberg

In order to represent accurately uncertainty, many applications of stochastic programming consider large scenario trees. However, a large number of scenarios makes the numerical solution too difficult to deal with. For the particular case of two-stage programs, we consider an inexact bundle method applied in a Benders-like decomposition framework. As shown by encouraging numerical experience, the inexact bundle method allows to skip subproblems solution while keeping controlled the accuracy error.

■ FA17

Gleacher Center - 204

Logistics and Transportation F

Contributed Session

Chair: Olivia Smith, University of Melbourne, Department of Mathematics and Statistics, University of Melbourne, Parkville, vi, 3052, Australia, omadill@ms.unimelb.edu.au

1 - Optimized Order Policies for Multi-echelon Spare-part Distribution Systems

Konrad Schade, Universität Bayreuth, Lehrstuhl Wirtschaftsmathematik, Universität Bayreuth 95440 Bayreuth, Bayreuth, Germany, konrad.schade@uni-bayreuth.de

Order policies are crucial in supply chain management. This talk is about finding cost-minimizing orderpoints within a multi-echelon inventory system that uses the (s,S)-strategy. The Guaranteed-Service-Model (GSM) provides such orderpoints under the assumption of reliable internal lead times and bounded total demand. We extend the GSM to a two-stage stochastic MILP to enable recourse actions. First computational results indicate that the value of the stochastic solution is substantial.

2 - Robust Airline Scheduling: Improving Schedule Robustness with Flight Re-timing and Aircraft Swapping

Sophie Dickson, The University of Melbourne, Dept of Maths & Stats, Parkville, 3010, Australia, sophiedickson@gmail.com, Natashia Boland

All plans go astray on the day; airline schedules are no exception. Flight delays often have knock-on effects that frustrate passengers and cost airlines money. Most schedules have slack time that helps reduce knock-on delays. We present new models that re-time flights and swap flights between aircraft in a schedule, redistributing the slack time to minimise knock-on effects. We discuss the models' properties, how parameters are set from real airline data, and results from numerical experiments.

3 - Weight Constrained Shortest Path Problems with Replenishment Arcs

Olivia Smith, University of Melbourne, Department of Mathematics and Statistics, University of Melbourne, Parkville, vi, 3052, Australia, omadill@ms.unimelb.edu.au, Natashia Boland, Hamish Waterer

In many contexts, such as airline scheduling, there is a need to find paths which satisfy weight constraints with replenishment. An example is airline crew pairing where we seek paths which reflect 2-5 days of flying. In this context, the crew can only work a set number of hours before they must have a long enough break to sleep. These long breaks are replenishment arcs. We consider the problem of finding weight feasible shortest paths in such a network.

■ FA18

Gleacher Center - 206

Dike Height Optimization in the Netherlands

Cluster: Nonlinear Mixed Integer Programming

Invited Session

Chair: Kees Roos, Professor, Delft University of Technology, Mekelweg 4, Delft, 2628 CD, Netherlands, c.roos@tudelft.nl

1 - A Numerical Method for the Control of Dike Levels in Continuous Time

Sander van der Pijl, Centrum Wiskunde & Informatica, Science Park 123, Amsterdam, 1098 XG, Netherlands, Sander.van.der.Pijl@cwi.nl

The optimal control of dike heights is a trade-off between the investment costs of dike increases and the expected costs due to flooding. The optimization problem is formulated in continuous time and leads to a so-called Hamilton-Jacobi-Bellman equation. It is a system of second order partial differential equations that need to be solved backward in time. This is achieved by combining a finite-difference ENO spacial discretization with a high-order TVD Runge-Kutta time integration method. As an example, the method is applied to compute the optimum control law for the dike heights of the island of Texel, that will be demonstrated.

2 - Computing Safe Dike Heights at Minimal Costs

Kees Roos, Professor, Delft University of Technology, Mekelweg 4, Delft, 2628 CD, Netherlands, c.roos@tudelft.nl, Dick den Hertog, Guoyong Gu

Safe dike heights are crucial for protecting life in the Netherlands and many other regions of the world. We discuss issues that arise when modeling the probability of floods, the expected damage and measures to prevent floods. Our aim is to minimize the sum of future investing costs and expected damage over a long period (of about 300 years). We present a mathematical optimization model and a dynamic programming model, as well as some computational results.

3 - A MINLP Approach for the Non-homogeneous Dike Height Optimization Problem

Ruud Brekelmans, Tilburg University, Warandelaan 2, P.O. Box 90153, Tilburg, 5000LE, Netherlands, r.c.m.brekelmans@uvt.nl, Kees Roos, Dick den Hertog

Dikes in the Netherlands protect a large part of the country against the water. After the serious flood in 1953 a cost-benefit model was developed by van Dantzig to determine optimal dike heights. Recently, Eijgenraam improved and extended van Dantzig's model, to update the dike investment plan. We show how Eijgenraam's approach can be extended to non-homogeneous dikes and model it as an MINLP problem. The goal is to minimize the sum of the expected loss of flooding and the costs of heightening the dikes. We also show a robust optimization approach that deals with the parameter uncertainty.

■ FA19

Gleacher Center - 208

Nonlinear Programming A

Contributed Session

Chair: Eiji Mizutani, NTUST, 43 Keelung Road, Section 4, Taipei, Taiwan - ROC, eiji@mail.ntust.edu.tw

1 - A Gauss-Newton Approach for Solving Constrained Optimization via Exact Penalty Functions

Ellen H. Fukuda, IME-USP, Rua Diogo Vaz, 370, apt. 111, Sao Paulo, 01527-020, Brazil, ellen.ime@gmail.com, Paulo J. S. Silva, Roberto Andreani

We propose a Gauss-Newton-type method for solving nonlinear programming problems with general constraints. It uses an extension of a continuous differentiable exact penalty function for variational inequalities, introduced recently by Andre and Silva, and based on the incorporation of a multiplier estimate in the classical augmented Lagrangian. With a less restrictive assumption, we prove exactness and convergence results. Preliminary numerical experiments are also presented.

2 - A Non-monotonic Method for Large-scale Non-negative Least Squares

Dongmin Kim, University of Texas at Austin, 1 University Station, C0500 Taylor Hall 2.124, Austin, TX, 78712, United States of America, dmkim@cs.utexas.edu, Suvrit Sra, Inderjit Dhillon

We present a method for large-scale non-negative least squares (NNLS) problem. In many applications in astronomy, chemometrics, medical sciences, and information retrieval non-negativity arise naturally, whereby the ordinary least-squares must be replaced by NNLS. Our method extends an unconstrained algorithm of Barzilai and Borwein to handle non-negativity constraints. In contrast to other methods based on BB, our algorithm does not curtail the non-monotonicity of the underlying BB method. Without line-search the BB method has been previously shown not to converge. However, by exploiting some properties of the NNLS objective and the simple constraints our algorithm is guaranteed to converge, despite the absence of line-search.

3 - Efficient Hessian Evaluations by Stagewise Backpropagation in Nonlinear Least Squares Problems

Eiji Mizutani, NTUST, 43 Keelung Road, Section 4, Taipei, Taiwan - ROC, eiji@mail.ntust.edu.tw, Stuart Dreyfus

We demonstrate a neural-network (NN) stagewise backpropagation procedure to evaluate the Hessian matrix H (of size n-by-n) "explicitly" in classical nonlinear least squares problems. A conventional wisdom is that the difference between the evaluation cost of H and that of the so-called Gauss-Newton Hessian is O(n-squared). In contrast, our stagewise procedure reduces it down to O(n-linear) when a given nonlinear model can be formatted as an NN-like layered structure.

■ FA20

Gleacher Center - 300

Large-Scale Nonlinear Optimization

Cluster: Nonlinear Programming
Invited Session

Chair: Jorge Nocedal, Professor, Northwestern University, EECS Dept, Evanston, IL, 60201, United States of America, nocedal@eecs.northwestern.edu

1 - On the Use of Piecewise Linear Models in Nonlinear Programming

Yuchen Wu, PhD Student, Northwestern University, 2145 Sheridan Rd., L375, Evanston, IL, 60208, United States of America, yuchen@northwestern.edu

This paper presents an algorithm for large-scale optimization that attempts to combine the best properties of sequential quadratic programming and sequential linear-quadratic programming methods. It consists of two phases. First, the algorithm constructs a piecewise linear approximation of a quadratic model of the Lagrangian and solves a linear programming problem to determine a working set. The second phase of the algorithm solves an equality constrained sub-problem whose goal is to accelerate convergence toward the solution. The paper studies the global and local convergence properties of the new algorithm and presents a set of numerical experiments to illustrate its practical performance.

2 - An Inequality Constrained Nonlinear Kalman-Bucy Smoother

James Burke, Professor, University of Washington, Box 354350, Seattle, WA, 98195, United States of America, burke@math.washington.edu, Gianluigi Pillonetto, Bradley Bell

Kalman-Bucy smoothers are used to estimate the state variables as a function of time in a system with stochastic dynamics and measurement noise. In this algorithm the number of numerical operations grows linearly with the number of time points. If other information is available, for example a bound on one of the state variables, it is often ignored because it does not fit into the standard Kalman-Bucy smoother algorithm. In this talk we show how an interior point approach to state constraints yields and algorithm whose number of operations also grows linearly with the number of time points by preserving the same decomposition obtained for the unconstrained Kalman-Bucy smoother.

3 - Trust Region Newton Krylov Methods for Nonlinear Systems

Richard Byrd, Professor, University of Colorado, Computer Science Dept., Boulder, CO, 80309, United States of America, richard@cs.colorado.edu, Daniel Crumly

It is well known that Newton's method with a line search can fail when applied to nonlinear systems of equations. The standard alternative is to use a trust region implementation, but this is not feasible for very large nonlinear systems, such as those arising in discretization of PDEs. We describe approximate trust region Newton methods for this problem that use Krylov subspace methods analogous to the Steihaug-Toint method that show promising results.

■ FA21

Gleacher Center - 304

Reliable Network Structures

Cluster: Telecommunications and Networks
Invited Session

Chair: Maren Martens, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, martens@zib.de

1 - 2-InterConnected Facility Location

Markus Chimani, TU Dortmund, Otto-Hahn-Str 14, Dortmund, 44227, Germany, markus.chimani@cs.uni-dortmund.de, Maren Martens, Maria Kandyba

Connected facility location problems combine cost-efficient facility placement with the requirement to connect the facilities among each other. In telecommunication applications, these facilities often have to form a reliable core network to which we attach the clients, i.e., there have to be at least two disjoint paths within the core between every pair of facilities. We establish the problem class of 2-interConnected Facility Location and categorize its central variants. On the one hand we show NP-hardness of, e.g., approximations. On the other hand we show constructive characterizations that allow feasibility checking, preprocessing, and heuristics. Finally, we show how to solve these problems to provable optimality in practice.

2 - Developing Ring-based Network Structures Allowing Interring Traffic

Silvia Schwarze, University of Hamburg, Von-Melle-Park 5, Hamburg, 20146, Germany, schwarze@econ.uni-hamburg.de, Marco Caserta, Stefan Voss

One approach to ensure reliability in telecommunication networks is to enforce 1+1 protection. That is, for each origin-destination pair, two node-disjoint paths have to be established, an approach which is naturally ensured by rings. We are focusing on the construction of ring-based networks where interring traffic is possible at transit nodes. Given restrictions on ring size in terms of length and number of nodes, we address the question of finding minimum cost network structures, when costs arise at edges (ring kilometres) and nodes (transit traffic). We present results from a real-world case study.

3 - Survivable Two-layer Network Design

Andreas Bley, TU Berlin / Matheon, Straße des 17. Juni 136, Berlin, D, 10623, Germany, bley@math.tu-berlin.de, Sebastian Orlowski, Christian Raack, Roland Wessaely, Arie M.C.A. Koster

We present an integer programming approach for a survivable two-layer network design problem. This problem arises in the planning of optical communication networks, where traffic demands are routed in a network of logical links, which are paths in an underlying fiber network. We describe our model, reduction techniques and cutting planes, and specially tailored primal heuristics. Finally, we report computational results for realistic instances, which show the effectiveness of our techniques.

■ FA22

Gleacher Center - 306

COIN-OR Open-source Software for Mathematical Programming

Cluster: Implementations, Software
Invited Session

Chair: Robert Fourer, Professor, Northwestern University, Dept. of Industrial Eng & Mgmnt Sciences, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States of America, 4er@iems.northwestern.edu

1 - COIN-OR Triennial Update

Robert Fourer, Professor, Northwestern University, Dept. of Industrial Eng & Mgmnt Sciences, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States of America, 4er@iems.northwestern.edu

The Computational Infrastructure for Operations Research (COIN-OR) initiative was launched 9 years ago at ISMP 2000 to facilitate and encourage development of open software for computational math programming and other OR methods. There has since been considerable growth and development of the initiative, now managed by an independent nonprofit foundation. This update describes opportunities to make use of the initiative,Äôs projects and suggests ways to become part of the COIN-OR community.

2 - Bigger, Better, Faster: Update on World's Fastest Open-source MIP Solver

Laszlo Ladanyi, IBM, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States of America, ladanyi@us.ibm.com, Robin Lougee-Heimer, John Forrest

COIN-OR Branch and Cut (Cbc) is the world's fastest open-source mixed-integer program solver. New heuristics, a 2x increase in preprocessing speed, and improved dynamic use of cutting planes have helped realize a significant speedup from version 2.0 (2007) to 2.3 (2008), reducing the geometric mean of time for solved problems by 55% and the problems unsolved within the time limit by 75% on the Mittelmann benchmarks. We survey the recent enhancements and ongoing efforts at further improvement.

3 - New CoinMP Release 1.5: A Simple Free C-API Windows DLL and Unix Solver Library (LP/MIP) based on COIN

Bjarni Kristjansson, President, Maximal Software, Inc., 2111 Wilson Boulevard, Suite 700, Arlington, VA, 22201, United States of America, bjarni@maximalsoftware.com

The COIN Open Source Initiative has become very popular in the recent years. To make life easier for users that simply want to solve models and not compile C++ applications, we have developed a standard C-API Windows DLL CoinMP.DLL that implements most of the functionality of CLP, CBC, and CGL. A Linux/Unix version using AutoMake is also available. We will also discuss how CoinMP is currently used with MPL, and how it plays a major role in the Free Development and the Free Academic programs for MPL.

■ FA23

Gleacher Center - 308

Sparse Optimization A

Contributed Session

Chair: Noam Goldberg, Rutgers University, 640 Bartholomew Rd, Piscataway, United States of America, ngoldberg@rutcor.rutgers.edu

1 - Dual Averaging Methods for Regularized Stochastic Learning and Online Optimization

Lin Xiao, Researcher, Microsoft Research, 1 Microsoft Way, Redmond, WA, 98052, United States of America, lin.xiao@microsoft.com

We consider regularized stochastic learning and online optimization problems, where the objective function is the sum of two convex terms: one is the loss function of the learning task, and the other is a simple regularization term such as 1-norm for sparsity. We develop extensions of Nesterov's dual averaging method that can explicitly exploit the regularization structure in an online setting. The method achieves the optimal convergence rate O(1/sqrt(t)) for general convex regularization, and a faster rate O(log(t)/t) for strongly convex regularization. Computational experiments confirms the effectiveness of the method for l1-regularized online learning.

2 - Rank-Sparsity Incoherence for Matrix Decomposition

Venkat Chandrasekaran, Massachusetts Institute of Technology, 77 Massachusetts Avenue, 32-D570, Cambridge, MA, 02139, United States of America, venkatc@mit.edu, Sujay Sanghavi, Pablo A. Parrilo, Alan S. Willsky

Suppose we are given a matrix that is formed by adding an unknown sparse matrix to an unknown low-rank matrix. Our goal is to decompose the given matrix into its sparse and low-rank components. Such a problem arises in a number of applications in model and system identification, but obtaining an exact solution is NP-hard in general. We consider a convex optimization formulation for the decomposition problem. We develop a notion of rank-sparsity incoherence - a condition under which matrices cannot be both sparse and low-rank - to characterize both fundamental identifiability as well as sufficient conditions for exact recovery using our method.

3 - Sparse Linear Combination of Data Classifiers Through Relaxed L0 Regularization

Noam Goldberg, Rutgers University, 640 Bartholomew Rd, Piscataway, United States of America, ngoldberg@rutcor.rutgers.edu, Jonathan Eckstein

We propose a discrete optimization approach to constructing binary classifiers using sparse linear combination of base classifiers. Instead of minimizing the sum of deviations from the margin with respect to a subset of the input data and an L1 penalty, we minimize the number of misclassified points subject to a generalized L0 penalty. We tighten the LP relaxation of the resulting MIP model with novel cutting planes, and approximately solve the model using a column and cut generation algorithm.

■ FA25

Gleacher Center - 404

Nonsmooth Dynamic Systems and Semi-algebraic Set-valued Maps

Cluster: Variational Analysis
Invited Session

Chair: Jim Zhu, Western Michigan University, 1903 W Michigan Avenue, Kalamazoo, MI, 49008, qiji.zhu@wmich.edu

1 - Generic Continuity of Semi-algebraic Set-valued Maps

C. H. Jeffrey Pang, Dr., Fields Institute, 222 College Street, Toronto, ON, M5T 3J1, Canada, cp229@cornell.edu, Aris Daniilidis

Functions appearing in practice, whether single-valued or set-valued, are often semi-algebraic. Using recent results in tame metric regularity due to Ioffe, we show that a semi-algebraic closed-valued set-valued map is strictly continuous outside a set of strictly smaller dimension than its domain, extending the stratification property of single-valued tame maps. We illustrate some applications of our result, and show a Sard type theorem for minimums for general functions.

2 - Equilibrium Problems on Hadamard Manifolds

Victoria Martìn-Márquez, PhD Student, Universidad de Sevilla, Sevilla, Spain, victoriam@us.es, Genaro López, Vittorio Colao

Several problems in optimization and variational analysis can be formulated as an equilibrium problem in the setting of linear spaces. Our aim is to develop an equilibrium theory in Hadamard manifolds, i. e. complete Riemannian manifolds of nonpositive curvature. In particular, firmly nonexpansive mappings, resolvents and Yosida approximations will be studied in order to approximate either singularities of monotone vector fields or equilibrium points in this setting.

3 - How Many Tricks Does a Variational Analysts Have?

Jim Zhu, Western Michigan University, 1903 W Michigan Avenue, Kalamazoo, MI, 49008, qiji.zhu@wmich.edu

It is said that even a great mathematician has only a few tricks. We will explain that many important tools in convex and nonsmooth analysis are different facets of two basic tricks of variational methods: a variational principle and a decoupling method. We will also discuss interesting directions in which one may need more.

Friday, 2:00pm - 3:30pm

■ FB01

Marriott - Chicago A

Linear Programming

Contributed Session

Chair: Fabio Tardella, Professor, University of Rome La Sapienza Via del C. Laurenziano, 9, Roma, 00161, Italy, fabio.tardella@uniroma1.it

1 - D-Wolfe Decompositions Putting in the Subproblem the Degenerated Constraints of a Linear Problem

Francois Soumis, Professor, Polytechnique, 2900 Chemin de la Tour, Montreal, H3C 3A7, Canada, francois.soumis@gerad.ca

We propose a new Dantzig-Wolfe decomposition based on the improved primal simplex algorithm (IPS). The original problem is partitioned automatically according to its deep algebraic structure rather than by the modeler. Experimental results on some degenerate instances (between 44 and 71%) show that the proposed algorithms yields computational times that are reduced by an average factor ranging between 3.32 and 13.16 compared to the primal simplex of CPLEX.

2 - Dual Face Algorithm for Linear Programming

Ping-Qi Pan, Professor, Southeast University, Dept. of Math., Southeast University, Nanjing, 210096, China, panpq@seu.edu.cn

The proposed algorithm proceeds from dual face to dual face, until reaching a dual optimal face along with a pair of dual and primal optimal solutions, compared with the simplex algorithm, which moves from vertex to vertex. In each iteration, it solves a single small triangular system, compared with four triangular systems handled by the simplex algorithm. We report preliminary but favorable computational results with a set of standard Netlib test problems.

3 - The Fundamental Theorem of Linear Programming: Extensions and Applications.

Fabio Tardella, Professor, University of Rome La Sapienza Via del C. Laurenziano, 9, Roma, 00161, Italy, fabio.tardella@uniroma1.it

We describe a common extension of the fundamental theorem of LP and of the Frank-Wolfe theorem for QP problems. We then show that several known and new results providing continuous formulations for discrete optimization problems can be easily derived and generalized with our result. Furthermore, we use our extension to obtain efficient algorithms and polynomiality results for some nonlinear problems with simple polyhedral constraints, like nonconvex (standard) QP.

■ FB02

Marriott - Chicago B

Applications of Discrete Optimization

Cluster: Discrete Optimization

Chair: Nikolas Tautenhahn, Universitaet Bayreuth, Lehrstuhl fuer Wirtschaftsmathematik, Bayreuth 95440, Germany, nikolas.tautenhahn@uni-bayreuth.de

1 - Conflict-free Univeristy Course Time and Room Scheduling

Tobias Kreisel, Universität Bayreuth, Lehrstuhl Wirtschaftsmathematik, Universitätsstraße 30, 95440 Bayreuth, Bayreuth, Germany, tobias.kreisel@uni-bayreuth.de

Our goal is a conflict-free schedule with respect to courses of study, i.e. two courses of any course of study must not clash. We approach the problem by means of linear integer programming techniques. To handle the inherently large scale decomposition methods are considered. Acceptance issues are addressed by having persons responsible review automatically generated schedules; based on their remarks new schedules are iteratively generated.

2 - Optimal Control of Opinion-forming Dynamics

Sascha Kurz, Research Assistant / PD Doctor, Universität Bayreuth, Universitätsstraße 30, Lehrstuhl für Wirtschaftsmathematik, Bayreuth 95440, Germany, sascha.kurz@uni-bayreuth.de

Affecting the opinion of a group of individuals is the key target of marketing or an election campaign. We assume that the opinions (modeled as real numbers) of the individuals evolve according to the discrete turn-based bounded-confidence model and consider the problem of placing opinions such that after r turns the number of individuals whose opinion is within a given range is maximized. For this problem both exact and heuristic algorithms will be presented.

3 - Fair Assignment of Voting Weights

Nikolas Tautenhahn,Universitaet Bayreuth, Lehrstuhl fuer Wirtschaftsmathematik, Bayreuth 95440, Germany, nikolas.tautenhahn@uni-bayreuth.de

Assume we have a board of n members who have integral voting weights and a quota q so that a proposal is accepted if the number of votes in favor of the proposal meets or exceeds q. Finding voting weights which resemble a fair power distribution (e.~g. Penrose's square-root law) according to some power index (e.~g. the Shapley-Shubik index) is accomplished by complete enumeration of a superclass of voting games. We characterize these discrete structures and enumerate them.

■ FB03

Marriott - Chicago C

Models for Electricity Optimization Under Uncertainty

Cluster: Optimization in Energy Systems
Invited Session

Chair: Paul Johnson, Research Associate, University of Manchester, Alan Turing Building, Oxford Road, Manchester, M13 9PL, United Kingdom, paul.johnson-2@manchester.ac.uk

1 - Numerical Ideas for Two-stage Stochastic Programs with Chance Constraints

Paul Bosch, Universidad Diego Portales, Facultad de Ingenierìa, Ave. Ejército 441, Santiago, Santiago, Chile, paul.bosch@udp.cl

Motivated by problems coming from planning and operational management in power generation companies, this work extents the traditional two-stage linear stochastic program by adding probabilistic constraints in the second stage where we consider that the level of production of energy is limited by the random level of permitted emission. We describe, under special assumptions, how this problem can be treated computationally. As the first idea, we will study the different convex conservative approximations of the chance constraints defined in second stage of our model, and using Monte Carlo simulation techniques for approximate the expectation function in the first stage by the average.

2 - Making Wind Power Tradable by Electricity Storage

Paul Johnson, Research Associate, University of Manchester, Alan Turing Building, Oxford Road, Manchester, M13 9PL, United Kingdom, paul.johnson-2@manchester.ac.uk

PDEs can model the continuous time dynamics of electricity price, a wind generator's output and a jointly operated energy store. We derive an optimal rule for the output rate to commit during the next hour, so as to maximize the expected joint NPV of wind power and storage over many operating days. Results can test the viability of storage, and optimise the joint design of the store, the wind generator(s) and their connection to the distribution system.

■ FB03

Marriott - Chicago C

Models for Electricity Optimization Under Uncertainty

Cluster: Optimization in Energy Systems
Invited Session

Chair: Paul Johnson, Research Associate, University of Manchester, Alan Turing Building, Oxford Road, Manchester, M13 9PL, United Kingdom, paul.johnson-2@manchester.ac.uk

1 - Numerical Ideas for Two-stage Stochastic Programs with Chance Constraints

Paul Bosch, Universidad Diego Portales, Facultad de Ingenierìa, Ave. Ejército 441, Santiago, Santiago, Chile, paul.bosch@udp.cl

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■ FB04

Marriott - Denver

Combinatorial Optimization K

Contributed Session

Chair: Pavlos Eirinakis, PhD Student, Athens University of Economics and Business, Department of Management Science and Technology, 76 Patission Str., Athens, 10434, Greece, peir@aueb.gr

1 - Sequencing and Scheduling in Coil Coating with Shuttles

Felix Koenig, TU Berlin, Strasse des 17. Juni 136, Berlin, Germany, fkoenig@math.TU-Berlin.DE, Wiebke Hohn, Marco Luebbecke, Rolf Moehring

Applying combinatorial optimization in real life yields cost savings delighting the industry. Beyond that, at the core of some applications also lies a pretty (sub)problem rejoicing the mathematician. In our application coils of sheet metal are coated with k layers out of hundreds of colors. Coils are stapled together to run through k coaters, and non-productive time occurs e.g. when the color in a coater needs to be changed. Some coaters have two parallel tanks, enabling either parallel colors or cleaning of one tank during production. We present our sequencing and scheduling scheme in use at the plant today, lower bounds proving solution quality, and problems in the edge-wise union of interval graphs as a pretty mathematical subproblem.

2 - On Eulerian Extension Problems and Their Application to Sequencing Problems

Wiebke Hohn, TU Berlin, Strasse des 17. Juni 136, Berlin, 10623, Germany, hoehn@math.TU-Berlin.DE, Tobias Jacobs, Nicole Megow

We introduce a new technique for solving several sequencing problems. We consider the Gilmore-Gomory type Traveling Salesman Problem and two variants of no-wait two-stage flowshop scheduling, the classical makespan minimization problem and a new problem arising in the multistage production process in steel manufacturing. Our technique is based on an intuitive interpretation of sequencing problems as Eulerian Extension Problems. This view reveals new structural insights and leads to elegant and simple algorithms and proofs for this ancient type of problems. As a major effect, we compute not only a single solution; instead, we represent the entire space of optimal solutions.

3 - Weighted Stable B-matchings and Their Implications to Supply Chain Networks

Pavlos Eirinakis, PhD Student, Athens University of Economics and Business, Department of Management Science and Technology, 76 Patission Str., Athens, 10434, Greece, peir@aueb.gr, Dimitris Magos, Ioannis Mourtos, Panagiotis Miliotis

The stable b-matching problem is usually defined in the context of a job market and asks for an assignment of workers to firms satisfying the quota of each agent and being stable with respect to given preference lists. In our current work, we present an $O(n^3(\log n)^2)$ algorithm for solving the minimum weight problem, which also applies to special optimality cases. Further, we explore the possibility of applying our work on a multi-sided Supply Chain Network configuration.

■ FB05

Marriott - Houston

Combinatorial Optimization R

Contributed Session

Chair: Luidi Simonetti, Institute of Computing (IC) - University of Campinas (UNICAMP), Caixa Postal 6176, Campinas, SP, 13083-970, Brazil, luidi@ic.unicamp.br

1 - An Exact Method for the Minimum Caterpillar Spanning Problem

Luidi Simonetti, Institute of Computing (IC) - University of Campinas (UNICAMP), Caixa Postal 6176, Campinas, SP, 13083-970, Brazil, luidi@ic.unicamp.br, Cid de Souza, Yuri Frota

A spanning caterpillar in a graph is a tree which has a path such that all vertices not in the path are leaves. In the Minimum Spanning Caterpillar Problem (MSCP) each edge has two costs: a path cost when it belongs to the path and a connection cost when it is incident to a leaf. The goal is to find a spanning caterpillar minimizing the sum of all path and connection costs. Here we formulate the MSCP as a minimum Steiner arborescence problem. This reduction is the basis for the development of an efficient branch-and-cut algorithm for the MSCP. Computational experiments carried out on modified instances from TSPLib 2.1 revealed that the new method is capable to solve to optimality MSCP instances with up to 300 nodes in reasonable time.

■ FB06

Marriott - Kansas City

Conic Programming Approaches to Combinatorial Problems

Cluster: Conic Programming

Invited Session

Chair: Etienne de Klerk, Tilburg University, P.O. Box 90153, Tilburg, 5000 LE, Netherlands, e.deklerk@uvt.nl

1 - Optimizing a Polyhedral-semidefinite Relaxation of Completely Positive Programs

Samuel Burer, University of Iowa, S346 Pappajohn Business Building, Iowa City, IA, 52242-1994, United States of America, samuel-burer@uiowa.edu

It has recently been shown that a large class of NP-hard quadratic minimization problems can be modeled as so-called "completely positive programs." A straightforward convex relaxation of this type of program, while theoretically tractable, is still expensive for interior-point methods. In this talk, we propose a decomposition technique to solve the relaxation, which also readily produces lower bounds on the NP-hard objective value. We illustrate effectiveness of the approach for quadratic box-constrained, quadratic assignment, and quadratic multiple knapsack problems. Further, for the box and knapsack cases, we incorporate the lower bounds within an efficient branch-and-bound implementation.

2 - The Difference Between 5 x 5 Doubly Nonnegative and Completely Positive Matrices

Mirjam Dur, University of Groningen, P.O. Box 407, Groningen, 9700 AK, Netherlands, M.E.Dur@rug.nl, Samuel Burer, Kurt Anstreicher

The convex cone of completely positive (CPP) matrices and its dual cone of copositive matrices arise in several areas of applied mathematics, including optimization. Every CPP matrix is doubly nonnegative (DNN), i.e., positive semidefinite and component-wise nonnegative. Moreover, for n smaller than 5, every DNN matrix is CPP. We investigate the difference between 5 x 5 DNN and CPP matrices. We give a precise charaterization of how a 5 √ó 5 DNN matrix that is not CPP differs from a DNN matrix, and use this charaterization to show how to separate an extreme DNN matrix that is not CPP from the cone of CPP matrices.

3 - Conic Programming Formulations of the Traveling Salesman Problem

Etienne de Klerk, Tilburg University, P.O. Box 90153, Tilburg, 5000 LE, Netherlands, e.deklerk@uvt.nl, Dmitrii Pasechnik

The traveling salesman problem (TSP) is to find a Hamiltonian cycle of minimum weight in a weighted graph, and is arguably the most famous NP-hard problem in combinatorial optimization. We present a conic programming reformulation of TSP, by describing the convex hulls of association schemes, and applying the result to the association scheme of a Hamiltonian cycle (the so-called Lee scheme). The conic programming reformulation of TSP is related to the copositive programming reformulation of the more general quadratic assignment problem from: [Janez Povh, Franz Rendl: Copositive and Semidefinite Relaxations of the Quadratic Assignment Problem, to appear in Discrete Optimization, 2009].

■ FB07

Marriott - Chicago D

Integer and Mixed Integer Programming K

Contributed Session

Chair: Elvin Coban, Carnegie Mellon University, 5000 Forbes Avenue, Tepper School of Business, Pittsburgh, PA, 15213, United States of America, ecoban@andrew.cmu.edu

1 - New World of Discrimination – Do I Discover the New World as Same as Christopher Columbus

Shuichi Shinmura, Professor, Seikei Universtiy, 3-3-1 Kichijoji Kitamachi,Musashino-shi, Tokyo, Japan, shinmura@econ.seikei.ac.jp

Discrimination is very important in the science. It is approached from the statistics and mathematical programming such as SVM. Several discriminant models are developed by IP and LP. Especially, IP-OLDF based on minimum misclassification number criterion reveals new surprised facts about discrimination. It is evaluated by training data (four kinds of data sets) and evaluation data (100 sets of re-sampling data). LINGO models prove its robustness (generalization ability).

2 - On the Polyhedral Properties of a Discrete-time MIP Formulation for Production Planning

Konstantinos Papalamprou, PhD Student, London School of Economics and Political Science, Operational Research Group, London School of Economics,Houghton Str., London, WC2A 2AE, United Kingdom, k.papalamprou@lse.ac.uk, Christos Maravelias

We study the properties of the polyhedron defined by the constraints of a discrete-time mixed integer programming formulation for the production planning of chemical processes. This formulation is decomposed into two subproblems and polyhedral results regarding their linear programming relaxations are provided. Furthermore, we show how extensions of total unimodularity can be used. We are mainly concerned with k-regularity and we show how this property can be used in order to address large scale production planning problems. We are also focused on presenting special cases of this problem for which combinatorial algorithms can be applied.

3 - Single-machine Scheduling over Long Time Horizons by Logic-based Benders Decomposition

Elvin Coban, Carnegie Mellon University, 5000 Forbes Avenue, Tepper School of Business, Pittsburgh, PA, 15213, United States of America, ecoban@andrew.cmu.edu, John Hooker

We use logic-based Benders decomposition to minimize tardiness in single-facility scheduling problems with many jobs and long time horizons. Release dates and due dates are given. An MILP-based master problem allocates jobs to segments of the time horizon, and a constraint programming-based subproblem schedules the jobs in each segment. Computational results are reported on the success of decomposition for scaling up exact solution methods for problems of this kind.

■ FB08

Marriott - Chicago E

Trends in Mixed Integer Programming IX

Cluster: Integer and Mixed Integer Programming
Invited Session

Chair: Andrea Lodi, DEIS, University of Bologna, Viale Risorgimento, 2, Bologna, 40136, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Professor, Otto-von-Guericke University Magdeburg, Institute for Mathematical Optimization, Universitaetsplatz 2, Magdeburg, 39106, Germany, weismant@mail.math.uni-magdeburg.de

1 - A Study of MIP Branching Direction Heuristics

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

The branching direction heuristic used in a MIP solver has a significant impact on the solution speed. We report on an extensive empirical study of branching direction selection heuristics used in reaching the first integer-feasible solution. The conventional wisdom about branching up is examined, and a new method that performs well is introduced.

2 - An Extended Formulation for the Traveling Salesman Problem with Time Windows

Andrea Tramontani, DEIS, University of Bologna, Viale Risorgimento, 2, Bologna, 40136, Italy, andrea.tramontani@unibo.it, Sanjeeb Dash, Oktay Gunluk, Andrea Lodi

The Traveling Salesman Problem with Time Windows (TSPTW) is a well known generalization of the classical TSP where each node must be visited within a given time window. We present an extended integer linear programming formulation for TSPTW, based on a relaxed discretization of time windows. The proposed formulation yields strong lower bounds and leads to strong valid inequalities which can be efficiently separated within a classical branch-and-cut framework. The resulting branch-and-cut algorithm is tested on hard benchmark instances from the literature. The results show that the proposed formulation is effective in practice for tackling TSPTW. Interestingly, several unsolved benchmark instances are here solved for the first time.

3 - Computational Results on the Cunningham-Geelen Algorithm for Solving Integer Programs

Susan Margulies, Pfeiffer-VIGRE Post-doctoral Instructor, Rice University, Dept. of Computational and Applied Math, 6100 Main P.O. Box 1892, Houston, TX, 77251, United States of America, susan.margulies@rice.edu, Illya Hicks, Jing Ma

Consider the integer program max(c^Tx : Ax = b, x >= 0,) where A is non-negative and the column-matroid of A (denoted by M(A)) has constant branch width. Cunningham and Geelen introduce a pseudo-polynomial time algorithm for solving this integer program that takes a branch decomposition T of M(A) as input. We describe a heuristic for finding T and report on computation results of a C++ implementation of this algorithm, where the input branch decomposition T is produced by this heuristic.

■ FB09

Marriott - Chicago F

Branch-and-Price IV

Cluster: Integer and Mixed Integer Programming
Invited Session

Chair: Marco Luebbecke, TU Berlin, Institute of mathematics, Strasse des 17. Juni 136, Berlin, 10623, Germany, m.luebbecke@math.tu-berlin.de

1 - DECOMP: A Framework for Decomposition in Integer Programming

Matthew Galati, Optimization Interface Lead, SAS Institute, Philadelphia Regional Office, Suite 201, 1400 Morris Drive, Chesterbrook, PA, 19087, United States of America, Matthew.Galati@sas.com, Ted Ralphs

Decomposition techniques such as Lagrangian Relaxation and Dantzig-Wolfe decomposition are well-known methods of developing bounds for discrete optimization problems. We draw connections between these classical approaches and techniques based on dynamic cut generation. We discuss methods for integrating cut generation and decomposition in a number of different contexts and present DECOMP, an open-source framework that provides a uniform interface for implementation of these various techniques.

2 - Solving Steel Mill Slab Problems with Branch-and-Price

Stefan Heinz, Zuse Institute Berlin, Takustr, Berlin, Germany, heinz@zib.de, Thomas Schlechte, Ruediger Stephan

In this talk we introduce a branch-and-price approach for the steel mill slab problem which is problem 38 of the CSPLib. We show how this approach can be easily realized in the branch-and-price framework SCIP. Finally, we present computational results which prove that this method is superior to the previous approaches.

3 - Partial Path Column Generation for the ESPPRC

Mads Kehlet Jepsen, PhD Student, Technical University of Denmark, Produktionstorvet bygn. 424, Kgs. Lyngby, 2800, Denmark, mitzi@diku.dk, Bjorn Petersen

This talk introduces a decomposition of the Elementary Shortest Path Problem with Resource Constraints(ESPPRC), where the path is combined by smaller sub paths. We show computational result by comparing different approaches for the decomposition and compare the best of these with existing algorithms. We show that the algorithm for many instances outperforms a bidirectional labeling algorithm.

■ FB10

Marriott - Chicago G

Black-box Optimization of Expensive Functions with Many Variables and Many Nonlinear Constraints

Cluster: Global Optimization
Invited Session

Chair: Don Jones, General Motors, 3023 Sylvan Drive, Royal Oak, MI, 48073, don.jones@gm.com

1 - Radial Basis Function Algorithms for Large-scale Nonlinearly Constrained Black-box Optimization

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

We develop derivative-free optimization algorithms that are suited for expensive black-box objective functions with many variables and many nonlinear black-box constraints. Our algorithms utilize radial basis function models to approximate the objective function and the black-box constraints and to identify promising function evaluation points for subsequent iterations. We present some numerical results on a black-box optimization problem in the automotive industry.

2 - Implementation of a One-stage EGO Algorithm

Nils-Hassan Quttineh, PhD Student, Mälardalen University, U3-269, Högskoleplan 1, Rosenhill, Västerås, 721 23, Sweden, nisse.quttineh@mdh.se, Kenneth Holmström

The original EGO algorithm finds a new point to sample in a two-stage process. First, the interpolation parameters are optimized with respect to already sampled points, then in a second step these estimated values are considered true in order to optimize the location of the new point. The use of estimated values introduces a source of error. Instead, in the One-Stage EGO algorithm, both parameter values and the location of a new point are optimized at once, removing the source of error. The new subproblem becomes more difficult, but eliminates the need of solving two subproblems. Difficulties in implementing a fast and robust One-Stage EGO algorithm in TOMLAB are discussed, especially the solution of the new subproblem.

3 - Enhancements to the Expected Improvement Criterion

Alexander Forrester, Lecturer, University of Southampton, School of Engineering Sciences, University Road, Southampton, SO17 1BJ, United Kingdom, Alexander.Forrester@soton.ac.uk, Don Jones

Optimization methods relying on kriging surrogate models often use the "expected improvement" criterion. Unfortunately, with sparse sampling (few points in many dimensions), the prediction error in the kriging models may be severely underestimated, resulting in an excessively local search. A modification of the standard method is presented which avoids the underestimation of error and thereby ensures bias towards global search.

■ FB11

Marriott - Chicago H

Robust Optimization B

Contributed Session

Chair: Jeff Linderoth, Associate Professor, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States of America, linderot@cae.wisc.edu

1 - Design Optimization Under Uncertainty Using Clouds

Martin Fuchs, CERFACS, 42 avenue Gaspard Coriolis, Toulouse, F-31057, France, martin.fuchs81@gmail.com

Bilevel design optimization problems with nonlinear black box objective functions constrained by mixed integer design choices arise naturally in uncertain real-world models. We represent uncertainties by a polyhedral cloud in the inner level which allows us to model incomplete information even in case of a large number of uncertain parameters. We propose a solution approach, highlight the difficulties and discuss how to overcome them.

2 - Robustness in Multi-objective Optimization Based on a User Perspective

Peter Lindroth, Chalmers University of Technology / Volvo 3P, Chalmers Tvargata 3, Gothenburg, SE-41296, Sweden, peter.lindroth@chalmers.se, Christoffer Cromvik

The question of robustness is essential for practical problems that are sensitive to small perturbations in the variables or the model parameters. We present a new definition of robustness of solutions to multi-objective optimization problems. The definition is based on an approximation of the underlying utility function for each decision maker. We show an efficient computational procedure to evaluate robustness, and we present numerical results for real-world problems.

■ FB12

Marriott - Los Angeles

Inverse Problems and Mathematical Imaging

Cluster: PDE-constrained Optimization
Invited Session

Chair: Eldad Haber, Emory University, 400 Dowman Drive, E414, 30322, United States of America, haber@mathcs.emory.edu

1 - Polynomial Time Algorithms for Clustering and Image Segmentation Problems

Dorit Hochbaum, Professor, UC Berkeley, Haas School of Business and, IEOR department Etcheverry Hall, Berkeley, Ca, 94720, United States of America, hochbaum@ieor.berkeley.edu

We address here a few clustering problems common in the image segmentation literature. We devise here the first known polynomial time algorithms solving optimally bi-criteria clustering problems including the ratio region problem, a variant of normalized cut, as well as a few other ratio problems in clustering and a model of the co-segmentation problem. The algorithms are efficient and combinatorial and are based on the use of an s,t-cut procedure as a subroutine.

2 - Constrained Sparse Poisson-intensity Reconstruction Algorithm for Compressive Imaging

Roummel Marcia, Duke University, 3424 CIEMAS, Durham, NC, 27708, United States of America, roummel@ee.duke.edu, Rebecca Willett, Zachary Harmany

The problem addressed in this talk is the estimation of a signal from data in a photon-limited compressed sensing (CS) context. The noise in this setting is not additive, zero-mean, Gaussian noise, and therefore, the conventional l2-l1 CS optimization approach will be ineffective. We recently developed photon-limited CS theory that uses a Poisson process to model the noise in this setting. The resulting optimization problem uses a negative log-likelihood objective function with non-negativity constraints (since photon intensities are naturally nonnegative). This talk explores computational methods for solving the constrained photon-limited CS problem.

3 - Nonsmooth Minimization with Spatially Adapted Regularization Parameter

Maria Rincon Camacho, PhD Student, University of Graz, Institute of Mathematics and Scientific, Heinrichstrasse 36, Graz, 8010, Austria, maria.rincon-camacho@uni-graz.at, Michael Hintermueller

A total variation (TV) model with a L1 fidelity term and a spatially adapted regularization parameter is presented in order to reconstruct images contaminated by impulse noise. This model intends to preserve small details while homogeneous features are still smooth. The regularization parameter is locally adapted according to a local mean estimator depending on the statistical characteristics of the noise. The solution of the L1-TV minimization problem is obtained by a superlinearly convergent algorithm based on Fenchel-duality and inexact semismooth Newton techniques, which is stable with respect to noise in the data. Numerical results justifying the advantage of such a regularization parameter choice rule are presented.

■ FB13

Marriott - Miami

Derivative-free and Simulation-based Optimization A

Contributed Session

Chair: Wolfgang Hess, Technische Universitaet Darmstadt, Fachbereich Mathematik, Schlossgartenstr. 7, Darmstadt, 64289, Germany, whess@mathematik.tu-darmstadt.de

1 - Shape Optimization Governed by the Linear Elasticity Equations

Wolfgang Hess, Technische Universitaet Darmstadt, Fachbereich Mathematik, Schlossgartenstr. 7, Darmstadt, 64289, Germany, whess@mathematik.tu-darmstadt.de, Stefan Ulbrich

Shape optimization can be applied to support the product development of profiles manufactured using sheet metal forming. We present an efficient multilevel SQP method for the nonconvex geometry optimization problems that arise in this context, though it is also suited for other design problems. We use detailed PDE-based models, e.g., 3D linear elasticity for stiffness optimization. Our algorithm employs nested iterations and uses a posteriori error estimators to generate adaptively refined meshes. Numerical results are presented.

■ FB14

Marriott - Scottsdale

Game Theory A

Contributed Session

Chair: G Ravindran, Head, SQC and OR Unit, Indian Statistical Institute Chennai Centre, Old No.110, New No.37, I Floor, Nelson Manickam Road, Aminjikarai, Chennai, TN, 600029, India, gravi@hotmail.com

1 - On Techniques to Solve Perfect Information Stochastic Games

G Ravindran, Head, SQC and OR Unit, Indian Statistical Institute Chennai Centre, Old No.110, New No.37, I Floor,, Nelson Manickam Road, Aminjikarai, Chennai, TN, 600029, India, gravi@hotmail.com, Nagarajan Krishnamurthy, T Parthasarathy

We discuss techniques to solve 2-player, Perfect Information Stochastic Games and some subclasses. We look at solving these games through Linear Complementarity Problem (LCP) formulations and Vertical LCP formulations. We also discuss feasibility of solving different Linear Programs (LP) simultaneously.

2 - On the Structure of Simple Stochastic Games and Algorithms to Solve Them

Nagarajan Krishnamurthy, PhD Student, Chennai Mathematical Institute, Plot H1, SIPCOT IT Park,, Padur PO, Siruseri., Kancheepuram District, TN, 603103, India, naga.research@gmail.com, T Parthasarathy, G Ravindran

We study the structure of Simple Stochastic Games (SSG) and propose new Linear Complementarity Problem (LCP) formulations. We analyze the structure of the underlying matrices in these formulations and discuss feasibility of solving them. We also discuss polynomial time algorithms to solve some subclasses of SSGs.

■ FB15

Gleacher Center - 100

Stochastic Programming

Cluster: Stochastic Optimization
Invited Session

Chair: Urmila Diwekar, President, Vishwamitra Research Institute, 368 56th Street, Clarendon Hills, IL, 60514, US Minor Outlying Islands, urmila@vri-custom.org

1 - A Novel Stochastic Programming Algorithm for Minimization of Fresh Water Consumption in Power Plants

Juan Salazar, Vishwamitra Research Institute, 368 56-th Street, Clarendon Hills, IL, 60514, United States of America, juan@vri-custom.org, Steven Zitney, Urmila Diwekar

Coal-fired power plants are widely recognized as major water consumers. Water consumption in thermoelectric generation is affected by uncertain variables like atmospheric conditions and power demand. Employment of a novel better optimization of nonlinear uncertain systems (BONUS) algorithm dramatically decreased the computational requirements of the stochastic optimization for this problem.

2 - Computational Experience of Solving Two-stage Stochastic Linear Programming Problems

Viktar Zviarovich, CARISMA, Brunel University, UB8 3PH, Uxbridge (Middlesex), United Kingdom, viktar.zviarovich@brunel.ac.uk, Gautam Mitra, Csaba Fabian, Francis Ellison

We present a computational study of two-stage SP models for a range of benchmark problems. We consider application of Simplex method and IPM to solve deterministic equivalent problems, Benders decomposition and two regularisation methods. The first method is experimental and has not been considered in the literature before. The second is based on the level decomposition of the expected recourse function by Fabian and Szoke. The scale-up properties and the performance profiles are presented.

3 - L-Shaped BONUS Algorithm for Large Scale Stochastic Nonlinear Programming Problem Solution

Yogendra Shastri, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, United States of America, yogendra@vri-custom.org, Urmila Diwekar

The class of stochastic nonlinear programming (SNLP) problems is important in optimization due to the presence of nonlinearity and uncertainty in many applications related to mathematical programming. This work proposes a new algorithm called L-shaped BONUS to solve the SNLP problems in a computationally efficient manner. The algorithm has been applied to solve various problems to illustrate the computational advantages.

■ FB16

Gleacher Center - 200

Stochastic Optimization H

Contributed Session

Chair: Yuntao Zhu, Assistant Professor, Arizona State University, P.O. Box 37100, Phoenix, AZ, 85069-7100, United States of America, yuntao.zhu@asu.edu

1 - Colorful Carathéodory Selections from Convex Hulls of Unions & Sumsets, for Variational Analysis

James E. Blevins, Uppsala University, Statistics Department (Ekonomikum), Box 513, Uppsala, 751 20, Sweden, James.Blevins@statistik.uu.se

Carathéodory's lemma was generalized for unions & sums (Bár·ny; Shapley Folkman). Algorithms for computing colourful Caratheodory (CC) selections are proposed; their polynomial time complexities proved. In Banach spaces of Rademacher type p>1, randomized methods for sparse convex approximation use CC selections. Whether convexified or not, the unions & sums of (nonconvex) setsósubdifferentials, epigraphs & levelsetsóconcern variational analysis, nonsmooth optimization & stochastic programming.

2 - Stochastic Semidefinite Programming under Uncertainty

Yuntao Zhu, Assistant Professor, Arizona State University, P.O. Box 37100, Phoenix, AZ, 85069-7100, United States of America, yuntao.zhu@asu.edu, K. A. Ariyawansa

In this talk we introduce a new stochastic optimization paradigm termed Stochastic Semidefinite Programming (SSDP). The formulation of SSDP is stressed as well as applications and solving algorithms.

■ FB17

Gleacher Center - 204

Logistics and Transportation G

Contributed Session

Chair: Mette Gamst, PhD Student, Technical University of Denmark, Produktionstorvet, Building 426, Room 58, Kgs. Lyngby, 2800, Denmark, gamst@man.dtu.dk

1 - A Heuristic Approach for the Team Orienteering Problem

Francisco Viana, MSc., PUC-Rio, Barata Ribeiro 502/509, Rio de Janeiro, Brazil, henrique.viana@gmail.com

The Team Orienteering Problem is a variant of the VRP. There is a set of points and a profit is collected for the visit of each point. A fleet is available to visit them. Then, the objective is construct a set of routes such that the total collected reward received from visiting a subset of the customers is maximized. The route length is restricted by a limit. This approach generates an initial solution by taboo search. After, the algorithm minimizes the smallest route to insert more customers.

2 - Models for Designing Trees with Node Dependent Costs

Pedro Moura, DEIO - CIO, Faculdade de Ciencias da Universidade de Lisboa, Campo Grande, Bloco C6 - Piso 4, Lisbon, 1749-016, Portugal, pmmoura@fc.ul.pt, Luis Gouveia

We discuss models for a variant of the classical Minimum Spanning Tree Problem and the Prize-Collecting Steiner Tree Problem where, besides the traditional costs/prizes in the objective function we include a concave modular cost function which depends on the degree value of each node in the solution. Computational results taken from instances with up to 100 nodes will be presented.

3 - An Exact Solution Approach for the Maximum Multicommodity K-splittable Flow Problem

Mette Gamst, PhD Student, Technical University of Denmark, Produktionstorvet, Building 426, Room 58, Kgs. Lyngby, 2800, Denmark, gamst@man.dtu.dk, Bjorn Petersen

This talk concerns the NP-hard Maximum Multicommodity k-splittable Flow Problem (MMCkFP) in which each commodity may use at most k paths between its origin and its destination. A new branch-and-cut-and-price algorithm is presented. The master problem is a two-index formulation of the MMCkFP and the pricing problem is the shortest path problem with forbidden paths. A new branching strategy forcing and forbidding the use of certain paths is developed. The new branch-and-cut-and-price algorithm is computationally evaluated and compared to results from the literature. The new algorithm shows very promising performance by outperforming existing algorithms for several instances.

■ FB18

Gleacher Center - 206

Dynamic Networks

Cluster: Nonlinear Mixed Integer Programming
Invited Session

Chair: Alexander Martin, Technische Universitaet Darmstadt, FB Mathematik, AG 7, Schlossgartenstr. 7, Darmstadt, D-64289, Germany, martin@mathematik.tu-darmstadt.de

1 - Discrete-Continuous Optimal Control with PDEs on Networks

Oliver Kolb, Technische Universitaet Darmstadt, Schlossgartenstr. 7, Darmstadt, Germany, Oliver.Kolb@gmx.net

This talk deals with the solution of discrete-continuous optimization problems for flow processes in gas and water supply networks. The aim is to run the network cost-efficiently whereas demands of consumers have to be satisfied. This results in a complex nonlinear mixed integer problem. We address this task with methods provided by discrete and continuous optimization. We present numerical simulation and optimization results based on our models.

2 - Adaptive Piecewise Linearization in MIP Optimization of PDE-constrained MINLPs

Antonio Morsi, Technische Universitaet Darmstadt, FB Mathematik, AG 7, Schlossgartenstr. 7, Darmstadt, D-64289, Germany, morsi@mathematik.tu-darmstadt.de, Oliver Kolb, Jens Lang, Bjoern Geissler, Alexander Martin

Adaptive grid refinement is an effective way to reduce the complexity of a problem while keeping the accuracy of the solution. We formulate a MIP model using piecewise linearizations (PWL) to represent nonlinearities in a discretized pde model. We show how to use an adaptive refinement strategy of the PWL to reduce the complexity of the solution process of this MIP based on error estimators. Applications of water and gas network optimization will reveal its practical benefits.

3 - MIP Relaxations of Nonconvex MINLPs by Piecewise Linear Approximation

Bjoern Geissler, Technische Universitaet Darmstadt, FB Mathematik, AG 7, Schlossgartenstr. 7, Darmstadt, D-64289, Germany, geissler@mathematik.tu-darmstadt.de, Antonio Morsi, Alexander Martin

We present a method for constructing arbitrary tight mixed integer linear relaxations of nonconvex MINLPs. Our method starts with constructing a piecewise linear approximation of the nonlinearities. Next, we use convex underestimators and concave overestimators to calculate upper bounds for the linearization error on each simplex. Finally, we use this information to build bounding volumes around the graphs of the nonlinear functions. These bounding volumes can be modeled in terms of mixed integer linear constraints by applying slightly modified versions of well-known MIP-techniques for piecewise linear functions.

■ FB20

Gleacher Center - 300

Nonlinear Programming D

Contributed Session

Chair: Darin Mohr, University of Iowa, 15 MacLean Hall, Iowa City, IA, 52242-1419, United States of America, dgmohr@math.uiowa.edu

1 - Hybrid Algorithms for Unconstrained Optimization Problems

Darin Mohr, University of Iowa, 15 MacLean Hall, Iowa City, IA, 52242-1419, United States of America, dgmohr@math.uiowa.edu

Quasi-Newton algorithms are widely used in unconstrained optimization while Runge-Kutta methods are widely used for the numerical integration of ODEs. In this work we consider hybrid algorithms combining low order implicit Runge-Kutta methods for gradient systems and quasi-Newton type updates of the Jacobian matrix such as the BFGS update.

■ FB21

Gleacher Center - 304

Incentives and Pricing

Cluster: Telecommunications and Networks
Invited Session

Chair: Rudolf Mueller, Maastricht University, Department of Quantitative Economics, Maastricht, Netherlands, R.Muller@KE.unimaas.nl

1 - Optimal Mechanism Design for Single Machine Scheduling

Marc Uetz, University of Twente, Applied Mathematics, P.O. Box 217, Enschede, 7500 AE, Netherlands, m.uetz@utwente.nl, Birgit Heydenreich, Debasis Mishra, Rudolf Mueller

Optimal mechanism design is concerned with coordinating the selfish behavior of noncooperative agents, while minimizing the total expected cost for the mechanism designer. We study optimal mechanisms in settings where job-agents compete for being processed on a single machine. We derive closed formulae for the one dimensional case, showing that the problem is solvable in polynomial time. We also discuss difficulties with the two dimensional case, suggesting that the problem might be hard.

2 - Characterizing Incentive Compatibility for Convex Valuations

Seyed Hossein Naeemi, Maastricht University, Department of Quantitative Economics, P.O. Box 616, Maastricht, 6200 MD, Netherlands, h.naeemi@maastrichtuniversity.nl, Andre Berger, Rudolf Mueller

We characterize implementability in dominant strategies of social choice functions when types are multi-dimensional, sets of outcomes are arbitrary, valuations for outcomes are convex functions in the type, and utilities are quasi-linear. We generalize a result by Archer and Kleinberg (2008) showing that for linear valuation functions on convex type domains monotonicity in combination with locally disappearing path-integrals on triangles are equivalent with implementability. Using our characterization, we generalize a theorem by Saks and Yu (2005), showing that for finite set of outcomes monotonicity alone is sufficient, to convex valuations. This provides a very short proof for the special case of linear valuations.

3 - Pricing in Networks

Martin Hoefer, RWTH Aachen University, Informatik I, Ahornstrasse 55, Aachen, D-52074, Germany, mhoefer@cs.rwth-aachen.de, Luciano Guala, Carmine Ventre, Piotr Krysta, Patrick Briest

We consider a general model for pricing in networks. A seller has to set revenue maximizing prices for a subset of network connections. Customers decide upon their purchase by efficiently optimizing a minimization problem such as MST or shortest path. We present a general approximation algorithm for revenue maximization in this model and improved results for special cases. We also consider the case, in which the optimization problem for customers is NP-hard and they use approximation algorithms.

■ FB25

Gleacher Center - 404

Proximal Point Methods and Infinite Dimensional Control

Cluster: Variational Analysis
Invited Session

Chair: Alexander Zaslavski, Professor, Technion Israel Institute of Technology, Haifa, Israel, ajzasl@techunix.technion.ac.il

1 - Exact Finite Approximations of Average-cost Countable Markov Decision Processes

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We introduce an embedding of a countable Markov decision process which produces a finite Markov decision process. The embedded process has the same optimal cost, and shares dynamics of the original process within the approximating set. The embedded process can be used as an approximation which, being finite, is more convenient for computation and implementation.

2 - A Proximal Point Method in Nonreflexive Banach Spaces

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We propose an inexact version of the proximal point method and study its properties in nonreflexive Banach spaces, both for the problem of minimizing convex functions and of finding zeroes of maximal monotone operators. Using surjectivity results for enlargements of maximal monotone operators, we prove existence of the iterates in both cases. Then we recover most of the convergence properties known to hold in reflexive and smooth Banach spaces for the convex optimization problem.

3 - Version of the Second Welfare Theorem for Welfare Economies with Public Goods

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In this paper we have considered nonconvex infnite dimensional welfare economic model with public goods and obtained necessary optimality conditions, a version of the second welfare theorem, in both approximate and exact forms. The approximate forms are expressed in terms of Fraµechet normal cone and the exact forms are expressed in terms of the basic normal cones. Our main tool from variational analysis is the so called extremalprinciple.