IP1

Universal Gradient Methods

In Convex Optimization, numerical schemes are always developed for some specific problem classes. One of the most important characteristics of such classes is the level of smoothness of the objective function. Methods for nonsmooth functions are different from the methods for smooth ones. However, very often the level of smoothness of the objective is difficult to estimate in advance. In this talk we present algorithms which adjust their behavior in accordance to the actual level of smoothness observed during the minimization process. Their only input parameter is the required accuracy of the solution. We discuss also the abilities of these schemes in reconstructing the dual solutions.

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IP2

Optimizing and Coordinating Healthcare Networks and Markets

Healthcare systems pose a range of major access, quality and cost challenges in the U.S. and globally. We survey several healthcare network optimization problems that are typically challenging in practice and theory. The challenge comes from network affects, including the fact that in many cases the network consists of selfish and competing players. Incorporating the complex dynamics into the optimization is rather essential, but hard to models and often leads to computationally intractable models. We focus attention to computationally tractable and practical policies, and analyze their worst-case performance compared to optimal policies that are computationally intractable and conceptually impractical.

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IP3

Recent Progress on the Diameter of Polyhedra and Simplicial Complexes

The Hirsch conjecture, posed in 1957, stated that the graph of a d-dimensional polytope or polyhedron with n facets cannot have diameter greater than $n - d$. The conjecture itself has been disproved (Klee-Walkup (1967) for unbounded polyhedra, Santos (2010) for bounded polytopes), but what we know about the underlying question is quite scarce. Most notably, no polynomial upper bound is known for the diameters that were conjectured to be linear. In contrast, no polyhedron violating the Hirsch bound by more than 25% is known. In this talk we review several recent attempts and progress on the question. Some of these work in the world of polyhedra or (more often) bounded polytopes, but some try to shed light on the question by generalizing it to simplicial complexes. In particular, we show that the maximum diameter of arbitrary simplicial complexes is in $n^{\Theta(d)}$, we sketch the proof of Hirsch's bound for "flag' polyhedra (and more general objects) by Adiprasito and Benedetti, and we summarize the main ideas in the `polymath 3` project, a web-based collective effort trying to prove an upper bound of type nd for the diameters of polyhedra.

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IP4

Combinatorial Optimization for National Security Applications

National-security optimization problems emphasize safety, cost, and compliance, frequently with some twist. They may merit parallelization, have to run on small, weak platforms, or have unusual constraints or objectives. We describe several recent such applications. We summarize a massively-parallel branch-and-bound implementation for a core task in machine classification. A challenging spam-classification problem scales perfectly to over 6000 processors. We discuss math programming for benchmarking practical wireless-sensor-management heuristics. We sketch theoretically justified algorithms for a scheduling problem motivated by nuclear weapons inspections. Time permitting, we will present open problems. For example, can modern nonlinear solvers benchmark a simple linearization heuristic for placing imperfect sensors in a municipal water network?

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IP5

The Euclidean Distance Degree of an Algebraic Set

It is a common problem in optimization to minimize the Euclidean distance from a given data point u to some set X. In this talk I will consider the situation in which X is defined by a finite set of polynomial equations. The number of critical points of the objective function on X is called the Euclidean distance degree of X, and is an intrinsic measure of the complexity of this polynomial optimization problem. Algebraic geometry offers powerful tools to calculate this degree in many situations. I will explain the algebraic methods involved, and illustrate the formulas that can be obtained in several situations ranging from matrix analysis to control theory to computer vision. Joint work with Jan Draisma, Emil Horobet, Giorgio Ottaviani and Bernd Sturmfels.

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IP6

Modeling Wholesale Electricity Markets with Hydro Storage

Over the past two decades most industrialized nations have instituted markets for wholesale electricity supply. Optimization models play a key role in these markets. The understanding of electricity markets has grown substantially through various market crises, and there is now a set of standard electricity market design principles for systems with mainly thermal plant. On the other hand, markets with lots of hydro storage can face shortage risks, leading to production and pricing arrangements in these markets that vary widely across jurisdictions. We show how stochastic optimization and complementarity models can be used to improve our understanding of these systems.

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IP7

Large-Scale Optimization of Multidisciplinary Engineering Systems

There is a compelling incentive for using optimization to design aerospace systems due to large penalties incurred by their weight. The design of these systems is challenging due to their complexity. We tackle these challenges by developing a new view of multidisciplinary systems, and by combining gradient-based optimization, efficient gradient computation, and Newton-type methods. Our applications include wing design based on Navier–Stokes aerodynamic models coupled to finite-element structural models, and satellite design including trajectory optimization. The methods used in this work are generalized and proposed as a new framework for solving large-scale optimization problems.

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IP8

A Projection Hierarchy for Some NP-hard Optimization Problems

There exist several hierarchies of relaxations which allow to solve NP-hard combinatorial optimization problems to optimality. The Lasserre and Parrilo hierarchies are based on semidefinite optimization and in each new level both the dimension and the number of constraints increases. As a consequence even the first step up in the hierarchy leads to problems which are extremely hard to solve computationally for nontrivial problem sizes. In contrast, we present a hierarchy where the dimension stays fixed and only the number of constraints grows exponentially. It applies to problems where the projection of the feasible set to subproblems has a 'simple' structure. We consider this new hierarchy for Max-Cut, Stable-Set and Graph-Coloring. We look at some theoretical properties, discuss practical issues and provide computational results, comparing the new bounds with the current state-of-the-art.

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SP1

SIAG/OPT Prize Lecture: Efficiency of the Simplex and Policy Iteration Methods for Markov Decision Processes

We prove that the classic policy-iteration method (Howard 1960), including the simple policy-iteration (or simplex method, Dantzig 1947) with the most-negative-reduced-cost pivoting rule, is a strongly polynomial-time algorithm for solving discounted Markov decision processes (MDP) of any fixed discount factor. The result is surprising since almost all complexity results on the simplex and policy-iteration methods are negative, while in practice they are popularly used for solving MDPs, or linear programs at large. We also present a result to show that the simplex method is strongly polynomial for solving deterministic MDPs regardless of discount factors.

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CP1

Superlinearly Convergent Smoothing Continuation Algorithms for Nonlinear Complementarity Problems over Definable Convex Cones

We consider the superlinear convergence of smoothing continuation algorithms without Jacobian consistency. In our approach, we use a barrier based smoothing approximation, which is defined for every closed convex cone. When the barrier has definable derivative, we prove the superlinear convergence of a smoothing continuation algorithm for solving nonlinear complementarity problems over the cone. Such barriers exist for cones definable in the o-minimal expansion of globally analytic sets by power functions with real algebraic exponents.

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CP1

On the Quadratic Eigenvalue Complementarity Problem

A new sufficient condition for the existence of solutions to the Quadratic Eigenvalue Complementarity Problem (QEiCP) is established. This condition exploits the reduction of QEiCP to a normal EiCP. An upper bound for the number of solutions of the QEiCP is presented. A new strategy for QEiCP is analyzed which solves the resulting EiCP by an equivalent Variational Inequality Problem. Numerical experiments with a projection VI method illustrate the interest of this methodology in practice.

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CP1

Complementarity Formulations of ℓ_0-Norm Optimization Problems

There has been interest recently in obtaining sparse solutions to optimization problems, eg in compressed sensing. Minimizing the number of nonzeroes (also known as the ℓ_0-norm) is often approximated by minimizing the ℓ_1-norm. In contrast, we give an exact formulation as a mathematical program with complementarity constraints; our formulation does not require a big-M term. We discuss properties of the exact formulation such as stationarity conditions, and solution procedures for determining local and global optimality. We compare our solutions with those from an

ℓ_1-norm formulation.

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CP1

Competitive Equilibrium Relaxations in General Auctions

In practice, many auctions do not possess a competitive equilibrium. For this reason, we provide two relaxations which compute solutions similar to a competitive equilibrium. Both relaxations determine one price per commodity by solving a non-convex optimization problem. The first model (an MPEC) allows for a fast heuristic and an exact decomposition algorithm. The second model ensures that no participant can be made better off without making another one worse off.

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CP1

Global Convergence of Smoothing and Scaling Conjugate Gradient Methods for Systems of Nonsmooth Equations

The systems of nonsmooth equations is important class of problems, because it has many applications, for example, the variational inequality and the complementarity problems. In this talk, we treat numerical methods for solving systems of nonsmooth equations. Systems of nonsmooth equations are reformulated as least squares problems by using the smoothing technique. We propose scaling conjugate gradient methods for solving this least squares problems. Moreover, we show the global convergence of the proposed methods.

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CP1

Computing a Cournot Equilibrium in Integers

We give an efficient algorithm for computing a Cournot equilibrium when the producers are confined to integers, the inverse demand function is linear, and costs are quadratic. The method also establishes existence, which follows in much more generality because the problem can be modelled as a potential game.

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CP2

Newton's Method for Solving Generalized Equations Using Set-Valued Approximations

Results on stability of both local and global metric regularity under set-valued perturbations will be presented. As an application, we study (super-)linear convergence of a Newton-type iterative process for solving generalized equations. We will investigate several iterative schemes such as the inexact Newton's method, the non-smooth Newton's method for semi-smooth functions and the inexact proximal point algorithm.

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CP2

Polynomiality of Inequality-Selecting Interior-Point Methods for Linear Programming

We present a complexity analysis for interior-point frameworks that solve linear programs by dynamically selecting constraints from a known but possibly large set of inequalities. Unlike conventional cutting-plane methods, our method predicts constraint violations and integrates needed inequalities using new types of corrector steps that maintain feasibility at each major iteration. Our analysis provides theoretical insight into conditions that may cause such algorithms to jam or that guarantee their convergence in polynomial time.

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CP2

FAIPA_SDP: A Feasible Arc Interior Point Algorithm for Nonlinear Semidefinite Programming

FAIPA_SDP deals with the minimization of nonlinear functions with constraints on nonlinear symmetric matrix-valued functions, in addition to standard nonlinear constraints. FAIPA_SDP generates a decreasing sequence of feasible points. At each iteration, a feasible descent arc is obtained and a line search along this arc is then performed. FAIPA_SDP merely requires the solution of three linear systems with the same matrix. We prove global and superlinear convergence. Several numerical examples were solved very efficiently.

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CP2

An Efficient Algorithm for the Projection of a Point on the Intersection of M Hyperplanes with Nonnegative Coefficients and The Nonnegative Orthant

In this work, we present an efficient algorithm for the projection of a point on the intersection of an arbitrary number of nonnegative hyperplanes and the nonnegative orthant. Interior point methods are the most efficient algorithm in the literature to solve this problem. While efficient in practice, the complexity of interior point methods is bounded by a polynomial in the dimension of the problem and in the accuracy of the solution. In addition, their efficiency is highly dependent on a series of parameters depending on the specific method chosen (especially for nonlinear problems), such as step size, barrier parameter, accuracy, among others. We propose a new method based on the KKT optimality conditions. In this method, we write the problem as a function of the Lagrangian multipliers of the hyperplanes and seek to find an m-tuple of multipliers that corresponds to the optimal solution. We present the numerical experiments for m = 2, 5, 10.

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CP2

A Quadratic Cone Relaxation-Based Algorithm for Linear Programming

We present and analyze a linear programming algorithm based on replacing the non-negative orthant with larger quadratic cones. For each quadratic relaxation that has an optimal solution, there naturally arises a parameterized family of quadratic cones for which the optimal solutions create a path leading to the linear programs optimal solution. We show that this path can be followed efficiently, thereby resulting in an algorithm whose complexity matches the best bounds proven for interior-point methods.

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CP3

An Analytic Center Algorithm for Semidefinite Programming

In this work, we study the method of analytic centers, which was developed with the Newton method, applied to semidefinite programming. In this method, we compute a descent direction using either Newton's method. We present the complexity analysis and computational experiments performed with the semidefinite programming test problems available on SDPLIB.

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CP3

A Low-Rank Algorithm to Solve SDP's with Block Diagonal Constraints via Riemannian Optimization

We solve

$$\min_X f(X) \text{ such that } X \succeq 0 \text{ and } X_{ii} = I_d \text{ for all } i,$$

where f is convex, I_d denotes the $d \times d$ identity matrix and

X_{ii} is the i^{th} diagonal block of X. These appear in approximation algorithms for some NP-hard problems, where the solution is expected to have low rank. To fully exploit this structure, we demonstrate that the search space admits a Riemannian geometry when $\text{rank}(X)$ is fixed, and show how to obtain a solution by gradually incrementing the rank, using Riemannian optimization.

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CP3

The Simplex Method and 0-1 Polytopes

We will derive two results of the primal simplex method by constructing simple LP instances on 0-1 polytopes. One of the results is that, for any 0-1 polytope and any its two vertices, we can construct an LP instance for which the simplex method finds a path between them, whose length is at most the dimension of the polytope. This proves a well-known result that the diameter of any 0-1 polytope is bounded by its dimension. Next we show that an upper bound for the number of distinct solutions generated by the simplex method is tight. We prove these results by using a basic property of the simplex method.

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CP3

On a Polynomial Choice of Parameters for Interior Point Methods

In this work we solve Linear optimization problems on a Interior Point Method environment by combining different directions, such as predictor, corrector or centering ones, to produce a *better* direction. We measure how good the new direction by using a polynomial merit function on variables (α, μ, σ), where α is the step length, μ defines the central path and σ models the weight that a corrector directions should have in a predictor-corrector method. Some numerical test show that this approach is competitive when compared to more well established solvers as `PCx`, using the `Netlib` test set.

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CP3

Gradient Methods for Least-Squares Over Cones

Nesterov's excessive gap method is extended to more general problems. Fast gradient methods are used to solve the least squares problem over convex cones – include the semidefinite least squares problem. Numerical examples are given.

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CP3

Augmented Lagrangian-Type Solution Methods for Second Order Conic Optimization

We consider the minimization of a nonlinear function partly subjected to nonlinear second order conic constraints. Augmented Lagrangian-type functions for the problem are discussed, with focus on the Log-Sigmoid approach. We then respectively apply the Newton and Quasi-Newton methods to solve the resulting unconstrained model. In this talk, we present the method and numerical experiments done on some problems from trust topology.

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CP4

Nonmonotone Grasp

A Greedy Randomized Adaptive Search Procedure (GRASP) is an iterative multistart metaheuristic for difficult combinatorial optimization. Each GRASP iteration consists of two phases: a construction phase and a local search phase that applies iterative improvement until a locally optimal solution is found. During this phase, starting from the current solution only improving neighbor solutions are accepted and considered as new current solution. In this talk, we propose a new variant of the GRASP framework that explores the neighborhood of the current solution in a nonmonotone fashion resembling a nonmonotone line search technique proposed by Grippo et al. in 1986 for Newton's method in nonlinear optimization. We prove the convergence of the resulting Nonmonotone GRASP (NM-GRASP) and illustrate its effectiveness on the Maximum Cut Problem (MAX-CUT), a classical hard combinatorial optimization problem.

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CP4

A New Exact Appoach for a Generalized Quadratic Assignment Problem

The quadratic matching problem (QMP) asks for a matching in a graph that optimizes a quadratic objective in the edge variables. The QMP generalizes the quadratic assignment problem. In our approach we strengthen the linearized IP-formulation by cutting planes that are derived from facets of the corresponding matching problem with only one quadratic term in the objective function. We present methods to strengthen these new inequalities for the general QMP and report computational results.

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CP4

Binary Steiner Trees and Their Application in Biological Sequence Analysis

Advances in molecular bioinformatics have led to increased information about biological sequences. Alignments and phylogentic trees of these sequences play an important role in inferring evolutionary history. The problem of finding tree alignments or phylogentic trees can be modeled as a binary Steiner tree problem. We study the computational complexity of this problem and introduce the binary Steiner tree polytop and valid inequalities. An approach for computing binary Steiner trees and computational results are presented.

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CP4

The Discrete Ordered Median Problem Revisited

This paper compares classical and new formulations for the discrete ordered median location problem. Starting with three already known formulations that use different spaces of variables, we introduce two new ones based on new properties of the problem. The first formulation is based on an observation about how to use scheduling constraints to model sorting. The second one is a novel approach based on a new mixed integer non-linear programming paradigm. Some of the new formulations decrease considerably the number of constraints to define the problem with respect to some previously known formulations. Furthermore, the lower bounds provided by their continuous relaxations improve the ones obtained with previous formulations in the literature even when strengthened is not applied. Extensive computational results are presented.

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CP4

The Graph Partitioning into Constrained Spanning Sub-Trees

Lukes (1974) suggested a heuristic of partitioning a general graph by taking a maximum spanning tree of the graph and then partitioning the tree based on his pseudo-polynomial algorithm to solve a uniformly constrained tree partition problem. We generalize the heuristic to the maximum graph partitioning into k constrained spanning sub-trees and develop a tree updating heuristic to solve the generalized problem. As a sub-problem of the generalized problem, the constrained tree partition problem is tackled by Lagrangian relaxation method based on the branch-and-cut algorithm which Lee,Chopra and Shim (2013) gave to solve the unconstrained tree partition problem.

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CP4

Effects of the Lll Reduction on Integer Least Squares Estimation

Solving an integer least squares problem is often needed to estimate an unknown integer parameter vector from a linear model. It has been observed that the LLL reduction can improve the success probability of the Babai point, a suboptimal solution, and decrease the cost of the sphere decoders by simulations. In this talk, we will theoretically show that these two observations are indeed true.

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CP5

Parallelized Branch-and-Fix Coordination Algorithm (P-Bfc) for Solving Large-Scale Multistage Stochastic Mixed 0-1 Problems

The parallelization is performed in two levels. The inner one parallelizes the optimization of the set of MIP submodels attached to the set of scenario clusters in our Branch-and-Fix Coordination methodology. The outer level defines a set of 0-1 variables where the combinations of their 0-1 values, so named paths allow independent models to be optimized in parallel. Computational results are reported on a broad testbed.

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CP5

Robust Decision Analysis in Discrete Scenario Spaces

In this paper, we introduce an efficient method for finding optimal dynamic policies in decision making problems with discrete scenario space. We assume the probability distribution belongs to an arbitrary box uncertainty set.

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CP5

On Solving Multistage Mixed 0-1 Optimization Problems with Some Risk Averse Strategies

We extend to the multistage case two recent risk averse measures defined for two-stage stochastic mixed 0-1 problems solving such than an objective function is maximized in the domain of a feasible region subject to time consistent first- and second- order Stochastic Dominance Constraints integer-recourse. We also present an extension of our Branch-and-Fix Coordination Algorithm, where a special treatment is given to cross scenario constraints that link variables from different scenarios.

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CP5

Distributed Generation for Energy-Efficient Buildings: A Mixed-Integer Multi-Period Optimization Approach

We study a two-stage mixed-integer program with application in distributed generation for energy-efficient buildings. This challenging problem is beyond the capacity of current solvers, because the second-stage problem contains a large number of binary variables. By exploiting periodicity structure in daily, weekly, seasonal, and yearly demand profiles, we develop a column generation approach that significantly reduces the number of binary variables, consequently, rendering computationally tractable problems. Furthermore, our approach provides bounds with provable performance guarantees.

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CP5

Linear Programming Twin Support Vector Regression Using Newton Method

In this paper, a new linear programming formulation of a 1-norm twin support vector regression is proposed whose solution is obtained by solving a pair of dual exterior penalty problems as unconstrained minimization problems using Newton method. The idea of our formulation is to reformulate TSVR as a strongly convex problem by incorporated

regularization technique and then derive a new 1-norm linear programming formulation for TSVR to improve robustness and sparsity. Our approach has the advantage that a pair of matrix equation of order equals to the number of input examples is solved at each iteration of the algorithm. The algorithm converges from any starting point and can be easily implemented in MATLAB without using any optimization packages. The efficiency of the proposed method is demonstrated by experimental results on a number of interesting synthetic and real-world datasets.

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CP5

An Integer L-Shaped Algorithm for the Single-Vehicle Routing Problem with Simultaneous Delivery and Stochastic Pickup

Stochastic vehicle routing with simultaneous delivery and pickup is addressed. Quantities to be delivered are fixed, whereas pick-up quantities are uncertain. For route failures, i.e., arriving at a customer with insufficient vehicle capacity, compensation strategies are developed. In the single vehicle case, a recourse stochastic program is formulated and solved by the integer L-shaped method. Algorithm efficiency is improved by strengthening lower bounds for recourse cost associated to partial routes encountered throughout the solution process.

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CP6

Optimal Low-Rank Inverse Matrices for Inverse Problems

Inverse problems arise in scientific applications such as biomedical imaging, computational biology, and geophysics, and computing accurate solutions to inverse problems can be both mathematically and computationally challenging. By incorporating probabilistic information, we reformulate the inverse problem as a Bayes risk optimization problem. We present theoretical results for the low-rank Bayes optimization problem and discuss efficient methods for solving associated empirical Bayes risk optimization problems. We demonstrate our algorithms on examples from image processing.

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CP6

Two-Stage Portfolio Optimization with Higher-Order Conditional Measures of Risk

We describe a study of novel risk modeling and optimization techniques to daily portfolio management. First, we develop and compare specialized methods for scenario generation and scenario tree construction. Second, we construct a two-stage stochastic programming problem with conditional measures of risk, which is used to re-balance the portfolio on a rolling horizon basis, transaction costs included in the model. Third, we present an extensive simulation study on real-world data.

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CP6

Semi-Stochastic Gradient Descent Methods

In this paper we study the problem of minimizing the average of a large number (n) of smooth convex loss functions. We propose a new method, S2GD (Semi-Stochastic Gradient Descent), which runs for one or several epochs in each of which a single full gradient and a random number of stochastic gradients is computed, following a geometric law. The total work needed for the method to output an ε-accurate solution in expectation, measured in the number of passes over data, or equivalently, in units equivalent to the computation of a single gradient of the loss, is $O((\kappa/n)\log(1/\varepsilon))$, where κ is the condition number. This is achieved by running the method for $O(\log(1/\varepsilon))$ epochs, with a single gradient evaluation and $O(\kappa)$ stochastic gradient evaluations in each. The SVRG method of Johnson and Zhang arises as a special case. If our method is limited to a single epoch only, it needs to evaluate at most $O((\kappa/\varepsilon)\log(1/\varepsilon))$ stochastic gradients. In contrast, SVRG requires $O(\kappa/\varepsilon^2)$ stochastic gradients. To illustrate our theoretical results, S2GD only needs the workload equivalent to about 2.1 full gradient evaluations to find an 10^{-6}-accurate solution for a problem with $n = 10^9$ and $\kappa = 10^3$.

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CP6

Risk Averse Computational Stochastic Programming

This work proposed a (general purpose) framework to compute an approximate optimal non-stationary policy for finite-horizon, discrete-time Markov decision problems, when the optimality criteria explicitly includes the expected value and a given risk measure of the total cost. The methodology relies on a parametric decision rule, direct policy search, spline approximation, and a nested parallel derivative free optimization. A Java implementation of the approach is provided in a software package, called *Smart*

Parallel Policy Search (Smart-PPS). Tractability and efficiency of the devised method are illustrated by an energy system risk management problem.

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CP6

Support Vector Machines Via Stochastic Optimization

We discuss the problem of identifying two classes of records by means of a classifier function. We propose a new approach to determine a classifier using techniques of stochastic programming and risk-averse optimization. The approach is particularly relevant when the observations of one of the classes of interest are substantially less than the data available for the other class. We compare the proposed new methods to existing ones and analyze their classification power.

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CP6

Decomposition Algorithms for the Optimal Power Flow Problem under Uncertainty

A two-stage non-linear stochastic formulation for the optimal power flow problem under renewable-generation uncertainty is investigated. Certain generation decisions are made only in the first stage and fixed for the second stage, where the actual renewable generation is realized. The uncertainty in renewable output is captured by a finite number of scenarios. We present two outer-approximation algorithms to solve the large-scale non-convex problem, where a global solution is obtained under some suitable assumptions.

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CP7

Adaptive Multilevel Sqp Method for State Constrained Optimization with Navier-Stokes Equations

We consider an adaptive multilevel method for optimal control problems with state constraints. More precisely, we combine an SQP algorithm with Moreau-Yosida regularization where adaptive mesh refinements and the penalty parameter update are appropriately connected. Afterwards, convergence results without and with second-order sufficient optimality condition are presented. In order to apply our results to flow control problems, we present an (SSC) condition on a suitable critical cone. We conclude with first numerical results.

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CP7

Optimal Decay Rate for the Indirect Stabilization of Hyperbolic Systems

We consider the indirect stabilization of systems of hyperbolic-type equations, such as wave and plate equations with different boundary conditions. By energy method, we show that a single feedback allows to stabilize the full system at a polynomial rate. Furthermore, we exploit refined resolvent estimates deducing the optimal decay rate of the energy of the system. Numerical simulations show resonance effect between the components of the system and confirm optimality of the proven decay rate.

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CP7

Recent Advances in Optimum Experimental Design for PDE Models

Mathematical models are of great importance in engineering and natural sciences. Usually models contain unknown parameters which must be estimated from experimental data. Often many expensive experiments have to be performed for estimating the parameters in order to get enough information for parameter estimation. The number of experiments can be drastically reduced by computing optimal experiments. Our talk presents an efficient method for computing optimal experiments for processes described by partial differential equations (PDE).

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CP7

Optimal Control of Index 1 PDAEs

We consider optimal control problems constrained by Partial Differential-Algebraic Equations, which we interpret as abstract DAEs on Banach spaces. The latter translates to coupled systems of each a parabolic/hyperbolic- and a quasi-stationary elliptic equation for two unknown functions. We set up the general optimality theory and explore implications of the so-called index of a (P)DAE, i.e., an invertibility supposition for the deriviative of the differential-operator for the elliptic equation.

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CP7

Optimal Control of Nonlinear Hyperbolic Conservation Laws with Switching

Entropy solutions of hyperbolic conservation laws generally contain shocks, which leads to non-differentiability of the solution operator. The notion of shift-differentiability turned out to be useful in order to show Fréchet-differentiabilty of the reduced objective for Initial-(Boundary-) Value Problems. In this talk we consider problems motivated by traffic flow modeling, that involve conservation laws with additional discontinuities introduced by switching. We discuss how the ideas from the I(B)VP-case can be transfered to such problems.

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CP7

A Numerical Method for Design of Optimal Experiments for Model Discrimination under Model and Data Uncertainties

The development and validation of complex nonlinear differential equation models is a difficult task that requires the support by numerical methods for sensitivity analysis, parameter estimation, and optimal design of experiments. The talk presents an efficient method for design of optimal experiments for model discrimination by lack-of-fit test. Mathematically this leads to highly structured, multiple experiments, multiple models optimal control problems with integer controls. Special emphasis is placed on robustification of optimal designs against uncertainties.

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CP8

Stochastic Optimal Control Problem for Delayed Switching Systems

This paper provides necessary condition of optimality, in the form of a maximum principle, for optimal control problem of switching systems with constraints. Dynamics of the constituent processes take the form of stochastic differential equations with delay on state and control terms . The restrictions on the transitions or switches between operating mode, are described by collections of functional constraints.

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CP8

A Semismooth Newton-Cg Method for Full Waveform Seismic Tomography

We present a semismooth Newton-PCG method for full waveform seismic inversion governed by the elastic wave equation. We establish results on the differentiability of the solution operator and analyze a Moreau-Yosida regularization to handle constraints on the material parameters. Numerical results are shown for an example of geophysical exploration on reservoir scale. Additionally, we outline the application of the semismooth Newton method to a nonsmooth sparsity regularization in curvelet space.

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CP8

A New Semi-Smooth Newton Multigrid Method for Control-Constrained Semi-Linear Elliptic PDE Problems

In this paper a new multigrid algorithm is proposed to accelerate the semi-smooth Newton method that is applied to the first order necessary optimality systems arising from a class of semi-linear control-constrained elliptic optimal control problems. Under admissible assumptions on the nonlinearity, the discretized Jacobian matrix is proved to have an uniformly bounded inverse with respect to mesh size. Different from current available approaches, a new numerical implementation that leads to a robust multigrid solver is employed to coarsen the grid operator. Numerical simulations are provided to illustrate the efficiency of the proposed method, which shows to be computationally more efficient than the full-approximation-storage multigrid in current literature.

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CP8

Iterative Solvers for Time-Dependent Pde-Constrained Optimization Problems

A major area of research in continuous optimization, as well as applied science more widely, is that of developing fast and robust solution techniques for PDE-constrained optimization problems. In this talk we construct preconditioned iterative solvers for a range of time-dependent problems of this form, using the theory of saddle point systems. Our solvers are efficient and flexible, involve storing relatively small matrices, can be parallelized, and are tailored towards a number of scientific applications.

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CP8

Second Order Conditions for Strong Minima in the Optimal Control of Partial Differential Equations

I this talk we summarize some recent advances on the theory of optimality conditions for the optimization of partial differential equations. We focus our attention on the concept of strong minima for optimal control problems governed by semi-linear elliptic and parabolic equations. Whereas in the field of calculus of variations this notion has been deeply investigated, the study of strong solutions for optimal control problems of partial differential equations has been addressed only recently. We first revisit some well-known results coming from the calculus of variations that will highlight the subsequent results. We then present a characterization of strong minima satisfying quadratic growth for optimal control problems of semi-linear equations and we end by describing some current investigations.

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CP8

Branch and Bound Approach to the Optimal Control of Non-Smooth Dynamic Systems

We consider optimal control problems, given in terms of a set of ordinary differential and algebraic equations. We allow for non-smooth functions in the model equations, in particular for piecewise linear functions, commonly used to represent linearly interpolated data. In order to solve these problems, we reformulate them into mixed-integer nonlinear optimization problems, and apply a tailored branch-and-bound approach. The talk will present the approach as well as numerical results for test instances.

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CP9

On the Full Convergence of Descent Methods for Convex Optimization

A strong descent step h from x for a convex function f satisfies $f(x+h)-f(x) \leq -\alpha F'(x)\|h\|$, where $F'(x) = \min\{\|\gamma\| \mid \gamma \in \partial f(x)\}$ and $\alpha \in (0,1)$. Algorithms like steepest descent, trust region and quasi-Newton using Armijo descent conditions are strong. We show that under a mild growth condition on f these methods generate convergent sequences of iterates. The condition, which is implied by sub-analyticity, is $f(x) - f(x^*) \geq \beta d(x, X^*)^p$ for some $\beta, p > 0$, where $x^* \in X^*$, the optimal set.

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CP9

A Flexible Inexact Restoration Method and Application to Multiobjective Constrained Optimization

We introduce a new flexible Inexact-Restoration (IR) algorithm and an application to Multiobjective Constrained Optimization Problems (MCOP) under the weighted-sum scalarization approach. In IR methods each iteration has two phases. In the first phase one aims to improve feasibility and, in the second phase, one minimizes a suitable objective function. In the second phase we also impose bounded deterioration of the feasibility obtained in the first phase. Here we combine the basic ideas of the Fischer-Friedlander approach for IR with the use of approximations of the Lagrange multipliers. We present a new option to obtain a range of search directions in the optimization phase and we employ the sharp Lagrangian as merit function. Furthermore, we introduce a flexible way to handle sufficient decrease requirements and an efficient way to deal with the penalty parameter. We show that with the IR framework there is a natural way to explore the structure of the MCOP in both IR phases. Global convergence of the proposed IR method is proved and examples of the numerical behavior of the algorithm are reported.

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CP9

The Alpha-BB Cutting Plane Algorithm for Semi-Infinite Programming Problem with Multi-Dimensional Index Set

In this study, we propose the alpha-BB cutting plane algorithm for semi-infinite program (SIP) in which the index set is multi-dimensional. When the index set is one-dimensional, the “refinement step’ in the algorithm is just to divide a closed interval into the left and the right. However, such a division is not unique in the multi-dimensional case. We also show that the sequence generated by the algorithm converges to the SIP optimum under mild assumptions.

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CP9

Optimality Conditions for Global Minima of Non-

convex Functions on Riemannian Manifolds

A version of Lagrange multipliers rule for locally Lipschitz functions is presented. Using Lagrange multipliers, a sufficient condition for x to be a global minimizer of a locally Lipschitz function defined on a Riemannian manifold, is proved. Then a necessary and sufficient condition for feasible point x to be a global minimizer of a concave function on a Rimennian manifold is obtained.

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CP9

A Multiresolution Proximal Method for Large Scale Nonlinear Optimisation

The computational efficiency of optimisation algorithms depends on both the dimensionality and the smoothness of the model. Several algorithms have been proposed to take advantage of lower dimensional models (e.g. multi grid methods). In addition several methods smooth the model and apply a smooth optimisation algorithm. In this talk we present an algorithm that simultaneously smooths out and reduces the dimensions of the model. We discuss the convergence of the algorithm and discuss its application to the problem of computing index-1 saddle points.

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CP9

Global Convergence Analysis of Several Riemannian Conjugate Gradient Methods

We present a globally convergent conjugate gradient method with the Fletcher-Reeves β on Riemannian manifolds. The notion of “scaled” vector transport plays an important role to guarantee the global convergence property without any artificial assumptions. We also discuss a Riemannian conjugate gradient method with another β and show that the method has global convergence property if a Wolfe step size is chosen in each iteration, while a strong Wolfe step size has to be chosen in the Fletcher-Reeves type method.

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CP10

Approaching Forex Trading Through Global Optimization Techniques

In applying optimization techniques to trading in Forex, given a strategy and defined the optimization problem properly, a reliable global optimization method must be chosen. This study is aimed to highlight possible relationships between the behavior of the particular security and the performance of the global optimization technique. Moreover, comparing the results on different trading strategies, the best strategy could be identified on a given item. Learning principles are a main key of the procedure.

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CP10

Globie: An Algorithm for the Deterministic Global Optimization of Box-Constrained Nlps

A novel algorithm for the deterministic global optimization of box-constrained NLPs is presented. A key feature of the proposed algorithm is mapping the objective function to a modified subenergy function. This mapping can be used to impose arbitrary bounds on the negative eigenvalues of the Hessian matrix of the new objective function. This property is exploited to identify sub-domains that cannot contain the global solution, using the aBB algorithm.

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CP10

ParDYCORS for Global Optimization

ParDYCORS (Parallel DYnamic COordinate search using Response Surface models) is based on DYCORS [Regis and Shoemaker (2013)], in which the next evaluation points are selected from random trial solutions obtained by perturbing only a subset of the coordinates of the best solution. To reduce the computation time, selected evaluation points are evaluated in parallel. Several numerical results are illustrated, demonstrating that ParDYCORS makes a fast decrease in $f(x)$ and is well suited for a high-dimensional problem.

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CP10

Derivative-Free Multi-Agent Optimization

We present an algorithm for the cooperative optimization of multiple agents connected by a network. We attempt to optimize a global objective which is the sum of the agents' objectives when each agent can only query his objective. Since each agent does not have reliable derivative information, we show that agents building local models of their objectives can achieve their collective goal. We lastly show

how our algorithm performs on benchmark problems.

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CP10

An Interval Algorithm for Global Optimization under Linear and Box Constraints

We describe a method based on interval analysis and branch and bound to find at least one global minimum of a differentiable nonconvex function under linear and box constraints. We use KKT conditions to bound Lagrange multipliers and to apply constraint propagation. Our approach needs only the first derivative of objective function and can also find solutions on the boundary of box. We implement our ideas in C++ and compare our results with Baron

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CP10

Complexity and Optimality of Subclasses of Zero-Order Global Optimization

The problem class of Zero-order Global Optimization is split into subclasses according to a proposed “complexity measure”. For each subclass, Complexity and Branch-and-Bound methods' Laboriousness are rigorously estimated. For conventional “Cubic” BnB upper and lower laboriousness estimates are obtained. A new method based on the A_n^* lattice is presented with upper laboriousness bound smaller than the lower bound of the conventional method by factor $O(3^{n/2})$. All results are extended to Adaptive Covering problems.

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CP11

Stochastic On-time Arrival Problem for Public Transportation Networks

We formulate the stochastic on-time arrival problem on public transportation networks. Link travel times are modeled using a route-based headway diffusion model, which allows the computation of associated waiting times at transit nodes. We propose a label-setting algorithm for computing the solution to this problem, and show that this formulation leads to efficient computations tractable for large networks, even in the case of time-varying distributions. Algorithm performance is illustrated using publicly available and synthetic transit data.

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CP11

Optimal Unit Selection in Batched Liquid Pipelines with DRA

Petroleum products with different physical properties are often transported as multiple discrete batches in a cross-country pipeline. Tens of millions of dollars per year are typically spent on chemical drag reducing agents (DRA) and electric power for pump stations with multiple independent units. An important issue is that DRA is heavily degraded by certain operational conditions. We consider hybrid algorithms that handle both the discrete and continuous aspects of this problem very effectively.

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CP11

Polynomial Optimization for Water Distribution Networks

Pressure management in water networks can be modeled as a polynomial optimization problem. The problem is challenging to solve due to the non-linearities in the hydraulic and energy conservation equations that define the way water flows through a network. We propose an iterative scheme for improving semidefinite-based relaxations of the pressure management problem. The approach is based on a recently proposed dynamic approach for generating valid inequalities to polynomial programs. Computational results are presented.

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CP11

Pump Scheduling in Water Networks

We present a mixed integer nonlinear program for the pump scheduling problem in water networks. The proposed model uses a quadratic approximation for the nonlinear hydraulic equations. We propose a Lagrangian decomposition coupled with a simulation based heuristic as a solution methodology and present results on water networks from the literature.

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CP11

Generation of Relevant Elementary Flux Modes in Metabolic Networks

Elementary flux modes (EFMs) are a set of pathways in a metabolic reaction network that can be combined to define any feasible pathway in the network. It is in general prohibitive to enumerate all EFMs for complex networks. We present a method based on a column generation technique that finds EFMs in a dynamic fashion, while minimizing the norm of the difference between extracellular rate measurements and calculated flux through the EFMs in the network.

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CP11

Discrete Optimization Methods for Pipe Routing

Our problem comes from the planning of a power plant which involves the routing of a high-pressure pipe. Optimizing the life cycle costs of the pipe not only depends on the length but also on its bendings, that can be incorporated with an extended graph. An approach based on a convex reformulation that yields a mixed-integer-second-order-cone problem, and a decomposition algorithm that can handle non-convex constraints that arise from regulations, are proposed.

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CP12

Hipad - A Hybrid Interior-Point Alternating Direction Algorithm for Knowledge-Based Svm and Feature Selection

We propose a new hybrid optimization algorithm that solves the elastic-net SVM through an alternating direction method of multipliers in the first phase, followed by an interior-point method in the second. Our algorithm addresses three challenges: a. high optimization accuracy, b. automatic feature selection, and c. algorithmic flexibility for including prior knowledge. We demonstrate the effectiveness and efficiency of our algorithm and compare it with existing methods on a collection of synthetic and real-world datasets.

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CP12

A Parallel Optimization Algorithm for Nonnegative Tensor Factorization

We present a new algorithm for bound constrained optimization. The algorithm uses multiple points to build a representative model of the objective function. Using the new information gathered from those multiple points; a local step is gradually improved by updating its direction as well as its length. The algorithm scales well on a shared-memory system. We provide parallel implementation details accompanied with numerical results on nonnegative tensor factorization models.

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CP12

Topology Optimization of Geometrically Nonlinear Structures

We present a Sequential Piecewise Linear Programming algorithm for topology optimization of geometrically nonlinear structures, that require the solution of a nonlinear system each time the objective function is evaluated. The method relies on the solution of convex piecewise linear programming subproblems that include second order information. To speed up the algorithm, these subproblems are converted into linear programming ones. The new method is globally convergent to stationary points and also shows good numerical performance.

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CP12

Nonlinear Material Architecture Using Topology

Optimization

This paper proposes a computational topology optimization algorithm for tailoring the nonlinear response of periodic materials through optimization of unit cell architecture. Material design via topology optimization has been achieved in the past for elastic properties. We discuss on the different nonlinear mechanisms in the optimization problem to compare results and suggest more powerful mechanisms. The challenges of topology optimization under nonlinear constitutive equations include singularities and excessive distortions in the low stiffness space of the topology optimized design domain. Low stiffness and void elements are meant to represent holes in the final topology. We propose extending the logic of HPM to nonlinear mechanics by eliminating modeling of low-stiffness elements. Therefore we can remove the element from analysis part without removing that from sensitivity analysis. This method helps avoid numerical instability in the analysis in the optimization process.

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CP12

A Barycenter Method for Direct Optimization

The purpose of this paper is to advocate a direct optimization method based on the computation of the barycenter of a sequence of evaluations or measurements of a given function. The weight given to each point x_i is $e^{-\mu f(x_i,t_i)}$, where $f(\cdot)$ is the function to be optimized, x_i is a point probed at time t_i, and μ is a suitable constant. We develop formulas that relate the derivative-free barycenter update rule to gradient-type methods. Extensions of note include optimization on Riemannian manifolds, and the use of complex weightings, deriving intuition from Richard Feynman's interpretation of quantum electrodynamics.

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CP12

Distributed Benders Decomposition Method

The combined network design and (distributed) traffic routing problem can be formulated as a large-scale multi-period mixed integer optimization problem. Its resolution on realistic instances is intractable and unscalable with state-of-the-art solvers which ignore the distributed nature of routing. We decompose the global optimization problem by means of a distributed version of the Benders decomposition method. Using this method, the initial optimization problem subdivides into a distributed master problem solved at each node and several subproblems of tractable size involving only local decisions when nodes compute routing path(s) online.

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CP13

Riemannian Optimization in Multidisciplinary Design Optimization

Standard gradient-based optimization algorithms are derived for Euclidean spaces. However, Multidisciplinary Design Optimization (MDO) problems exist on Riemannian manifolds defined by the state equations. As such, Riemannian Optimization (RO) algorithms may be particularly effective for MDO; our differential geometry framework for MDO now makes it possible to apply these algorithms to MDO problems. Following a review of RO and our framework, we make qualitative and quantitative comparisons between standard optimization algorithms and their Riemannian counterparts.

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CP13

A Unified Approach for Solving Continuous Multifacility Ordered Median Location Problems

In this paper we propose a general methodology for solving a broad class of continuous, multifacility location problems with ℓ_τ-norms ($\tau \geq 1$) proposing two different methodologies: 1) by a new second order cone mixed integer programming formulation and 2) by formulating a sequence of semidefinite programs that converges to the solution of the problem; each of these relaxed problems solvable with SDP solvers in polynomial time. We apply dimensionality reductions of the problems by sparsity and symmetry in order to be able to solve larger problems.

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CP13

A Near-Optimal Dynamic Learning Algorithm for Online Matching Problems with Concave Returns under Random Permutations Model

We propose a near-optimal dynamic learning algorithm for online matching problem with concave objective functions. In this problem, the input data arrives sequentially and decisions have to be made in an online fashion. Our algorithm is of primal-dual type, which dynamically uses the optimal solutions to selected partial problems in assisting future decisions. This problem has important application in online problems such as the online advertisement allocation problem.

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CP13

A Scenario Based Optimization of Resilient Supply

Chain with Dynamic Fortification Cost

Considering all possible disruption scenarios, the developed stochastic optimization model looks for the most efficient solution to allocate the fortification budget and emergency inventory while minimizing the expected shortage costs. The reliability of each supplier depends on the assigned fortification budget and varies from no reliability to fully reliable. As the reliability of the supplier increases the fortification cost to improve its level of reliability will grow dynamically.

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CP13

Linear Regression Estimation under Different Censoring Models of Survival Data

In survival analysis, data are often censored and different censoring patterns can be utilized to model the censored data. During this talk we will propose the methods of estimating parameters in the linear regression analysis when the data are under different censoring models including the general right censoring model, the Koziol-Green model, and partial Koziol-Green model. Simulations to compare the efficiencies of the estimators under these censoring models are described.

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CP13

PDE-Constrained Optimization Using Hyper-Reduced Models

The large computational cost associated with high-fidelity, physics-based simulations has limited their use in many practical situations, particularly PDE-constrained optimization. Replacing the high-fidelity model with a hyper-reduced (physics-based, surrogate) model has been shown to generate a 400x speedup. A novel approach for incorporating hyper-reduced models in the context of PDE-constrained optimization will be presented and the technology demonstrated on a standard shape optimization problem from computational fluid dynamics, shape design of a simplified rocket nozzle.

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CP14

Deterministic Mesh Adaptive Direct Search with Uniformly Distributed Polling Directions

We consider deterministic instances of mesh adaptive direct search (MADS) algorithms based on equal area hypersphere partitionings introduced by Van Dyke (2013). These nearly-orthogonal directional direct search instances of MADS provide better uniformity of polling directions relative to other MADS instances. We consider the relative the performance among several MADS instances on a variety of test problems.

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CP14

Coupling Surrogates with Derivative-Free Continuous and Mixed Integer Optimization Methods to Solve Problems Coming from Industrial Aerodynamic Applications

We focus on two DFO frameworks, Minamo and NOMAD, developed to solve costly black-box (continuous or mixed-integer) problems coming from industrial applications. We compare the numerical performance of the surrogate-assisted evolutionary algorithm Minamo, a solver developed at Cenaero, with that of NOMAD, an implementation of the mesh-adaptive pattern-search method. Our goal is to improve the efficiency of both frameworks by appropriately combining their attractive features in the context of aerodynamic applications.

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CP14

Parallel Hybrid Multiobjective Derivative-Free Optimization in SAS

We present enhancements to a SAS high performance procedure for solving multiobjective optimization problems in a parallel environment. The procedure, originally designed as a derivative-free solver for mixed-integer nonlinear black-box single objective optimization, has now been extended for multiobjective problems. In the multiobjective case the procedure returns an approximate Pareto-optimal set of nondominated solutions to the user. We will discuss the software architecture and algorithmic changes made to support multiobjective optimization and provide numerical results.

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CP14

A Derivative-Free Method for Optimization Problems with General Inequality Constraints

In this work, we develop a new derivative-free algorithm to solve optimization problems with general inequality constraints. An active-set method combined with trust-region techniques is proposed. This method is based on polynomial interpolation models, making use of a self-correcting geometry scheme to maintain the quality of geometry of the sample set. Initial numerical results are also presented at last.

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CP14

An SQP Trust-Region Algorithm for Derivative-Free Constrained Optimization

We want to propose a new trust-region model-based algorithm for solving nonlinear generally constrained optimization problems where derivatives of the function and constraints are not available. To handle the general constraints, an SQP method is applied. The bound constraints are handled by an active-set approach as was proposed in [Gratton et al., 2011]. Numerical results are presented on a set of CUTEr problems and an application from engineering design optimization.

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CP15

Medication Inventory Management in the International Space Station (ISS): A Robust Optimization Approach

Medication inventory management in space is highly complex, performed in resource-constrained, highly-uncertain settings. Shortage of drugs during exploration missions may result in detrimental impacts. In space, the shelf space is limited; replenishment may not be possible; and the shelf life and stability of medications are uncertain due to the unique space environment. This research explores the potential of the Robust Optimization approach to provide the robust inventory (no or minimal drugs shortages) strategy.

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CP15

Robust Optimization of a Class of Bi-Convex Functions

Robust optimization is a methodology that has gain a lot of attention in the recent years. This is mainly due to the simplicity of the modeling process and ease of resolution even for large scale models. Unfortunately, the second property is usually lost when the function that needs to be "robustified" is not concave (or linear) with respect to the perturbed parameters. In this work, we propose a new scheme for constructing safe tractable approximations for the robust optimization of a class of bi-convex functions; specifically, those that decompose as the sum of maximum of bi-affine functions (with respect to the decisions and the perturbation). Such functions arise very naturally in a wide range of application, including news-vendor, inventory, and classification problems and multi-attribute utility theory. We will present conditions under which our approximation scheme is exact. Some empirical results will illustrate the performance that can be achieved.

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CP15

Tractable Robust Counterparts of Distributionally Robust Constraints on Risk Measures

In optimization problems risk measures of random variables often need to be kept below some fixed level, whereas knowledge about the underlying probability distribution is limited. In our research we apply Fenchel duality for robust optimization to derive computationally tractable robust counterparts of such constraints for commonly used risk measures and uncertainty sets for probability distributions. Results may be used in various applications such as portfolio optimization, economics and engineering.

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CP15

Robust Approaches for Stochastic Intertemporal Production Planning

In many industries, production planning is done in different time horizons: tactical and operational, and several inconsistencies between them arise due to data aggregation and uncertainty. We model this problem as 2-stages stochastic problem, for which we have used Robust Optimization, to estimate the degree of robustness needed and also some modifications to a Stochastic Mirror Descent method, as

well as some other first order methods. We show results from a real industrial problem.

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CP15

Distributionally Robust Inventory Control When Demand Is a Martingale

In distributionally robust inventory control, one assumes that the joint distribution (over time) of the sequence of future demands belongs to some set of joint distributions. Although such models have been analyzed previously, the cost and policy implications of positing different dependency structures remains poorly understood. In this talk, we combine the framework of distributionally robust optimization with the theory of martingales, and consider the setting in which the sequence of future demands is assumed to belong to the family of martingales with given mean and support. We explicitly compute the optimal policy and value, and compare to the analogous setting in which demand is independent across periods. We identify several interesting qualitative differences between these settings. In particular, in a symmetric case, we show the ratio of the optimal cost in the martingale model to the optimal cost in the independence model converges to 1/2 as the number of periods grow.

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CP15

Robust Solutions for Systems of Uncertain Linear Equations

We develop a new way for obtaining robust solutions of a system of uncertain linear equations, where the parameter uncertainties are column-wise. Firstly, we construct a convex representation of the solution set. We then employ adjustable robust optimization to approximate the robust solution, i.e., the center of the maximum volume inscribed ellipsoid only with respect to a subset of variables. Finally, our method is applied to find robust versions of Google's PageRank and Colley's Rankings.

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CP16

Optimal Cur Matrix Decompositions

Given a matrix $A \in R^{m\times n}$ and integers $c < n$ and $r < m$, the CUR factorization of A finds $C \in R^{m\times c}$ with c columns of A, $R \in R^{r\times n}$ with r rows of A, and $U \in R^{c\times r}$ such that $A = CUR + E$. Here, $E = A - CUR$ is the residual error matrix. CUR is analogous to the SVD but is more interpretable since it replaces singular vectors with actual columns and rows from the matrix. We describe novel input-sparsity time and deterministic optimal algorithms for CUR.

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CP16

Convex Sets with Semidefinite Representable Sections and Projections

We investigate projections and sections of semidefinite representable (SDR) convex sets. We prove: a convex cone C is closed and SDR iff sections by hyperplanes are boundedly SDR and lineality space is contained in C. We prove that the closure of a bounded convex set is SDR if all its projections are SDR. Closed convex sets are SDR if all their sections are SDR. We construct explicit semidefinite representation using representations of sections or projections.

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CP16

Ellipsoidal Rounding for Nonnegative Matrix Factorization Under Noisy Separability

We present a numerical algorithm for nonnegative matrix factorization (NMF) problems under noisy separability. An NMF problem under separability can be stated as one of finding all vertices of the convex hull of data points. The interest of this study is to find the vectors as close to the vertices as possible in a situation where noise is added to the data points. We show that the algorithm is robust to noise from theoretical and practical perspectives.

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CP16

A Semidefinite Approximation for Symmetric Travelling Salesman Polytopes

A. Barvinok and E. Veomett had introduced a hierarchy of approximations of a convex set via projections of spectrahedra. The main results of this talk are quantitative measurements on the quality of these approximations for the symmetric travelling salesman polytopes T_n and $T_{n,n}$ associated to the complete graph K_n and the complete bipartite graph $K_{n,n}$ respectively. By a result of Veommett it is known that scaling the $k-$th approximation by the factor $n/k + O(1/n)$ contains the polytope T_n for $k \leq \lfloor n/2 \rceil$. We show that these metric bounds can be improved by a factor of $\frac{1}{3}\sqrt{\frac{k-1}{\frac{n}{2}-1}} + \frac{2}{3}$. Moreover, we give new metric bounds for the k-th spectrahedral approximation of the travelling salesman polytope $T_{n,n}$. These results are joint work with M. Velasco.

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CP16

On Solving An Application Based Completely Positive Program of Size 3

In this talk, I will discuss a (dual) completely positive program, with matrices involved to be of size 3, that arises from a supply chain problem. This (dual) completely positive program is solved completely to obtain a closed form solution. The supply chain problem will also be discussed in the talk.

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CP16

Parallel Matrix Factorization for Low-Rank Tensor Recovery

Multi-way data naturally arises in applications, among which there are many with missing values or compressed data. In this talk, I will present a parallel matrix factorization method for low-rank recovery. Existing methods either unfold the tensor to a matrix and then apply low-rank matrix recovery, or employ nuclear norm minimization to each mode unfolding of the tensor. The former methods are often inefficient since they only utilize one mode low-rankness of the tensor, while the latter ones are usually slow due to expensive SVD. We address both these two problems. Though our model is highly non-convex, I will show that our method performs reliably well on a wide range of low-rank tensors including both synthetic data and real-world 3D images and videos.

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CP17

Design and Operating Strategy Optimization of Wind, Diesel and Batteries Hybrid Systems for Isolated Sites

Simultaneous optimization of hybrid electricity production systems (HEPS) design and operating strategy for isolated sites is a real challenge. Our approach: Off Grid Electricity Supply Optimization (OGESO) is based on a mixed integer programing model to find HEPS optimal design and optimal one year hourly power dispatch with deterministic data. This hourly dispatch is then analyzed by data mining to find an appropriate operating strategy. First results show benefits of using OGESO rather than simulation.

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CP17

A Mixed Integer Programming Approach for the Police Districting Problem

We have developed a multiobjective mixed integer programming approach for a districting problem based on the Carabineros de Chile's case. This approach has shape considerations and balance constraints between the districts. This problem is difficult to solve for small instances (50 nodes). We solve this problem with a Location Allocation Heuristic and we can found a lot of feasibles solutions with good properties in few seconds for realistics size instances (over 400 nodes).

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CP17

Mixed Integer Linear Programming Approach to a Rough Cut Capacity Planning in Yogurt Production

A rough cut capacity plan is important to meet weekly demand of multiple stock-keeping units (SKU) of perishable products like yogurt. We propose a mixed integer linear programming (MILP) model, that create a capacity plan considering the relevant process parameters, capacity and processing times of the different production stages while incorporating relevant constraints in the filling and packaging processes. The model helps identifying the bottleneck processes and in exploring possible alternatives to meet demand.

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CP17

Solution Methods for Mip Models for Chemical Production Scheduling

We discuss three solution methods for MIP models for chemical production scheduling. First, we develop a propagation algorithm to calculate bounds on the number of batches needed to meet demand and valid inequalities based on these bounds. Second, we generate models that employ multiple time grids, thereby substantially reducing the number of binaries. Third, we propose reformulations which lead to more efficient branching. The proposed methods reduce solution times by several orders of magnitude.

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CP17

Power Efficient Uplink Scheduling in SC-FDMA: Bounding Global Optimality by Column Generation

We study resource allocation in cellular systems and consider the problem of finding a power efficient scheduling in an uplink single carrier frequency division multiple access (SC-FDMA) system with localized allocation of subcarriers. An integer linear programming and column-oriented formulation is provided. The computational evaluation demonstrates that the column generation method produces very high-quality subcarrier allocations that either coincide with the global optimum or enable an extremely sharp bounding interval.

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CP17

Rectangular Shape Management Zone Delineation in Agriculture Planning by Using Column Generation

We consider an optimization model for the delineation of a field into rectangular-shape site-specific management zones and propose a column generation method for solving it. At each iteration of the algorithm, the subproblem verifies the optimality condition of the solution proposed by the reduced master problem, or provides a new set of feasible zones. This master problem gives a partition of the field minimizing the number of zones, while maximizing the homogeneity within this zones.

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CP18

Optimal Scenario Set Partitioning for Multistage Stochastic Programming with the Progressive Hedging Algorithm

We propose a new approach to construct scenario bundles that aims to enhance the convergence rate of the progressive hedging algorithm. We apply a heuristic to partition the scenario set in order to minimize the number of non-anticipativity constraints on which an augmented Lagrangian relaxation must be applied. The proposed method is tested on an hydroelectricity generation scheduling problem covering a 52-week planning horizon.

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CP18

A Modified Sample Approximation Method for Chance Constrained Problems

In this talk, we present a modified sample approximation (SA) method to solve the chance constrained problems. We show that the modified SA problem has similar convergence properties as the previous SA approximation one. Moreover, the modified SA problem is convex under some conditions. Finally, numerical experiments are conducted to illustrate the strength of the modified SA approach.

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CP18

Multiple Decomposition and Cutting-Plane Generations for Optimizing Allocation and Scheduling

with a Joint Chance Constraint

We study a class of stochastic resource planning problems where we integrate resource allocation and job scheduling decisions under uncertain job processing time. We minimize the number of resource units allocated, subject to a low risk of resource use overtime modeled as a joint chance constraint. We formulate a mixed-integer program based on discrete samples of the random processing time. We develop a multi-decomposition algorithm that first decomposes allocation and scheduling into two stages. We strengthen the first stage by adding a joint chance constraint related to the original one, and implement a cutting-plane algorithm using scenario-wise decomposition. At the second stage, we implement a resource-wise decomposition to verify the feasibility of the current first-stage solution. We test instances of operating room allocation and scheduling generated based on real hospital data, and show very promising results of our multi-decomposition approach.

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CP18

Uncertainty Quantification and Optimization Using a Bayesian Framework

This paper presents a methodology that combines uncertainty quantification, propagation and robustness-based design optimization. Epistemic uncertainty regarding model inputs/parameters is efficiently propagated using an auxiliary variable approach. The uncertainty quantification result is used to inform design optimization to improve the systems robustness and reliability. The proposed methodology is demonstrated using a challenge problem developed by NASA.

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CP18

Application of Variance Reduction to Sequential Sampling in Stochastic Programming

We apply variance reduction techniques, specifically antithetic variates and Latin hypercube sampling, to optimality gap estimators used in sequential sampling algorithms. We discuss both theoretical and computational results on a range of test problems.

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CP18

A New Progressive Hedging Algorithm for Linear Stochastic Optimization Problems

Progressive Hedging Algorithm, while introduced more than twenty years ago, remains a popular method dealing with multistage stochastic problems. The performance can be poor due to the number of quadratic penalty terms associated with nonanticipativity constraints. In this work, we investigate its connection with the developments in augmented Lagrangian methods. We consider linear penalty terms in order to preserve linearity when present in the original problem, and evaluate the numerical performance on various test problems.

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CP19

First-Order Methods Yield New Analysis and Results for Boosting Methods in Statistics/Machine Learning

Using mirror descent and other first-order convex optimization methods, we present new analysis, convergence results, and computational guarantees for several well-known boosting methods in statistics, namely AdaBoost, Incremental Forward Stagewise Regression (FS_ε), and their variants. For AdaBoost and FS_ε, we show that a minor variant of these algorithms corresponds to the Frank-Wolfe method on a constraint-regularized problem, whereby the modified procedures converge to optimal solutions at an $O(1/k)$ rate.

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CP19

Design Optimization with the Consider-Then-Choose Behavioral Model

The consider-then-choose model describes a decision-making process in which consumers first eliminate a large number of product alternatives with non-compensatory screening rules, subsequently performing careful tradeoff evaluation over the remaining alternatives. Modeling consideration introduces discontinuous choice probabilities to optimization problems using choice probabilities as a demand model. We compare several treatments of this discontinuous optimization problem: genetic algorithms, smoothing, and relaxation via complementary constraints. The application of methods is illustrated through a vehicle design example.

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CP19

Numerical Optimization of Eigenvalues of Hermitian Matrix-Valued Functions

We present numerical approaches for (i) unconstrained optimization of a prescribed eigenvalue of a Hermitian matrix-valued function depending on a few parameters analytically, and (ii) an optimization problem with linear objective and an eigenvalue constraint on the matrix-valued function. The common theme for numerical approaches is the use of global under-estimators, called support functions, for eigenvalue functions, that are built on the analyticity and variational properties of eigenvalues over the space of Hermitian matrices.

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CP19

Finite Hyperplane Traversal Algorithms for 1-Dimensional L^1pTV Minimization for $0 < p \leq 1$

We consider a discrete formulation of the one-dimensional L^1pTV functional and introduce finite algorithms that find exact minimizers for $0 < p < 1$ and exact global minimizers for $p = 1$. The algorithm returns solutions for all scale parameters λ at the same computational cost of a single λ solution. This finite set of minimizers contains the scale signature of the initial data. Variant algorithms are discussed for both general and binary data.

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CP19

A Feasible Second Order Bundle Algorithm for Nonsmooth, Nonconvex Optimization Problems

We extend the SQP-approach of the well-known bundle-Newton method for nonsmooth unconstrained minimization to the nonlinearly constrained case. Instead of using a penalty function or a filter or an improvement function to deal with the presence of constraints, the search direction is determined by solving a convex quadratically constrained quadratic program to obtain good iteration points. Issues arising with this procedure concerning the bundling process as well as in the line search are discussed. Furthermore, we show global convergence of the method under certain mild assumptions.

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CP19

A Multilevel Approach for L-1 Regularized Convex Optimization with Application to Covariance Selection

We present a multilevel framework for solving l-1 regularized convex optimization problems, which are widely popular in the fields of signal processing and machine learning. Such l-1 regularization is used to find sparse minimizers of the convex functions. The framework is used for solving the Covariance Selection problem, where a sparse inverse covariance matrix is estimated from a only few samples of a multivariate normal distribution. Numerical experiments demonstrate the potential of this approach, especially for large-scale problems.

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CP20

Improving Fast Dual Gradient Methods for Repetitive Multi-Parametric Programming

We show how to combine the low iteration cost of first order methods with the fast convergence rate of second order methods, when solving the dual to composite optimization problems with one quadratic term. This relies on a new characterization of the set of matrices $\mathcal{L}$ that approximate the negative dual Hessian $H(\lambda)$ such that $L - H(\lambda) \succeq 0$ for any dual variable λ and all $L \in \mathcal{L}$. A Hessian approximation is computed ones and used throughout the algorithm.

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CP20

Sliding Mode Controller Design of Linear Interval Systems Via An Optimised Reduced Order Model

This paper presents a method of designing the Sliding Mode Controller for large scale Interval systems. The Controller is designed via an optimised stable reduced order model. The proposed reduction method makes use of Interpolation criteria. It has been shown that the Sliding Mode Controller designed for the reduced order model, when applied to the higher order system, improves the performance of the controlled system. Some numerical examples are tested and found satisfactory.

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CP20

Moreau-Yosida Regularization in Shape Optimization with Geometric Constraints

We employ the method of mappings to obtain an optimal control problem with nonlinear state equation on a reference domain. The Lagrange multiplier associated with the geometric shape constraint has low regularity, which we circumvent by penalization and a continuation scheme. We employ a Moreau-Yosida-type regularization and assume a second-order condition. We study the properties of the regularized solutions, which we obtain by a semismooth Newton method. The theoretical results are supported by numerical tests.

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CP20

Intelligent Optimizing Controller: Development of a Fast Optimal Control Algorithm

In this paper we propose a novel algorithm to solve a trajectory optimization problem. The proposed algorithm does not need an explicit dynamic model of the system but computes partial derivatives of dynamic function numerically from observation history to estimate the adjoint variable and the Hamiltonian. A candidate optimal control trajectory is computed such that the resulting Hamiltonian is constant, which is a necessary condition for optimality. Simulations are used to test the algorithm.

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CP20

Sensitivity-Based Multistep Feedback MPC: Algorithm Design and Hardware Implementation

In model predictive control (MPC), an optimization problem is solved every sampling instant to determine an optimal control for a physical system. We aim to accelerate this procedure for fast systems applications and address the challenge of implementing the resulting MPC scheme on an embedded system. We present the sensitivity-based multistep feedback MPC a strategy which significantly reduces the time, cost and energy consumption in computing control actions while fulfilling performance expectations.

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CP20

Optimal Actuator and Sensor Placement for Dynamical Systems

Vibrations occur in many areas of industry and produce undesirable side effects. To avoid respectively suppress these effects actuators and sensors are attached to the structure. The appropriate positioning of actuators and sensors is of significant importance for the controllability and observability of the structure. In this talk, a method for determining the optimal actuator and sensor placement is presented, which leads to an optimization problem with binary and continuous variables and linear matrix inequalities.

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CP21

Some Mathematical Properties of the Dynamically Inconsistent Bellman Equation: A Note on the Two-Sided Altruism Dynamics

This article describes some dynamic aspects on dynastic utility incorporating two-sided altruism with an OLG setting. The dynamically inconsistent Bellman equation proves to be reduced to one-sided dynamic problem, but the effective discount factor is different only in the current generation. It is shown that a contraction mapping result of value function cannot be achieved in general, and that there can locally exist an infinite number of self-consistent policy functions with distinct steady states.

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CP21

Characterization of Optimal Boundaries in Reversible Investment Problems

This paper studies a reversible investment problem where a social planner aims to control its capacity production in order to fit optimally the random demand of a good. Our model allows for general diffusion dynamics on the demand as well as general cost functional. The resulting optimization problem leads to a degenerate two-dimensional singular stochastic control problem, for which explicit solution is not available in general and the standard verification approach can not be applied a priori. We use a direct viscosity solutions approach for deriving some features of the optimal free boundary function, and for displaying the structure of the solution. In the quadratic cost case, we are able to prove a smooth-fit C^2 property, which gives rise to a full characterization of the optimal boundaries and value function.

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CP21

Numerical Methods and Computational Results for Solving Hierarchical Dynamic Optimization Problems

We present numerical methods for hierarchical dynamic optimization problems with a regression objective on the upper level and a nonlinear optimal control problem in ordinary differential equations with mixed control-state constraints and discontinuous transitions on the lower level. Numerical results from a recent benchmarking study are provided. Furthermore, our hierarchical dynamic optimization methods are used to identify gait models from real-world data of the Orthopaedic Hospital Heidelberg that are used for treatment planning.

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CP21

Solution of Optimal Control Problems by Hybrid Functions

In this talk, a numerical method for solving the nonlinear constrained optimal control with quadratic performance index is presented. The method is based upon hybrid functions approximation. The properties of hybrid functions consisting of block-pulse functions and Bernoulli polynomials are presented. The numerical solutions are compared with available exact or approximate solutions in order to assess the accuracy of the proposed method.

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CP21

A Dual Approach on Solving Linear-Quadratic Control Problems with Bang-Bang Solutions

We use Fenchel duality to solve a class of linear-quadratic optimal control problems for which we assume a bang-bang solution. We determine that strong duality holds in this case. In numerical experiments we then compare the solution of both the dual and the original problem and figure out if computational savings can be obtained. The discretization of these problems will also be discussed.

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CP21

Improved Error Estimates for Discrete Regularization of Linear-Quadratic Control Problems with Bang-Bang Solutions

We consider linear–quadratic “state regulator problems' with “Bang–Bang' solutions. In order to solve these problems numerically, we analyze a combined regularization–discretization approach. By choosing the regularization parameter α with respect to the mesh size h of the discretization we approximate the optimal solution. Under the assumption that the optimal control has bang–bang structure we improve existing error estimates of order $\mathcal{O}(\sqrt{h})$ to $\mathcal{O}(h)$. Moreover we will show that the discrete and the continuous controls coincide except on a set of measure $\mathcal{O}(h)$.

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CP22

Optimal Subgradient Algorithms for Large-Scale Structured Convex Optimization

Optimal subgradient algorithms for solving wide classes of large-scale structured convex optimization are introduced. Our framework considers the first-order oracle and provides a novel fractional subproblem which can be explicitly solved by employing appropriate prox-functions. Convergence analysis certifies attaining first-order optimal complexity for smooth and nonsmooth convex problems. Comprehensive numerical experiments on problems in signal and image processing and machine learning including comparisons with state-of-the-art solvers are reported.

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CP22

The Block Coordinate Descent Method of Multipliers

In this paper, we consider a (possibly nonsmooth) convex optimization problem with multiple blocks of variables and a linear constraint coupling all the variables. We propose an algorithm called block coordinate descent method of multipliers (BCDMM) to solve this family of problems. The BCDMM is a primal-dual type of algorithm. It integrates the traditional block coordinate decent (BCD) algorithm and the alternating direction method of multipliers (ADMM), in which it optimizes the (approximated) augmented Lagrangian of the original problem one block variable each time, followed by a gradient update for the dual variable. Under certain regularity conditions, and when the order for which the block variables are either updated in a deterministic way or in a random fashion, we show that the BCDMM converges, under either a diminishing stepsize rule or a small enough stepsize for the dual update.

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CP22

A Unified Framework for Subgradient Algorithms Minimizing Strongly Convex Functions

We propose a unified framework for (sub)gradient algorithms for both non-smooth and smooth convex optimization problems whose objective function may be strongly convex. Our algorithms have as particular cases the mirror-descent, Nesterov's dual-averaging and variants of Tseng's accelerated gradient methods. We exploit Nesterov's idea to analyze those methods in a unified way. This framework also provides some variants of the conditional gradient method.

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CP22

The Exact Penalty Map for Nonsmooth and Nonconvex Optimization

Augmented Lagrangian duality provides zero duality gap and saddle point properties for nonconvex optimization. Hence, subgradient-like methods can be applied to the (convex) dual of the original problem, recovering the optimal value of the problem, but possibly not a primal solution. We prove that the recovery of a primal solution by such methods can be characterized in terms of the differentiability properties of the dual function and the exact penalty properties of the primal-dual pair.

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CP22

A Primal-Dual Augmented Lagrangian Method for Equality Constrained Minimization

We propose a primal-dual method for solving equality constrained minimization problems. This is a Newton-like method applied to a perturbation of the optimality system that follows from a reformulation of the initial problem by introducing an augmented Lagrangian to handle equality constraints. An important aspect of this approach is that the algorithm reduces asymptotically to a regularized Newton method applied to KKT conditions of the original problem. The rate of convergence is quadratic.

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CP22

A New Algorithm for Least Square Problems Based on the Primal Dual Augmented Lagrangian Approach

We propose a new algorithm for least square problems based on the Primal Dual Augmented Lagrangian approach of Gill and Robinson. This talk will explore the effects of the regularization term on constant objective problems and suggest strategies for improving convergence to the nonlinear constraint manifold in the presence of general objectives. Theoretical and numerical results will be given.

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CP23

A Three-objective Mathematical Model for One-dimensional Cutting and Assortment Problems

In this talk, a new three-objective linear integer programming model without the use of a set of cutting patterns is developed. The objectives are related to the trim loss amount, the total number of different standard lengths used, and the production amount that exceeds the given demand for each cutting order. The advantages of the proposed mathematical model are demonstrated on test problems.

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CP23

Nonlinear Programming in Runtime Procedure of Guidance, Navigation and Control of Autonomous Systems

We redefine a runtime procedure of guidance, navigation and control of autonomous systems as constraint programming. We build a list of nonlinear equality constraints that corresponds to nonlinear dynamics of the system under control, and a list of linear inequality constraints that specifies action commands subject to safety constraints and operational capability. Violations to the safety constraints and the constraints regarding the action are observed as hazardous action and loss of control, respectively. We report an issue of execution time that primal-dual interior point method IPOPT determines infeasible when there exists any input vectors that satisfy all constraints.

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CP23

Strong Formulations for Stackelberg Security Games

Recent work in security applications uses Stackelberg games to formulate the problem of protecting critical infrastructure from strategic adversaries. In this work we explore different integer programming formulations for these Stackelberg security games. Our results show that 1) there is a tight linear programming formulation in the case of one adversary; 2) this formulation exhibits a smaller integrality gap in general; 3) this formulation does not work with payoff structures common in security applications.

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CP23

Studying Two Stage Games by Polynomial Programming

We are investigating two stage games, such as those studied by Kreps and Scheinkman (1983). Two profit maximizing players choose simultaneously their capacity in a first stage. In the second stage there is a Bertrand-like price competition. In the original paper this produced a unique equilibrium, namely the Cournot outcome. We alter some of the functions used to specify the problem. Doing so we loose many of the nice properties exhibited by the original problem. This makes a numerical treatment necessary. Using the first order conditions for the second stage game does not work in this case, since the final system of KKT conditions might not even have the real equilibrium as a solution. We use a Positivstellensatz from real algebraic geometry to reformulate the second stage game. We then solve the resulting game with standard methods form nonlinear optimization.

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CP23

Multi-Agent Network Interdiction Games

Network interdiction games involve multiple leaders who utilize limited resources to disrupt the network operations of adversarial parties. We formulate a class of such games as generalized Nash equilibrium problems. We show that these problems admit potential functions, which enables us to design algorithms based on best response mechanisms that converge to equilibria. We propose to study the inefficiency of equilibria in such games using a decentralized algorithm that enables efficient computation.

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CP23

Using Optimization Methods for Efficient Fatigue Criterion Evaluation

In many industrial fields, computer simulations of durability are increasing in importance. In such simulations, critical plane criteria are often used to determine the probability of fatigue crack initiation in a point. This type of criterion involves searching, in each material point, for the plane where the combination of stresses is the most damaging. This talk concerns new efficient ways to evaluate this type of criterion, which are based on the use of optimization methods, shortening the lead time and increasing the accuracy of the results.

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CP24

Optimization of Radiotherapy Dose-Time Fractionation of Proneural Glioblastoma with Consideration of Biological Effective Dose for Early and Late Responding Tissues

We examined the optimal fractionation problem in the context of a novel model for radiation response in brain tumors recently developed in Leder et. al. (in press Cell), where the radiation response of stem-like and tumor bulk cells are considered separately. We find the minimal number of tumor cells at the conclusion of treatment while keeping the toxicity in early and late responding tissues at an acceptable level. This is carried out using non-linear programming methodology

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CP24

Robust Optimization Reduces the Risks Occurring from Delineation Uncertainties in HDR Brachytherapy for Prostate Cancer

Delineation inaccuracy is a widely recognized phenomenon in HDR brachytherapy, though with unknown effects on dosimetry. We show that these uncertainties yield a high risk of undesirably low target coverage, resulting in insufficient tumor control. The classical solution, using a margin, results in overdosage. Therefore, robust optimization techniques are used for taking these uncertainties into account when optimizing treatment plans. The model shows a crucial improvement in target coverage, without the risk of overdosage.

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CP24

An Re-Optimization Approach for the Train Dispatching Problem (tdp)

The TDP is to schedule trains through a network in a cost optimal way. Due to disturbances during operation existing track schedules often have to be re-scheduled and integrated into the timetable. This has to be done in seconds and with minimal timetable changes to guarantee conflict free operation. We present an integrated modeling approach for the re-optimization task using Mixed Integer Programming and provide computational results for scenarios deduced from real world data.

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CP24

Optimizing Large Scale Concrete Delivery Problems

In Ready Mixed Concrete (RMC) dispatching, common practice is to rely on human experts for any necessary real-time decision-making. This is due to the perceived complexity of RMC dispatching and the general lack of highly applicable optimization tools for the task. Critically, the accuracy of expert decisions (as compared to optimization approaches) has not been comprehensively examined in the literature. To address the question of current-practice expert accuracy in the context of optimized outcomes, this paper first models the RMC dispatching problem mathematically according to the introduced methods in the literature. Two approaches are taken, which are integer programming (without time windows) and mixed integer programming (with time windows). Further, the constructed models are tested with field data and compared with the decisions as made by experts. The results show that on average experts decisions are 90% accurate in comparison to the examined optimization models.

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CP24

Stochastic Patient Assignment Models for Balanced Healthcare in Patient Centered Medical Home

Recently, patient centered medical home (PCMH) has become a popular model for providing healthcare services. PCMH is a team based service and each team consists of a group of professionals. In order to make balance between healthcare supply and demand portfolios, we develop stochastic optimization models to allocate patients to all PCMH teams to have an equitable level of workload for each team member.

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CP24

A Novel Framework for Beam Angle Optimization in Radiation Therapy

Two important elements of a radiation therapy treatment plan are quality, which depends on dose to organs at risk (OARs), and delivery time, which depends on the number of beams. We propose a technique to find the plan with the minimum number of beams and a predetermined maximum deviation from the ideal plan, which uses all candidate beams. We use mixed integer programming for optimization and two heuristics to reduce the computation time.

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CP25

On Estimating Resolution Given Sparsity and Non-Negativity

We consider imaging problems where additional information such as sparsity or non-negativity may be used to reconstruct the image to a higher resolution than possible without such information. Just as optimization techniques are required to find the improved image estimate, optimization must also be used to describe the true system performance. We discuss linear and conic programming problems that estimate the data-dependent performance of a system given a particular image, and provide insight into the interpretation of the result in underdetermined cases.

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CP25

Some Insights from the Stable Compressive Principal Component Pursuit

We propose a new problem related to compressive principal component pursuit, i.e., a low rank and sparse matrix decomposition from a partial measurement, which additionally takes into account some noise. The computational results for randomly generated problems suggest that we can have a perfect recovery of a low rank matrix for small perturbations.

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CP25

The Convex Hull of Graphs of Polynomial Functions

The convex hull of the graph of a polynomial function over a polytope is the intersection of all closed half-spaces containing the graph. We give a description of these half-spaces using semi-algebraic sets. This gives a finite algorithm to compute the convex hull. For polynomials in low dimension and degree (related to real applications), a polyhedral relaxation can be computed quickly by an algorithm which can be extended to a spatial branch-and-bound algorithm for MINLPs.

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CP25

A Tight Iteration-complexity Bound for IPM via Redundant Klee-Minty Cubes

We consider two curvature integrals for the central path of a polyhedron. Redundant Klee-Minty cubes (Nematollahi et al., 2007) have central path whose geometric curvature is exponential in the dimension of the cube. We prove an analogous result for the curvature integral introduced by Sonnevend et al. 1990. For the Mizuno-Todd-Ye predictor-corrector algorithm, we prove that the iteration-complexity upper bound for the Klee-Minty cubes is tight.

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CP25

Quadratically Constrained Quadratic Programs with On/off Constraints and Applications in Signal Processing

Many applications from signal processing can be modeled as (non-convex) quadratically constrained quadratic programs (QCQP) featuring "on/off" constraints. Our solution strategy for solving the underlying QCQPs includes the consideration of a semidefinite programming relaxation as well as the sequential second-order cone programming algorithm. We deal with the "on/off" structure within a SDP-based Branch-and-Bound algorithm. Moreover, convergence results and some first numerical results are presented.

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CP25

A Fast Quasi-Newton Proximal Gradient Algorithm for Basis Pursuit

We propose a proximal-gradient algorithm in which the approximate Hessian is the identity minus a rank-one (abbreviated IMRO) matrix. IMRO is intended to solve the basis-pursuit denoising (BPDN) variant of compressive sensing signal recovery. Depending on how the rank-one matrix is chosen, IMRO can be regarded as either a generalization of linear conjugate gradient or a generalization of FISTA. According to our testing, IMRO often outperforms other published algorithms for BPDN.

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CP26

Super Linear Convergence in Inexact Restoration Methods

Inexact Restoration methods are optimization methods that address feasibility and optimality in different phases of each iteration. In 2005 Birgin and Martinez propose a method, within the Inexact Restoration framework, which has good local convergence properties. However the authors did not prove that the method is well defined, they only suggest an alternative to attempt to complete an iteration of the method. Our contributions are to present sufficient conditions to ensure that the iteration is well defined and to show a Newtonian way to complete the iteration under these assumptions.

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CP26

The Balance Optimization Subset Selection (BOSS) Model for Causal Inference

Matching is used to estimate treatment effects in observational studies. One mechanism for overcoming its restrictiveness is to relax the exact matching requirement to one of balance on the covariate distributions for the treatment and control groups. The Balance Optimization Subset Selection (BOSS) model is introduced to identify a control group featuring optimal covariate balance. This presentation discusses the relationship between the matching and BOSS models, providing a comprehensive picture of their relationship.

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CP26

Preconditioned Gradient Methods Based on

Sobolev Metrics

We give a description of the application of the Sobolev gradient method to continuous optimization problems, such as the the minimization of the Ginzburg-Landau and Gross-Pitaevskii energy functionals governing superconductivity and superfluidity. The Sobolev gradient method leads to operator preconditioning of the Euler-Lagrange equations. A significant gain in computational efficiency is obtained for the above problems. We end with an extension of the Sobolev gradient method to include quasi-Newton methods.

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CP26

Regional Tests for the Existence of Transition States

Aiming to locate the transition states (first-order saddle points) of general nonlinear functions, we introduce regional tests for the identification of hyper-rectangular areas that do not contain a transition state. These tests are based on the interval extensions of theorems from linear algebra and can be used within the framework of global optimization methods which would otherwise expend computational resources locating all stationary points.

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CP26

Primal and Dual Approximation Algorithms for Convex Vector Optimization Problems

Two approximation algorithms for solving convex vector optimization problems (CVOPs) are provided. Both algorithms solve the CVOP and its geometric dual problem simultaneously. The first algorithm is an extension of Benson's outer approximation algorithm, and the second one is a dual variant of it. Both algorithms provide an inner as well as an outer approximation of the (upper and lower) images. Only one scalar convex program has to be solved in each iteration. We allow objective and constraint functions that are not necessarily differentiable, allow solid pointed polyhedral ordering cones, and relate the approximations to an appropriate ϵ-solution concept.

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CP26

Approximating the Minimum Hub Cover Problem on Planar Graphs and Its Application to Query Optimization

We introduce a new combinatorial optimization problem which is NP-hard on general graphs. The objective is to cover the edges of a graph by selecting a set of hub nodes. A hub node covers its incident edges and also the edges between its adjacent neighbors. As an application, we discuss query processing over graph databases. We introduce an approximation algorithm for planar graphs arising in object recognition and biometric identification and investigate its empirical performance.

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MS1

Dynamic Extensible Bin Packing with Applications to Patient Scheduling

We present a multistage stochastic programming model formulation for a dynamic version of the stochastic extensible bin packing problem. Motivated by applications to health services, we discuss a special case of the problem that can be solved using decomposition methods. Results for a series of practical tests cases are presented. Performance guarantees for fast approximations are developed and their expected performance is evaluated.

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MS1

Online Stochastic Optimization of Radiotherapy Patient Scheduling

The effective management of a cancer treatment facility for radiation therapy depends mainly on optimizing the use of the linear accelerators. In this project, we schedule patients on these machines taking into account their priority for treatment, the maximum waiting time before the first treatment, and the treatment duration. We collaborate with the Centre Intgr de Cancrologie de Laval to determine the best scheduling policy. Furthermore, we integrate the uncertainty related to the arrival of patients at the center. We develop a hybrid method combining stochastic optimization and online optimization to better meet the needs of central planning. We use information on the future arrivals of patients to provide an accurate picture of the expected utilization of resources. Results based on real data show that our method outperforms the policies typically used in treatment centers.

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MS1

Scheduling Chemotherapy Patient Appointments

This talk reports our four year effort to improve chemotherapy appointment scheduling practices at the BC Cancer Agency (BCCA). It describes our initial work at the Vancouver Clinic including our process review, optimization model, software development, implementation, evaluation and modifications to address system changes. It then discusses the challenges encountered implementing the tool at three other BCCA clinic locations and more broadly.

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MS1

Chance-Constrained Surgery Planning under Uncertain or Ambiguous Surgery Time

In this paper, we consider surgery planning problems under uncertain operating time of surgeries. We decide which operating rooms (ORs) to open, allocation of surgeries to ORs, as well as the sequence and time to start each surgery. We formulate a binary integer program with individual and joint chance constraints to restrict the risk of having surgery delays and overtime ORs, respectively. We further analyze a distributionally robust problem variant by assuming ambiguous distributions of random surgery time, for which we build a confidence set using statistical divergence functions. The variant restricts the maximum risk of surgery delay and OR overtime for any probability function in the confidence set, and becomes equivalent to a chance-constrained program evaluated on an empirical probability function but with smaller risk tolerances. We compare different models, approaches and derive insights of surgery planning under surgery time uncertainty or ambiguity.

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MS2

Multiple Optimization Problems with Equilibrium Constraints (MOPEC)

We present a mechanism for describing and solving collections of optimization problems that are linked by equilibrium conditions. The general framework of MOPEC captures many example applications that involve independent decisions coupled by shared resources. We describe this mechanism in the context of energy planning, environmental and land-use problems. We outline several algorithms and investigate their computational efficiency. Some stochastic extensions will also be outlined.

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MS2

Methods of Computing Individual Confidence Intervals for Solutions to Stochastic Variational Inequalities

Stochastic variational inequalities provide a means for modeling various optimization and equilibrium problems where model data are subject to uncertainty. Often the true form of these problems cannot be analyzed and some approximation is used. This talk considers the use of a sample average approximation (SAA) and the question of building individual confidence intervals for components of the true solution computable only from the sample data. Two methods will be contrasted to illustrate the benefits of incorporating the SAA solution more directly in the computation of interval half-widths.

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MS2

Semismooth Newton Method for Differential Variational Inequalities

We study a semismooth Newton method for differential variational inequalities (DVIs). Such problems comprise the solution of an ODE and a variational inequality (VI) and have various applications in engineering as well as in economic sciences. The method we propose is based on a suitable time discretization scheme of the underlying ODE and a reformulation of the resulting finite dimensional problem as a system of nonlinear, nonsmooth equations. We will theoretically analyze the resulting method and finish with some numerical results.

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MS2

On the Optimal Control of a Class of Variational Inequalities of the Second Kind

We consider optimal control problems in which the feasible set is governed by a certain class of variational inequalities of the second kind. The class encompasses a number of important applications in mechanics and image processing. As a means of comparison to known results, we consider both discretized and continuous forms of the problem. The existence of a hierarchy of optimality conditions (S-/M-/C-stationarity) similar to MPCC and MPEC models is shown. Our approach uses sensitivity results for the control-to-state mapping of the variational inequality. Finally, a numerical method is developed and its performance is illustrated by a few examples.

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MS3

A Robust Additive Multiattribute Preference Model using a Nonparametric Shape-Preserving Perturbation

We develop a multiattribute preference ranking rule in the context of utility robustness. A nonparametric perturbation of a given additive reference utility function is specified to solve the problem of ambiguity and inconsistency in utility assessments, while preserving the additive structure and the decision maker's risk preference under each criterion. A concept of robust preference value is defined using the worst expected utility of an alternative incurred by the perturbation, and we rank alternatives by comparing their robust preference values.

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MS3

Distributionally-Robust Support Vector Machines for Machine Learning

We propose distributionally-robust Support Vector Machines (DR-SVMs) and present an algorithm to solve the DR-SVMs. We assume that the training data are drawn from an unknown distribution and consider the standard SVM as a sample average approximation (SAA) of a stochastic version of SVM with the unknown distribution. Using the ambiguity set based on the Kantorovich distance, we find the robust-counterpart of the stochastic SVM.

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MS3

Distributionally Robust Modeling Frameworks and Results for Least-Squares

Abstract not available.

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MS3

A Cutting Surface Algorithm for Semi-infinite Convex Programming and Moment Robust Optimization

We present a novel algorithm for distributionally robust optimization problems with moment uncertainty. First a new cutting surface algorithm is presented, that is applicable to problems with non-differentiable semi-infinite constraints indexed by an infinite-dimensional set. Our second ingredient is an algorithm to find approximately optimal discrete probability distributions subject to moment constraints. The combination of these algorithms yields a solution to a general family of distributionally robust optimization problems.

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MS4

The Two Facility Splittable Flow Arc Set

We study a generalization of the single facility splittable flow arc set which was studied by Magnanti et. al. (1993), who obtained the facial structure of the convex hull of this set. A simple separation algorithm for this set was later given by Atamturk and Rajan. The set is defined by a single capacity constraint, one nonnegative integer variable and any number of bounded continuous variables. We generalize this set by considering two integer variables and give its convex hull.

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MS4

How Good Are Sparse Cutting-Planes?

Sparse cutting-planes are often used in mixed-integer programming solvers, since they help in solving linear programs more efficiently. However, how well can we approximate the integer hull by just using sparse cutting-planes? In order to understand this question better, given a polyope P (e.g. the integer hull of a MIP), let P^k be its best approximation using cuts with at most k non-zero coefficients. We present various results on how well P^k approximates P.

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MS4

Finitely Convergent Decomposition Algorithms for Two-Stage Stochastic Pure Integer Programs

We study a class of two-stage stochastic integer programs with general integer variables in both stages and finitely many realizations of the uncertain parameters. We propose decomposition algorithms, based on Benders method, that utilize Gomory cuts in both stages. The Gomory cuts for the second-stage scenario subproblems are parameterized by the first-stage decision variables. We prove the finite convergence of the proposed algorithms and report our computations that illustrate their effectiveness.

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MS4

Water Networks Optimization: MILP vs MINLP Insights

We will consider some important applications in the design of energy networks, where energy is considered at large and includes the distribution of natural resources as for example water and gas. We will discuss the challenges of these applications and the good mathematical tools to deal with them, where often the difficulty arises in the decisions of when, where and what should be linearized.

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MS5

Rethinking MDO for Dynamic Engineering System Design

Dynamic engineering systems present distinctive design challenges, such as addressing time-varying behavior explicitly while managing the fundamentally connected activities of physical and control system design. Whole-system design strategies, such as multidisciplinary design optimization (MDO), are a promising solution. Existing MDO formulations, however, do not address explicitly the unique needs of dynamic systems. Recent results from the emerging area of multidisciplinary dynamic system design optimization (MDSDO) are presented that begin to address these gaps.

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MS5

Using Graph Theory to Define Problem Formulation in Openmdao

Graph theory is applied to develop a formal specification for optimization problem formulation. A graph can be constructed that uniquely defines the problem formulation. This graph syntax is implemented as the internal representation for problem formulation in the OpenMDAO framework. Combining the graph with standard graph traversal algorithms enables the framework compute system level analytic coupled derivatives very efficiently via Hwang and Martins general derivatives method. We demonstrate this capability on a large MDO problem with over 20 disciplines and 25000 design variables.

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MS5

A Matrix-free Trust-region SQP Method for Reduced-space PDE-constrained Optimization: Enabling Modular Multidisciplinary Design Optimization

In the reduced-space formulation of PDE-constrained optimization problems, the state variables are treated as implicit functions of the control variables via the PDE constraint. Such reduced-space formulations remain attractive in many applications, especially those with complex nonlinear physics that demand specialized globalization algorithms for the PDE. However, constraints (beyond the PDE) present a challenge for reduced-space algorithms, because the Jacobian is prohibitively expensive to form. This precludes many traditional optimization strategies — like null-space methods — that leverage factorizations of the Jacobian. This motivates the present work, which seeks a matrix-free trust-region SQP method to solve constrained optimization problems. In this talk, we will discuss the proposed algorithm and illustrate its use on a multidisciplinary design optimization problem in which the disciplines are coupled using constraints.

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MS5

A General Theory for Coupling Computational Models and their Derivatives

The computational solution of multidisciplinary optimization problems can be challenging due to the coupling between disciplines and the high computational cost. We have developed a general theory and framework that address these issues by decomposing the problem into variables managed by a central framework. The problem implementation then becomes a systematic process of defining each variable sequentially, and the solution of the multidisciplinary problem and the coupled derivatives can be automated.

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MS6

Cubic Regularization in Interior-Point Methods

We present several algorithms for nonlinear optimization, all employing cubic regularization. The favorable theoretical results of Griewank (1981), Nesterov and Polyak (2006), and Cartis et.al. (2011) motivate the use of cubic regularization, but its application at every iteration of the algorithm, as proposed by these papers, may be computationally expensive. We propose some modifications, and numerical results are provided to illustrate the robustness and efficiency of the proposed approaches on both unconstrained and constrained problems.

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MS6

A Stochastic Optimization Algorithm to Solve Sparse Additive Model

We present a new stochastic optimization algorithm to solve the sparse additive model problem. The problem is of the form $f(\mathbb{E}[g(x)])$. We prove that our algorithm converges almost surely to the optimal solution. This is the first algorithm solves the sparse additive model problem with a provably convergence result.

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MS6

An Exterior-Point Method for Support Vector Machines

We present an exterior-point method (EPM) for solving convex quadratic programming problems (QP) required to train support vector machines. The EPM allows iterates to approach the solution to the QP from the exterior of the feasible set. This feature helps design a simple active-passive strategy for reducing the size of linear systems solved at each EPM iteration and thus accelerating the algorithm. We present numerical results and discuss future directions for the EPM development.

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MS6

L1 Regularization Via the Parametric Simplex Method

An l_1 penalty term is often used to coerce sparsity in least-squares problems. The associated weighting parameter requires tuning to get the "right' answer. If the least-squares problem is changed to least-absolute-deviations (LAD), then the problem can be reduced to a linear programming problem that can be solved using the parametric simplex method thereby resolving the tuning question. We will report some comparisons between the least-squares approach and the LAD method.

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MS7

On Subspace Minimization Conjugate Gradient Method

The proposition of limited-memory BFGS method and Barzilai-Borwein gradient method heavily restrict the use of conjugate gradient method in large-scale optimization. This is, to the great extent, due to the requirement of a relatively exact line search at each iteration and the loss of conjugacy property of the search directions in various occasions. In this talk, I shall propose a new variant of the subspace minimization conjugate gradient method by Yuan and Stoer (1995). The new method shares with the Barzilai-Borwein gradient method a numerical advantage that the trial stepsize can be accepted by the corresponding line search when the iteration tends to the solution. Some theoretical properties of the method will be explored and some numerical results will be provided. Consequently, we can see that the proposed algorithm can become a promising candidate for large-scale optimization.

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MS7

Iteration-Complexity with Averaged Nonexpansive

Operators: Application to Convex Programming

In this paper, we establish the iteration-complexity bounds (pointwise and ergodic) for relaxed fixed point iteration built from the nonexpansive monotone operators, and apply them to analyze the convergence speed of various methods proposed in literature. Furthermore, for the generalized forward-backward splitting algorithm, recently proposed by Raguet, Fadili and Peyré for finding a zero of a sum of $n > 0$ maximal monotone operators and a cocoercive operator on a Hilbert space, we develop an easily verifiable termination criterion for finding an approximate solution, which is a generalization of the termination criterion for classic gradient descent methods. We then illustrate the usefulness of the above results by applying them to a large class of composite convex optimization problems of the form $f + \sum_{i=1}^{n} h_i$, where f has a Lipschitz-continuous gradient and the h_i's are simple (i.e. whose proximity operator is easily computable). Various experiments on signal and image recovery problem are shown.

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MS7

2. An Efficient Gradient Method Using the Yuan Steplength

We present a new gradient method for quadratic programming, which exploits the asymptotic spectral behaviour of the Yuan steplength to foster a selective elimination of the components of the gradient along the eigenvectors of the Hessian matrix. Numerical experiments show that this method tends to outperform other efficient gradient methods, especially as the Hessian condition number and the accuracy requirement increase.

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MS7

1. Faster Gradient Descent

How fast can practical gradient descent methods be? On average we observe cond($\sqrt{(}A)$), like for the conjugate gradient method. We will explain this, and also propose a new method related to Leja points. The performance of such methods as smoothers or regularizers is examined as well.

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MS8

A Two-Phase Augmented Lagrangian Filter Method

We present a new two-phase augmented Lagrangian filter method. In the first phase, we approximately minimize the augmented Lagrangian until a filter acceptable point is found. In the second phase, we use the active-set prediction from the first phase to an solve an equality-constrained QP. The algorithm also incorporates a feasibility restoration phase to allow fast convergence for infeasible problem. We show that the filter provides a nonmonotone global convergence mechanism, and present numerical results.

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MS8

Adaptive Observations And Multilevel Optimization In Data Assimilation

We propose to use a decomposition of large-scale incremental 4D-Var data assimilation problems in order to make their numerical solution more efficient. It is based on exploiting an adaptive hierarchy of the observations. Starting with a low-cardinality set and the solution of its corresponding optimization problem, observations are adaptively added based on a posteriori error estimates. The particular structure of the sequence of associated linear systems allows the use of an efficient variant of the conjugate gradient algorithm. The method is justified by deriving the relevant error estimates at different levels of the hierarchy and a practical computational technique is then derived. The algorithm is tested on a 1D-wave equation and on the Lorenz-96 system, which is of special interest because of its similarity with Numerical Weather Prediction (NWP) systems.

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MS8

Multilevel Methods for Very Large Scale NLPs Resulting from PDE Constrained Optimization

We discuss recent developments for multilevel optimization methods applied to PDE constrained problems. We propose a multilevel optimization approach that generates a hierarchy of discretizations during the optimization iteration using adaptive discrete approximations and reduced order models such as POD. The adaptive refinement strategy is based on a posteriori error estimators for the PDE-constraint, the adjoint equation and the criticality measure. We demonstrate the efficiency of the approach by numerical examples.

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MS8

A Class of Distributed Optimization Methods with Event-Triggered Communication

We present distributed optimization methods with event-triggered communication that keep data local and private as much as possible. Nesterov's first order scheme is extended to use event-triggered communication in networked environments. Then, this approach is combined with the proximal center algorithm by Necoara and Suykens. We use dual decomposition and apply our event-triggered version of Nesterov's scheme to update the multipliers. Extensions to problems with LMI constraints are also discussed and numerical results are presented.

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MS9

Regularization Methods for Stochastic Order Constrained Problems

We consider stochastic optimization problems with stochastic order constraints. We develop two numerical methods with regularization for their numerical solution. Our methods utilize the characterization of the stochastic order by integrated survival or integrated quantile functions to progressively approximate the feasible set. Convergence of the methods is proved in the case of discrete distributions.

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MS9

Stability of Optimization Problems with Stochastic Dominance Constraints

We consider convex optimization problems with kth order stochastic dominance constraints for $k \geq 2$. We establish quantitative stability results for optimal values and primal-dual solution sets of the optimization problems in terms of a suitably selected probability metric. Moreover, we provide conditions ensuring Hadamard-directional differentiablity of the optimal value function and derive a limit theorem for the optimal values of empirical (sample average) approximations of dominance constrained optimization models (joint work with Darinka Dentcheva).

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MS9

Stochastic Dominance in Shape Optimization under Uncertain Loading

Shape optimization under linearized elasticity and uncertain loading is considered from the viewpoint of two-stage stochastic programming. Emphasizing risk aversion we minimize volume under stochastic dominance (stochastic order) constraints involving compliance benchmark distributions. Numerical results for different types of stochastic orders, i.e.,the 'usual' stochastic order and the increasing convex order, are presented.

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MS9

Numerical Methods for Problems with Multivariate Stochastic Dominance Constraints

We consider risk-averse stochastic optimization problems involving the use of linear stochastic dominance of the second order. Various primal and dual methods have been proposed to solve these types of problems. The crux of any solution method involves solving a non-convex, nonlinear global optimization problem which verifies whether the linear stochastic dominance constraint is satisfied. Various solution techniques for this problem will be discussed along with their relevant numerical experience.

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MS10

On a Reduction of Cardinality to Complementarity in Sparse Optimization

A reduction of cardinality-constrained problems (CardCP) to complementarity constrained problems is presented. We prove their equivalence in the sense that they have the same global minimizers. A relation between their local minimizers is also discussed. Local optimality conditions for CardCPs are derived on the base of presenting cardinality constraints in a disjunctive form. A continuous reformulation of portfolio optimization problem with semi-continuous variables and cardinality constraint is given.

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MS10

Quasi-Newton methods for the Trust-Region Subproblem

This talk will discuss consider various quasi-Newton subproblem solvers. Numerical results will be presented.

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MS10

Sum Rate Maximization Algorithms for Mimo Relay Networks in Wireless Communications

Sum rate maximization problem is always of great interests in the field of wireless communications. For MIMO relay networks, we propose a new approach to approximate sum rate maximization, and prove it is a lower bound of achievable sum rate. To solve the nonlinear nonconvex optimization problem, we change the fraction function into a non-fraction function in the objective function, and show that the optimization problems share the same stationary points. By applying the alternating minimization method, we decompose the complex problem into nonconvex quadratic constraint quadratic programming subproblems. We propose an efficient algorithm to solve such subproblems. Numerical rsults show that our new model and algorithm perform well.

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MS10

Penalty Methods with Stochastic Approximation for Stochastic Nonlinear Programming

We propose a unified framework of penalty methods with stochastic approximation for stochastic nonlinear programming. In each iteration we solve a nonconvex stochastic composite optimization problem with structured nonsmooth term. A new stochastic algorithm is presented for solving this particular class of subproblems. We also analyse the worst-case complexity on the stochastic first-order oracle calls for the proposed methods. Furthermore, methods using only stochastic zeroth-order stochastic information are proposed and analysed.

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MS11

Plan-C, A C-Package for Piecewise Linear Models in Abs-Normal Form

Abstract not available.

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MS11

Evaluating Generalized Derivatives of Dynamic Systems with a Linear Program Embedded

Dynamic systems with a linear program embedded can be found in control and optimization of detailed bioreactor models. The optimal value of the embedded linear program, which is parameterized by the dynamic states, is first not continuously differentiable and second not directionally differentiable on the boundary of its domain. For evaluating generalized derivatives, these are two challenges that are overcome by computing elements of the lexicographic subdifferential based on a forward sensitivity system and determining strictly feasible trajectories.

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MS11

Evaluating Generalized Derivatives for Nonsmooth Dynamic Systems

Established numerical methods for nonsmooth problems typically require evaluation of generalized derivatives such as the Clarke Jacobian. However, existing methods for evaluating generalized derivatives for nonsmooth dynamic systems are limited either in scope or in quality of the evaluated derivatives. This presentation asserts that Nesterovs lexicographic derivatives are as useful as the Clarke Jacobian in numerical methods, and describes lexicographic derivatives of a nonsmooth dynamic system as the unique solution of an auxiliary dynamic system.

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MS11

Adjoint Mode Computation of Subgradients for McCormick Relaxations

Subgradients of McCormick relaxations of factorable functions can naturally be computed in tangent (or forward) mode Algorithmic Differentiation (AD). Subgradients are natural extensions of "usual" derivatives which allow the application of derivative-based methods to possibly non-differentiable convex and concave functions. In this talk an adjoint (reverse mode AD) method for the computation of subgradients for McCormick relaxations is presented. A corresponding implementation by overloading in Fortran is provided. The calculated subgradients are used in a deterministic global optimization algorithm based on a simple branch-and-bound method. The potential superiority of adjoint over tangent mode AD is discussed.

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MS12

Network Design with Probabilistic Capacity Constraints

We consider a network design problem with probabilistic capacity constraints and the corresponding separation problem. We derive valid combinatorial inequalities for improving solution times and present computational results.

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MS12

Disjunctive Conic Cuts for Mixed Integer Second Order Cone Optimization

We investigate the derivation and use of disjunctive conic cuts for solving MISOCO problems. We first describe the derivation of these cuts. Then, we analyze their effectiveness in a branch and cut framework. Various criteria are explored to select the disjunctions to build the cuts, as well as for node selection and branching rules. These experiments help to understand the impact these cuts may have on the size of the search tree and the solution time of the problems.

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MS12

Mixed Integer Programming with p-Order Cone and Related Constraints

Abstract Not Available

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MS13

Information Relaxations, Duality, and Convex Stochastic Dynamic Programs

We consider the information relaxation approach for calculating performance bounds for stochastic dynamic programs. We study convex DPs and consider penalties based on linear approximations of approximate value functions. We show that these "gradient penalties" in theory provide tight bounds and can improve on bounds provided by other relaxations, e.g. Lagrangian relaxations. We apply the method to a network revenue management problem and find that some relatively easy-to-compute heuristic policies are nearly optimal.

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MS13

High Dimensional Revenue Management

Motivated by online advertising, we discuss the problem of optimal revenue management in settings with a large, potentially exponential, number of customer types. We present a conceptually simple learning algorithm for this problem that has shown empirical promise in prior work. We show that when the 'revenue' functions arise from a practically interesting class of functions, the sample complexity of learning a near optimal control policy scales logarithmically in the number of customer types. A long stream of antecedent work on this problem has achieved a linear dependence.

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MS13

Dynamic Robust Optimization and Applications

Robust optimization has recently emerged as a tractable and scalable paradigm for modeling complex decision problems under uncertainty. Its applications span a wide range of challenging problems in finance, pricing, supply chain management or network design. In the context of dynamic robust decision models, a typical approach is to look for control policies that are directly parameterized in the uncertainties affecting the model. This has the advantage of leading to simple convex optimization problems for finding particular classes of rules (e.g., affine). However, the approach typically yields suboptimal policies, and is hard to analyze. In this talk, we seek to bridge this paradigm with the classical Dynamic Programming (DP) framework for solving decision problems. We provide a set of unifying conditions – based on the interplay between the convexity and supermodularity of the DP value functions, and the lattice structure of the uncertainty sets – which guarantee the optimality of the class of affine decision rules, and furthermore allow such rules to be found very efficiently. Our results suggest new modeling paradigms for dynamic robust optimization, and our proofs bring together ideas from three areas of optimization typically studied separately: robust, combinatorial (lattice programming and supermodularity), and global (the theory of concave envelopes). We exemplify our findings in a class of applications concerning the design of flexible production processes, where a firm seeks to optimally compute a set of strategic decisions (before the start of a selling season), as well as in-season replenishment policies. Our results show that – when the costs incurred are convex – replenishment policies that depend linearly on the realized demands are optimal. When the costs are also piece-wise affine, all the optimal decisions (strategic and tactical) can be found by solving a single linear program of small size.

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MS13

An Approximate Dynamic Programming Approach to Stochastic Matching

We consider a class of stochastic control problems where the action space at each time can be described by a class of matching or, more generally, network flow polytopes. Special cases of this class of dynamic matching problems include many problems that are well-studied in the literature, such as: (i) online keyword matching in Internet advertising (the 'adwords' problem); (ii) the bipartite matching of donated kidneys from cadavers to recipients; and (iii) the allocation of donated kidneys through exchanges over cycles of live donor-patient pairs. We provide an approximate dynamic program (ADP) algorithm for dynamic matching with stochastic arrivals and departures. Our framework is more general than the methods prevalent in the literature in that it is applicable to a broad range of problems characterized by a variety of action polytopes and generic arrival and departure processes. In order to access the performance of our ADP methods, we illustrate computationally tractable upper bounds on the performance of optimal policies in our setting. We apply our methodology to a series of kidney matching problems calibrated to realistic kidney exchange statistics, where we obtain a significant performance improvement over established benchmarks and, via upper bounds, illustrate that our approach is near optimal.

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MS15

On Some Sensitivity Results in Stochastic Optimal Control Theory: A Lagrange Multiplier Point of View

In this joint work with Francisco Silva, we provide a functional framework for classical stochastic optimal control problems and justify rigorously that the adjoint state (p, q) appearing in the stochastic Pontryagin principle corresponds to a Lagrange multiplier when the controlled stochastic differential equation is viewed as a constraint. Under some convexity assumptions the processes (p, q) correspond to the sensitivity of the value function wrt. the drift and the volatility of the equation. We apply this in concrete examples.

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MS15

Some Irreversible Investment Models with Finite Fuel and Random Initial Time for Real Options Analysis on Local Electricity Markets

We analyse a stochastic model for local, physical trading of electricity formulated as a mixed control/stopping problem. We derive the Real Option value for two-party contracts where one party (A) decides (optimally) at time τ to accept an amount P_0 from the other party (B) and commits to supplying a unit of electricity to B at a random time $T \geq \tau$. The aim is hedging B's exposure to real-time market prices of electricity.

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MS15

A Stochastic Reversible Investment Problem on a Finite-Time Horizon: Free-Boundary Analysis

We study a continuous-time, finite horizon optimal stochastic reversible investment problem of a firm. The production capacity is a one-dimensional diffusion controlled by a bounded variation process representing the cumulative investment-disinvestment strategy. We study the associated zero-sum optimal stopping game and characterize its value function through a free-boundary problem with two moving boundaries. The optimal control is then shown to be a diffusion reflected at the two boundaries.

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MS15

Probabilistic and Smooth Solutions to Stochastic Optimal Control Problems with Singular Terminal Values with Application to Portfolio Liquidation Problems

We review recent existence, uniqueness and characterization of solutions results for PDEs and BSPDEs with singular terminal values. Such equations arise in portfolio liquidation problems under price-sensitive market impact. Markovian control problems arise when the cost function depends only on the current price; non-Markovian problems arise if, for instance, the investors trading strategy is benchmarked against volume-weighted average prices. The former gives rise to a PDE with singular terminal value for which we establish existence of a smooth solution using analytic methods; the latter gives rise to a novel class of BSPDEs which we solve using probabilistic methods.

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MS16

Alternating Linearization Methods for Quadratic Least-Square Problem

Second-order least square problems have arisen widely in binary optimization, portfolio optimization, etc.. In this talk, we propose an alternating linearization framework to solve this set of problems which are potentially nonconvex. We show the effectiveness of our technique in terms of both theory and numerical experiments in the application of risk parity optimization in portfolio management.

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MS16

Sampling Within Algorithmic Recursions

Abstract not available.

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MS16

Convergence Rates of Line-Search and Trust Region Methods Based on Probabilistic Models

Abstract not available.

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MS16

On the Use of Second Order Methods in Stochastic Optimization

Estimating curvature with inherently noisy information is difficult, but could lead to improvements in the performance of stochastic approximation methods. A few algorithms that update Hessian approximations have been proposed in the literature, but most lose the attractive properties of their deterministic counterparts. We propose two methods based on Polyak-Ruppert averaging, which collect second-order information along the way, and only sparingly use it in a disciplined manner.

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MS17

Discounted Referral Pricing Between Healthcare Networks

Academic medical centers (AMC) receive referrals from low acuity networks, and usually use a fee for service contract. We consider referrals from a capitated provider (HMO), and characterize a two-tier discount contract. Our contract is mutually beneficial based on both parties risk preferences: it increases the AMCs expected revenue while decreasing the HMOs conditional value at risk of the cost. We extend the analysis to the case of asymmetric information about referral volume.

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MS17

Efficient Resource Allocation in Hospital Networks

Over the past several years the healthcare industry witnessed the consolidation of multiple community hospitals into larger care organizations. In order for large care providers to best utilize their growing networks, it is critical to understand not only system-wide demand and capacity, but also how the deployment of limited resources can be improved. We build an optimization model that allows deciding how to allocate network resources efficiently in order to offer additional services and to recapture leaked demand within the network-owned hospitals. The model was calibrated using real data from a network that consists of two community hospitals and one academic medical center.

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MS17

The Effectiveness of Uniform Subsidies in Increasing Market Consumption

We analyze a subsidy allocation problem with endogenous market response under a budget constraint. The central planner allocates subsidies to heterogeneous producers to maximize the consumption of a commodity. We identify marginal cost functions such that uniform subsidies are optimal, even under market state uncertainty. This is precisely the policy usually implemented in practice. Moreover, we show that uniform subsidies have a guaranteed performance in important cases where they are not optimal.

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MS17

On Efficiency of Revenue-sharing Contracts in Joint Ventures in Operations Management

We study capacity planning problems with resource pooling in joint ventures under uncertainties. When resources are heterogeneous, there exists a unique efficient revenue sharing contract under proportional fairness. This optimal contract rewards every player proportionally to her marginal cost. When resources are homogeneous, there does not exist an efficient revenue sharing contract. We propose a provably good contract that rewards each player inversely proportional to her marginal cost.

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MS18

Reduced-Complexity Semidefinite Relaxations Via Chordal Decomposition

We propose a new method for generating semidefinite relaxations of sparse quadratic optimization problems. The method is based on chordal conversion techniques: by dropping some equality constraints in the conversion, we obtain semidefinite relaxations that are computationally cheaper, but potentially weaker, than the standard semidefinite relaxation. Our numerical results show that the new relaxations often produce the same results as the standard semidefinite relaxation, but at a lower computational cost.

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MS18

Domain Decomposition in Semidefinite Programming with Application to Topology Optimization

We investigate several approaches to the solution of topology optimization problems using decomposition of the computational domain. We will use reformulation of the original problem as a semidefinite optimization problem. This formulation is particularly suitable for problems with vibration or global buckling constraints. Standard semidefinite optimization solvers exercise high computational complexity when applied to problems with many variables and a large semidefinite constraint. To avoid this unfavourable situation, we use results from the graph theory that allow us to equivalently replace the original large-scale matrix constraint by several smaller constraints associated with the subdomains. Alternatively, we directly decompose the computational domain for the underlying PDE, in order to formulate an equivalent optimization problem with many small matrix inequalities. This leads to a significant improvement in efficiency, as will be demonstrated by numerical examples.

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MS18

Decomposition and Partial Separability in Sparse Semidefinite Optimization

We discuss a decomposition method that exploits chordal graph theorems for large sparse semidefinite optimization. The method is based on a Douglas-Rachford splitting algorithm and uses a customized interior-point algorithm to evaluate proximal operators. In many applications, and depending on the structure of the linear constraints, these proximal operators can be evaluated in parallel. We give results showing the scalability of this algorithm for large semidefinite programs, compared against standard interior point methods.

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MS18

Preconditioned Newton-Krylov Methods for Topology Optimization

When modelling structural optimization problems, there is a perpetual need for increasingly accurate conceptual designs. This impacts heavily on the overall computational effort required by a computer, and it is therefore natural to consider alternative possibilities such as parallel computing. This talk will discuss the application of domain decomposition to a typical problem in topology optimization. Our aim is to consider the formation of a Newton-Krylov type approach, with an appropriate preconditioning strategy for the resulting interface problem.

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MS19

On the Regularizing Effect of a New Gradient Method with Applications to Image Processing

We investigate the regularizing properties of a recently proposed gradient method, named SDC, in the solution of discrete ill-posed inverse problems formulated as linear least squares problems. An analysis of the filtering features of SDC is presented, based on its spectral behaviour. Numerical experiments show the advantages offered by SDC, with respect to other gradient methods, in the restoration of noisy and blurred images.

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MS19

Gradient Descent Approaches to Image Registration

Image registration is an essential step in the processing of planetary satellite images, and involves the computation of an optimal low-order rigid, or high-order deformation, transformation between two or more images. The problem is complicated by the wide range of image data from different satellite systems (LANDSAT, SPOT, many others) and sensor systems (multi-band, hyperspectral, and others). The presentation will look at alternative approaches including basic and stochastic gradient methods.

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MS19

Adaptive Hard Thresholding Algorithm For Constrained l_0 Problem

The hard thresholding algorithm has proved very efficient for unconstrained l_0 sparse optimization. In this paper, we propose an adaptive hard thresholding (AHT) algorithm for finding sparse solutions of box constrained l_0 sparse optimization problems and prove that it can find a solution in a finite number of iterations. The equality and box constrained sparse optimization can be transformed box constrained l_0 sparse optimization problems by penalty and then can be solved by the AHT algorithm. Some numerical results are reported for compressed sensing problems with equality constraints and index tracking problems, which demonstrate that the algorithm is promising and time-saving. It can find the s-sparse solution in the former case and can guarantee out-of-sample prediction performance in the latter case.

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MS19

First Order Methods for Image Deconvolution in Microscopy

High-performance deconvolution algorithms become crucial to avoid long delays in data analysis pipelines, especially in case of large-scale imaging problems, such as those arising in astronomy and microscopy. In this work we present effective deconvolution approaches obtained by following two main directions: using acceleration strategies for first order methods and exploiting Graphics Processing Units (GPUs). Numerical experiments on large-scale image deconvolution problems are performed for evaluating the effectiveness of the proposed optimization algorithm.

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MS20

Adaptive Reduced Basis Stochastic Collocation for PDE Optimization Under Uncertainty

I discuss the numerical solution of optimization problems governed by PDEs with uncertain parameters using stochastic collocation methods. The structure of this method is explored in gradient and Hessian computations. A trust-region framework is used to adapt the collocation points based on the progress of the algorithm and structure of the problem. Reduced order models are constructed to replace the PDEs by low dimensional equations. Convergence results and numerical results are presented.

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MS20

Generalized Nash Equilibrium Problems in Banach Spaces

A class of non-cooperative Nash equilibrium problems is presented, in which the feasible set of each player is perturbed by the decisions of their competitors via an affine constraint. For every vector of decisions, the affine constraint defines a shared state variable. The existence of an equilibrium for this problem is demonstrated, first order optimality conditions are derived under a constraint qualification, and a numerical method is proposed. A new path-following strategy based in part on the Nikaido- Isoda function is proposed to update the path parameter.

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MS20

Risk-Averse PDE-Constrained Optimization using the Conditional Value-At-Risk

I discuss primal and dual approaches for the application of the conditional value-at-risk in PDE optimization under uncertainty. For the primal approach, I introduce a smoothing and quadrature-based discretization. I prove well-posedness of the smoothed-primal formulation as well as error bounds. For the dual approach, I derive rigorous optimality conditions and present a derivative-based solution technique constructed from these conditions. I conclude with a numerical comparison of these approaches.

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MS20

A-optimal Sensor Placement for Large-scale Nonlinear Bayesian Inverse Problems

We formulate an A-optimal criterion for the optimal placement of sensors in infinite-dimensional nonlinear Bayesian inverse problems. I will discuss simplifications required to make the problem computationally feasible and present a formulation as bi-level PDE-constrained optimization problem. Numerical results for the inversion of the permeability in ground water flow are used to illustrate the feasibility of the approach for large-scale inverse problems.

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MS21

Title not available

Abstract not available.

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MS21

Prospects for Reduced-Space Global Optimization

Reduced-space branch-and-bound, in which only a subset of the variables are branched on, appears a promising approach to mitigate the computational cost of global optimization. However, results to date have only exhibited limited success. This talk highlights the importance of the convergence order of any constraint propagation technique used to ensure convergence in a reduced-space approach.

In particular, a new second-order convergent method for bounding the parametric solutions of nonlinear equations will be demonstrated.

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MS21

New Classes of Convex Underestimators for Global Optimization

We introduce the theoretical development of a new class of convex underestimators based on edge-concavity. The linear facets of the convex envelop of the edge-concavity based underestimator, which are generated using an efficient algorithm for up to seven dimensions, are used to relax a nonconvex problem. We present computational comparison of different variants of aBB and the edge-concave based underestimator, and show under which condition the proposed underestimator is tighter than aBB.

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MS21

On Feasibility-based Bounds Tightening

Feasibility-based Bounds Tightening (FBBT) is used to tighten the variable ranges at the nodes of spatial Branch-and-Bound (sBB) algorithms for Mixed-Integer Nonlinear Programs (MINLP). FBBT may not converge finitely to its limit ranges, even in the case of linear constraints. Tolerance-based termination criteria may not yield a polytime behaviour. We model FBBT by using fixed-point equations in terms of the variable ranges. This yields an auxiliary linear program, which can be solved efficiently. We demonstrate the usefulness of our approach by improving the open-source sBB solver Couenne.

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MS22

Mixed-Integer Nonlinear Programming Problems in the Optimization of Gas Networks – Mixed-Integer Programming Approaches

Optimization method can play an important role in the planning and operation of natural gas networks. The talk describes mixed-integer programming approaches to solve the difficult mixed-integer nonlinear programming problems that arise in the planning and operation of such networks. In this talk we mainly discuss stationary models for gas transport and show computational results for real-world networks. We also discuss how the underlying techniques can be used for more general MINLPs.

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MS22

Nonlinear Programming Techniques for Gas Transport Optimization Problems

Since our goal is to replace simulation by optimization techniques in gas transport, nonlinear programming plays an important role for solving real-world optimization problems in order to achieve a physical and technical accuracy comparable with standard simulation software. In this talk, we address the involvement of discrete aspects in NLP models of gas transport and propose techniques for solving highly detailed NLP models that are comparable with today's simulation models.

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MS22

Hard Pareto Optimization Problems for Determinig Gas Network Capacities

Recent regulation of the German gas market has fundamentally changed the contractual relationship of network operators and customers. A key concept are so called technical capacities of network entries and exits: network operators must publish future capacities on a web platform where transport customers can book them independently. The talk will discuss hard optimization problems that arise from mid-term planning in this context, addressing mathematical modeling, theoretical analysis, computational aspects and practical consequences.

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MS22

Nonlinear Optimization in Gas Networks for Storage of Electric Energy

To ensure security of energy supply in the presence of highly volatile generation of renewable electric energy extensive storage is required. One possibility is to use electric compressors to store electric energy in terms of pressure increase in existing gas transport networks. We present a transient optimization model that incorporates gas dynamics and technical network elements. Direct discretization leads to an NLP which is solved by an interior point method. First results for a realistic gas pipeline are presented.

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MS23

Accelerated Gradient Methods for Nonconvex Nonlinear and Stochastic Programming

In this talk, we present a generalization of Nesterov's AG method for solving general nonlinear (possibly nonconvex and stochastic) optimization problems. We show that the AG method employed with proper stepsize policy possesses the best known rate of convergence for solving smooth nonconvex problems. We also show that this algorithm allows us to have a uniform treatment for solving a certain class of composite optimization problems no matter it is convex or not.

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MS23

Global Convergence and Complexity of a Derivative-Free Method for Composite Nonsmooth Optimization

A derivative-free trust-region algorithm is proposed for minimizing the composite function $\Phi(x) = f(x) + h(c(x))$, where f and c are smooth and h is convex but may be nonsmooth. Global convergence results are given and a worst-case complexity bound is obtained. The complexity result is then specialized to the case when the composite function is an exact penalty function, providing a worst-case complexity bound for equality-constrained optimization problems when the solution is computed using a derivative-free exact penalty algorithm.

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MS23

Subspace Decomposition Methods

Abstract not available.

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MS23

On the Use of Iterative Methods in Adaptive Cubic Regularization Algorithms for Unconstrained Optimization

We consider adaptive cubic regularization (ARC) algorithms for unconstrained optimization recently investigated in many papers. In order to reduce the cost required by the trial step computation, we focus on the employment of Hessian-free methods for minimizing the cubic model preserving the same worst-case complexity count as ARC. We present both a monotone and a nonmonotone version of ARC and we show the results of numerical experiments obtained using different methods as inexact solver.

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MS24

Stochastic Day-Ahead Clearing of Energy Markets

Abstract not available.

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MS24

Cutting Planes for the Multi-Stage Stochastic Unit Commitment Problem

Abstract not available.

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MS24

Modeling Energy Markets: An Illustration of the

Four Classes of Policies

The modeling of independent system operators such as PJM requires capturing the complex dynamics of energy generation, transmission and consumption. Classical algorithmic strategies associated with stochastic programming, dynamic programming or stochastic search will not work in isolation. We provide a unified framework for stochastic optimization that encompasses all of these fields, represented using four fundamental classes of policies. This framework is demonstrated in a model of the PJM grid and energy markets.

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MS24

New Lower Bounding Results for Scenario-Based Decomposition Algorithms for Stochastic Mixed-Integer Programs

Non-convexity and/or a restrictions on computation time may cause the progressive hedging (PH) algorithm to terminate with a feasible solution and a cost upper bound. A tight lower bound can provide reassurance on the quality of the PH solution. We describe a new method to obtain lower bounds using the information prices generated by PH. We show empirically, using these lower bounds, that for large-scale non-convex stochastic unit commitment problems, PH generates very high-quality solutions.

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MS25

Using Probabilistic Regression Models in Stochastic Derivative Free Optimization

We consider the use of probabilistic regression models in a classical trust region framework for optimization of a deterministic function f when only having access to noise-corrupted function values $\tilde{f}$. Contrasting to traditional requirements on the poisedness of the sample set, our models are constructed using randomly selected points while providing sufficient quality of approximation with high probability. We will discuss convergence proofs of our proposed algorithm based on error bounds from machine learning literature.

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MS25

DIRECT-Type Algorithms for Derivative-Free Constrained Global Optimization

In the field of global optimization many efforts have been devoted to globally solving bound constrained optimization problems without using derivatives. In this talk we consider global optimization problems where also general nonlinear constraints are present. To solve this problem we propose the combined use of a DIRECT-type algorithm with derivative-free local minimizations of a nonsmooth exact penalty function. In particular, we define a new DIRECT-type strategy to explore the search space by taking into account the two-fold nature of the optimization problems, i.e. the global optimization of both the objective function and of a feasibility measure. We report an extensive experimentation on hard test problems.

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MS25

A World with Oil and Without Derivatives

The unstoppable increase in world energy consumption has led to a global concern regarding fossil fuel reserves and their production. This in part motivates oil and gas companies to use complex modeling and optimization algorithms. However, these algorithms are very often designed independently, and, in general, derivative information in the optimization cannot be computed efficiently. This talk illustrates through a number of examples the use and importance of derivative-free optimization in oil field operations.

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MS25

Formulations for Constrained Blackbox Optimization Using Statistical Surrogates

This presentation introduces alternative formulations for using statistical surrogates and the Mesh Adaptive Direct Search (MADS) algorithm for constrained blackbox optimization. The surrogates that we consider are global models that provide diversification capabilities to escape local optima. We focus on different formulations of the surrogate problem considered at each search step of the MADS algorithm using a statistical toolbox called dynaTree. The formulations exploit different concepts such as interpolation, classification, expected improvement and feasible expected improvement. Numerical examples are presented for both analytical and simulation-based engineering design problems.

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MS26

Stochastic Variational Inequalities: Analysis and Algorithms

Variational inequality problems find wide applicability in modeling a range of optimization and equilibrium problems. We consider the stochastic generalization of such a problem wherein the mapping is pseudomonotone. We make three sets of contributions in this paper. First, we provide sufficiency conditions for the solvability of such problems that do not require evaluating the expectation. Second, we introduce an extragradient variant of stochastic approximation for the solution of such problems. Under suitable conditions, it is shown that this scheme produces iterates that converge in an almostsure sense. Furthermore, we present a rate of convergence analysis in a monotone regime under a weak-sharpness requirement. The paper concludes with some preliminary numerics.

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MS26

Polyhedral Variational Inequalities

PathVI is a Newton-based solver for variational inequalities (VIs) defined over a polyhedral convex set. It computes a solution by finding a zero of the normal map associated with a given VI, whose linearization in this case is an affine VI. At each iteration, we solve an affine VI using a pivotal method and do a path search to make a Newton step. A complementary pivoting method which follows a piecewise linear manifold for solving an affine VI will be introduced and a path search algorithm for a Newton step will be presented. Implementation issues regarding initial basis setup and resolving numerical difficulties will be discussed. Some experimental results comparing PathVI to other codes based on reformulations as a complementary problem will be given.

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MS26

Vulnerability Analysis of Power Systems: A Bilevel Optimization Approach

We consider a transmission line attack problem to identify the most vulnerable lines of an electric power grid. The attack is performed by increasing the impedances of each transmission lines and the disruption of the system is measured by the amount of load that needs to be shed to recover feasibility of the grid. We propose a continuous bilevel programming model based on AC power flow equations and a combination of algorithmic and heuristics techniques from optimization will be discussed.

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MS26

A SLPEC/EQP Method for Mathematical Programs with Variational Inequality Constraints

I will discuss a new method for mathematical programs with complementarity constraints that is globally convergent to B-stationary points. The method solves a linear program with complementarity constraints to obtain an estimate of the active set. It then fixes the activities and solves an equality-constrained quadratic program to obtain fast convergence. The method uses a filter to promote global convergence. We establish convergence to B-stationary points.

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MS27

Stochastic Nonlinear Programming for Natural Gas Networks

A robust and efficient parallel nonlinear solver is alway a challenge for large-scale stochastic NLP problems. We discuss the details of our implementation PIPS-NLP, which is a parallel nonlinear interior-point solver. The parallel strategy is designed by decomposing the problem structure and building the Schur Complement. We also present some numerical results of the stochastic natural gas network problem.

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MS27

A Sequential Linear-Quadratic Programming Method for the Online Solution of Mixed-Integer Optimal Control Problems

We are interested in mathematical programming methods for optimizing control of nonlinear switched systems. Computational evidence has shown that many problems of this class are amenable to MPEC or MPVC reformulations. In this talk, we present a framework for mixed-integer nonlinear model-predictive control of switched systems. Our method employs a direct and all-at-once method to obtain a nonlinear programming representation of the control problem. Complementarity and vanish constraints are used to model restrictions on switching decisions. A sequential linear-quadratic programming algorithm is developed and used in a real-time iteration scheme to repeatedly compute mixed-integer feedback controls.

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MS27

An Optimization Algorithm for Nonlinear Problems with Numerical Noise

We present a numerical algorithm for solving nonlinear optimization problems where the value and the gradient of objective function are distorted by numerical noise. The method is based on regression models and transitions smoothly from the regime in which noise can be ignored to the regime in which methods fail that do not explicitly address the noise.

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MS27

A Taxonomy of Constraints in Grey-Box Optimization

The types of constraints encountered in simulation-based or black-box optimization problems differ significantly from the constraints traditionally treated in nonlinear programming theory. We introduce a characterization of constraints to address this shortcoming. We provide formal definitions of these constraint classes and provide illustrative examples for each type of constraint in the resulting taxonomy. These constraint classes present challenges and opportunities for developing nonlinear optimization algorithms and theory.

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MS28

Elementary Closures in Nonlinear Integer Programming

The elementary closure of a Mixed Integer Programming (MIP) is obtained by augmenting the continuous relaxation of the MIP with all cuts in a give family. Because the number of cuts in a family is usually infinite, the elementary closure is not necessarily a polyhedron even if the continuous relaxation of the MIP is a rational polyhedron (i.e. for linear MIP). However, most elementary closures for linear MIP have been shown to be rational polyhedron. In this talk we study when the elementary closure of a nonlinear MIP (i.e. those with non-polyhedral continuous relaxations) is a rational polyhedron. We pay special attention to the case of nonlinear MIPs with continuous relaxations with unbounded feasible regions.

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MS28

Understanding Structure in Conic Mixed Integer Programs: From Minimal Linear Inequalities to Conic Disjunctive Cuts

In this talk, we will cover some of the recent developments in Mixed Integer Conic Programming. In particular, we will study nonlinear mixed integer sets involving a general regular (closed, convex, full dimensional, and pointed) cone K such as the nonnegative orthant, the Lorentz cone or the positive semidefinite cone, and introduce the class of K-minimal valid linear inequalities. Under mild assumptions, we will show that these inequalities together with the trivial cone-implied inequalities are sufficient to describe the convex hull. We study the characterization of K-minimal inequalities by identifying necessary, and sufficient conditions for an inequality to be K-minimal; and establish relations with the support functions of sets with certain structure, which leads to efficient ways of showing a given inequality is K-minimal. This framework naturally generalizes the corresponding results for Mixed Integer Linear Programs (MILPs), which have received a lot of interest recently. In particular, our results recover that the minimal inequalities for MILPs are generated by sublinear (positively homogeneous, subadditive and convex) functions that are also piecewise linear. However our study also reveals that such a cut generating function view is not possible for the conic case even when the cone involved is the Lorentz cone. Finally, we will conclude by introducing a new technique on deriving conic valid inequalities for sets involving a Lorentz cone via a disjunctive argument. This new technique also recovers a number of results from the recent literature on deriving split and disjunctive inequalities for the mixed integer sets involving a Lorentz cone. The last part is joint work with Sercan Yildiz and Gerard Cornuejols.

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MS28

Valid Inequalities and Computations for a Nonlin-

ear Flow Set

Many engineering applications concern the design and operation of a network on which flow must be balanced. We present analysis of a single node flow set that has been augmented with variables to capture nonlinear network behavior. Water networks, gas networks, and the electric power grid are applications that could benefit from our analysis. New classes of valid inequalities are given, and we plan to provide computational results demonstrating the utility of the new inequalities.

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MS28

MINOTAUR Framework: New Developments and an Application

MINOTAUR is an open-source software framework for solving MINLPs. We will describe some recent additions and improvements in the framework and demonstrate their impact on the performance on benchmark instances. We also show how this framework can be taiored to solve specific applications. We consider as an example a difficult nonlinear combinatorial optimization problem arising in the design of power-delivery networks in electronic components.

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MS29

Cutting Planes for Completely Positive Conic Problems

Many combinatorial problems as well as nonconvex quadratic problems can be reformulated as completely positive problems, that is, linear problems over the cone of completely positive matrices. unfortunately, this reformulation does not solve the difficulty of the problem because the completely positive cone is intractable. a tractable relaxation lies in substituting it by the semidefinite cone. In this talk, we show how we can construct cutting planes that will sharpen the relaxation.

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MS29

A Copositive Approach to the Graph Isomorphism Problem

The Graph Isomorphism Problem is the problem of deciding whether two graphs are the same or not. It is a problem with several application. It is also one of few combinatorial problems whose complexity is still unknown. In this talk we present a new approach to the graph isomorphism problem by formulating the problem as a copositive program. Then, using several hierarchies of cones approximating the copositive cone, we will attempt to solve the problem.

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MS29

The Order of Solutions in Conic Programming

The order of optimal solutions is connected with the convergence rate of discretization methods. Geometrically, it is related to the curvature of the feasible set around the solution. We study this concept for conic optimization problems and formulate conditions for first order solutions as well as higher order solutions. We also discuss stability of these properties.

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MS29

Combinatorial Proofs of Infeasibility, and of Positive Gaps in Semidefinite Programming

Farkas lemma in linear programming provides a certificate to easily verify the infeasibility of a linear system of inequalities. We prove that a similar certificate exists for semidefinite systems: the reader can verify the infeasibility using only elementary linear algebra. The main tool we use is a generalized Ramana type dual. We also present similar proofs for positive duality gaps in SDPs.

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MS30

Keller's Cube-Tiling Conjecture – An Approach Through Sdp Hierachies

Kellers cube-tiling conjecture (1930) states that in any tiling of Euclidean space by unit hypercubes, some two hypercubes share a full facet. The origin is tied to Minkowskis conjecture and the geometry of numbers. Dimension 7 is unresolved. For fixed dimension, Kellers conjecture reduces to an upper bound on the stability number of a highly symmetric graph. Exploiting explicit block-diagonalizations of the invariant algebras associated with the Lasserre hierarchy, this problem can be approached using SDP.

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MS30

SDP and Eigenvalue Bounds for the Graph Partition Problem

In this talk we present a closed form eigenvalue-based bound for the graph partition problem. Our result is a generalization of a well-known result in spectral graph theory for the 2-partition problem to any k-partition problem. Further, we show how to simplify a known matrix-lifting SDP relaxation for different classes of graphs, and aggregate additional triangle and independent set constraints. Our approach leads to interesting theoretical results.

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MS30

Completely Positive Reformulations for Polynomial Optimization

We consider the convex reformulation of polynomial optimization (PO) problems that are not necessarily quadratic. For this, we use a natural extension of the cone of CP matrices; namely, the cone of completely positive tensors. We provide a characterization of the class of PO problems that can be formulated as a conic program over the cone of CP tensors. As a consequence, it follows that recent results for quadratic problems can be further strengthened and generalized to higher order PO problems.

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MS30

Title Not Available

In this talk I will discuss a hierarchy of conic optimization problems which can be used to compute the minimal potential energy of a system of repelling particles. For instance, in the Thomson problem one distributes a fixed number of points on the unit sphere to minimize the Coulomb energy (the sum of the reciprocals of the pairwise distances). I will show how techniques from harmonic analysis and polynomial optimization can be used to compute these bounds.

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MS31

Primal-dual Subgradient Method with Partial Coordinate Update

In this talk we consider a primal-dual method for solving nonsmooth constrained optimization problem. This method consists in alternating updating strategies for primal and dual variables, such that one of them can be seen as a coordinate descent scheme. We show that such a method can be applied to the problems of very big size, keeping nevertheless the worst-case optimal complexity bounds.

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MS31

Accelerated, Parallel and Proximal Coordinate Descent

We propose a new stochastic coordinate descent method for minimizing the sum of convex functions each of which depends on a small number of coordinates only. Our method (APPROX) is simultaneously Accelerated, Parallel and PROXimal; this is the first time such a method is proposed. In the special case when the number of processors is equal to the number of coordinates, the method converges at the rate $2\bar{\omega}\bar{L}R^2/(k+1)^2$, where k is the iteration counter, $\bar{\omega}$ is an *average* degree of separability of the loss function, $\bar{L}$ is the *average* of Lipschitz constants associated with the coordinates and individual functions in the sum, and R is the distance of the initial point from the minimizer. We show that the method can be implemented without the need to perform full-dimensional vector operations, which is considered to be the major bottleneck of accelerated coordinate descent. The fact that the method depends on the average degree of separability, and not on the maximum degree of separability, can be attributed to the use of new safe large stepsizes, leading to improved expected separable overapproximation (ESO). These are of independent interest and can be utilized in all existing parallel stochastic coordinate descent algorithms based on the concept of ESO.

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MS31

Stochastic Dual Coordinate Ascent with ADMM

We present a new stochastic dual coordinate ascent technique that can be applied to a wide range of composite objective functions appearing in machine learning tasks, that is, regularized learning problems. In particular, our method employs alternating direction method of multipliers (ADMM) to deal with complicated regularization functions. Although the original ADMM is a batch method in the sense that it observes all samples at each iteration, the proposed method offers a stochastic update rule where each iteration requires only one or few sample observations. Moreover, our method can naturally afford mini-batch update and it gives speed up of convergence. We show that, under some strong convexity assumptions, our method converges exponentially.

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MS31

Recent Progress in Stochastic Optimization for Machine Learning

It has been demonstrated recently that for machine learning problems, modern stochastic optimization techniques such as stochastic dual coordinate ascent have significantly better convergence behavior than traditional optimization methods. In this talk I will present a broad view of this class of methods including some new algorithmic developments. I will also discuss algorithms and practical considerations in their parallel implementations.

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MS32

Computing Symmetry Groups of Polyhedral Cones

Knowing the symmetries of a polyhedron can be very useful for the analysis of its structure as well as for the practical solution of linear constrained optimization (and related) problems. In this talk I discuss symmetry groups preserving the linear, projective and combinatorial structure of a polyhedron. In each case I give algorithmic recipes to compute the corresponding group and mention some practical experiences.

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MS32

Alternating Projections As a Polynomial Algorithm for Linear Programming

We consider a polynomial algorithm for linear programming on the basis of alternating projections. This algorithm is strongly polynomial for linear optimization problems of the form $\min\{cx|Ax = b, x \geq \mathbf{0}\}$ having 0-1 optimal solutions. The algorithm is also applicable to more general convex optimization problems.

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MS32

Optimizing over the Counting Functions of Parameterized Polytopes

Let P_b be the family of polytopes defined by $Ax \leq b$. The number of integer points in P_b is a *piece-wise step-polynomial* in the parameter b that can be computed in polynomial time if the dimension of P_b is fixed. We investigate the problem of minimizing or maximizing this polynomial subject to constraints on b. We show that this problem is NP-hard even in two dimensions, but approximation schemes exist.

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MS32

Tropicalizing the Simplex Algorithm

Based on techniques from tropical geometry we show that special pivoting rules for the classical simplex algorithm admit tropical analogues which can be used to solve mean payoff games. In this way, any such pivoting rule with a strongly polynomial complexity (the existence of such an algorithm is open) would provide a strongly polynomial algorithm solving mean payoff games. The latter problem is known to be NP $\cap$ co-NP.

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MS33

A Parallel Bundle Framework for Asynchronous Subspace Optimization of Nonsmooth Convex Functions

Abstract not available.

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MS33

A Feasible Active Set Method for Box-Constrained Convex Problems

A primal-dual active set method for quadratic problems with bound constraints is presented which extends the infeasible active set approach of [K. Kunisch and F. Rendl. An infeasible active set method for convex problems with simple bounds. SIAM Journal on Optimization, 14(1):3552, 2003]. Based on a guess on the active set, a primal-dual pair (x,a) is computed that satisfies the first order optimality condition and the complementary condition. If x is not feasible, the variables connected to the infeasibilities are added to the active set and a new primal-dual pair (x,a) is computed. This process is iterated until a primal feasible solution is generated. Then a new active set is guessed based on the feasibility information of the dual variable a. Strict convexity of the quadratic problem is sufficient for the algorithm to stop after a finite number of steps with an optimal solution. Computational experience indicates that this approach also performs well in practice.

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MS33

BiqCrunch: A Semidefinite Branch-and-bound Method for Solving Binary Quadratic Problems

BiqCrunch is a branch-and-bound solver for finding exact solutions of any 0-1 quadratic problem, such as many combinatorial optimization problems in graphs. We present the underlying theory of the semidefinite bounding procedure of BiqCrunch, and how to use BiqCrunch to solve some general numerical examples. Note that F. Roupin's talk "BiqCrunch in action: solving difficult combinatorial optimization problems exactly" presents the performance of BiqCrunch on a variety of well-known combinatorial optimization problems.

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MS33

Local Reoptimization Via Column Generation and Quadratic Programming

We introduce a new reoptimization framework called Local Reoptimization for dealing with uncertainty in data. The framework aims to construct a solution as close as possible to a reference one not anymore feasible. Local Reoptimization is conceived for generic Set Partitioning formulations which are typically solved by column generation approaches. The goal becomes to optimize the original objective function plus the quadratic gains collected by reproducing as much as possible the reference solution.

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MS34

Regularization Techniques in Nonlinear Optimization

We present two regularization techniques for nonlinear optimization. The first one is based on an inexact proximal point method, the second one on an augmented Lagrangian reformulation of the original problem. We discuss the strong global convergence properties of both these approaches.

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MS34

Inexact Second-order Directions in Large-scale Optimization

Many large-scale problems defy optimization methods which rely on exact directions obtained by factoring matrices. I will argue that second-order methods (including interior point algorithms) which use inexact directions computed by iterative techniques and run in a matrix-free regime offer an attractive alternative to fashionable first-order methods. I will address a theoretical issue of how much of inexactness is allowed in directions and support the findings with computational experience of solving large-scale optimization problems.

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MS34

Reduced Order Models and Preconditioning

Reduced order models are a very successful tool in solving highly complex problems in engineering and otehr applications. In this talk we point out several ways how these models can be used in the context of preconditioning.

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MS34

Experiments with Quad Precision for Iterative

Solvers

Implementing conjugate-gradient-type methods in quad precision is a plausible alternative to reorthogonalization in double precision. Since the data for $Ax = b$ is likely to be double, not quad, products $y = Av$ (with quad y and v) need to take advantage of A being double; for example, by splitting $v = v_1 + v_2$ (with v_1 and v_2 double) and forming $y = Av_1 + Av_2$. This needs dot-products with double-precision data and quad-precision accumulation, but there is no such intrinsic function in Fortran 90. We explore ways of using double-precision floating-point to achieve quad-precision products.

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MS35

Semidefinite Relaxation for Orthogonal Procrustes and the Little Grothendieck Problem

The little Grothendieck problem over the Orthogonal Group consists of maximizing $\sum_{ij} Tr(C_{ij}^T O_i O_j^T)$ over variables O_i restricted to take values in the orthogonal group O(d), where C_{ij} denotes the (ij)-th d x d block of a positive semidefinite matrix C. Several relevant problems are encoded by the little Grothendieck over the orthogonal group, including Orthogonal Procrustes. The Orthogonal Procrustes problem consists of, given N point clouds in d-dimensional space, finding N orthogonal transformations that best simultaneously align the point clouds. We propose an approximation algorithm, to solve this version of the Grothendieck problem, based on a natural semidefinite relaxation. For each dimension d, we show a constant approximation ratio with matching integrality gaps. In comparison with the previously known approximation algorithms for this problem, our semidefinite relaxation is smaller and the approximation ratio is better.

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MS35

Convex Relaxations for Permutation Problems

Seriation seeks to reconstruct a linear order between variables using unsorted similarity information. It has direct applications in archeology and shotgun gene sequencing for example. We prove the equivalence between the seriation and the combinatorial 2-SUM problem (a quadratic minimization problem over permutations) over a class of similarity matrices. The seriation problem can be solved exactly by a spectral algorithm in the noiseless case and we produce a convex relaxation for the 2-SUM problem to improve the robustness of solutions in a noisy setting. This relaxation also allows us to impose additional structural constraints on the solution, to solve semi-supervised seriation problems. We present numerical experiments on archeological data, Markov chains and gene sequences.

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MS35

On Lower Complexity Bounds for Large-Scale Smooth Convex Optimization

We prove lower bounds on the black-box oracle complexity of large-scale smooth convex minimization problems. These lower bounds work for unit balls of normed spaces under a technical smoothing condition, and arbitrary smoothness parameter of the objective with respect to this norm. As a consequence, we show a unified framework for the complexity of convex optimization on ℓ^p-balls, for $2 \leq p \leq \infty$. In particular, we prove that the T-step Conditional Gradient algorithm as applied to minimizing smooth convex functions over the n-dimensional box with $T \leq n$ is nearly optimal. On the other hand, we prove lower bounds for the complexity of convex optimization over ℓ^p-balls, for $1 \leq p < 2$, by combining a random subspace method with the $p = \infty$ lower bounds. In particular, we establish the complexity of problem classes that contain the sparse recovery problem.

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MS35

Sketching Large Scale Convex Quadratic Programs

We consider a general framework for randomly projecting data matrices of convex quadratic programs, and analyze the approximation ratio of the resulting low-dimensional program. Solving a much lower dimensional problem when is very desirable in a computation/memory limited setting while it's also possible that the nature of the sensors might require random projections regardless of dimensions. We show that with a sub-gaussian sketching matrix, the data matrices can be projected down to the statistical dimension of the tangent cone at the original solution, which we show to be substantially smaller than original dimensions. Similar results also hold for partial Hadamard and Fourier projections. We discuss Lasso and interval constrained Least Squares, Markowitz portfolios and Support Vector Machines as examples of our general framework.

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MS36

Parallel Nonlinear Interior-Point Methods for Stochastic Programming Problems

The dominant computational cost in a nonlinear interior-point algorithms like IPOPT is solution of the linear KKT system at each iteration. When solving nonlinear stochastic programming problems, the linear system can be solved in parallel with a Schur-complement decomposition. In this presentation, we show the parallel performance of a PCG-based Schur-complement decomposition using an L-BFGS preconditioner that avoids the cost of forming and factoring the Schur-complement.

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MS36

Stochastic Model Predictive Control with Non-Gaussian Disturbances

We present a stochastic model predictive control algorithm designed to handle non-Gaussian disturbance distributions. The method relies on piecewise polynomial parameterization of the distribution, for which fast exact convolution is tractable. The problem formulation minimizes expected cost subject to linear dynamics, polyhedral hard constraints on inputs and chance constraints on states. Joint chance constraints are approximated using Boole's inequality, and conservatism in this approximation is reduced by optimal risk allocation and affine disturbance feedback.

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MS36

A Two Stage Stochastic Integer Programming Method for Adaptive Staffing and Scheduling under Demand Uncertainty with Application to Nurse Management

We present a two stage stochastic integer programming method with application of workforce planning. We convexify the recourse function by adding valid inequalities to the second stage. As a result, we present a tight formulation in which the integrality of the recourse can be relaxed. The model is solved by an integer L-shaped method with a novel multicut approach and a new hyperplane branching strategy. We also conduct computational experiments using real patient census data.

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MS36

Covariance Estimation and Relaxations for Stochastic Unit Commitment

Abstract not available.

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MS37

Multi-Phase Optimization of Elastic Materials, Using a Level Set Method

Abstract not available.

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MS37

Structural Optimization Based on the Topological Gradient

Abstract not available.

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MS37

A New Algorithm for the Optimal Design of Anisotropic Materials

A new algorithm for the solution of optimal design problems with control in parametrized coefficients is discussed.

The algorithm is based on the sequential convex programming idea, however, in each major iteration a model is established on the basis of the parametrized material tensor. The potentially nonlinear parametrization is then treated on the level of the sub-problem, where, due to block separability of the model, global optimization techniques can be applied. Theoretical properties of the algorithm like global convergence are discussed. The effectiveness of the algorithm is demonstrated by a series of numerical examples from the area of parametric and two-scale material design involving optimal orientation problems.

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MS37

Optimization of the Fibre Orientation of Orthotropic Material

Abstract not available.

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MS38

SI Spaces and Maximal Monotonicity

We introduce *SI spaces*, which include Hilbert spaces, negative Hilbert spaces and spaces of the form $E \times E^*$, where E is a nonzero reflexive real Banach space. We introduce *L–positive* subsets, which include monotone subsets of $E \times E^*$, and *BC–functions*, which include Fitzpatrick functions of monotone multifunctions. We show how convex analysis can be combined with SI space theory to obtain and generalize various results on maximally monotone multifunctions on a reflexive Banach space, such as the significant direction of Rockafellar's surjectivity theorem, and sufficient conditions for the sum of maximally monotone multifunctions to be maximally monotone. If time permits, we will also give an abstract Hammerstein theorem.

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MS38

Coderivative Characterizations of Maximal Monotonicity with Applications to Variational Systems

In this talk we provide various characterizations of maximal monotonicity in terms of regular and limiting coderivatives, which are new in finite-dimensional and infinite-dimensional frameworks. We also develop effective applications to obtaining Lipschitzian continuity of solution maps to conventional models of variational systems and variational conditions in nonlinear programming.

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MS38

New Techniques in Convex Analysis

Abstract not available.

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MS38

Resolvent Average of Monotone Operators

Monotone operators are important in optimization. We provide a new technique to average two or more monotone operators. The new maximal monotone operator inherits many nice properties of given monotone operators.

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MS39

The CP-Matrix Completion Problem

A symmetric matrix C is completely positive (CP) if there exists an entrywise nonnegative matrix B such that $C = BB^T$. The CP-completion problem is to study whether we can assign values to the missing entries of a partial matrix (i.e., a matrix having unknown entries) such that the completed matrix is completely positive. CP-completion has wide applications in probability theory, the nonconvex quadratic optimization, etc. In this talk, we will propose an SDP algorithm to solve the general CP-completion problem and study its properties. Computational experiments will also be presented to show how CP-completion problems can be solved.

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MS39

Convexity in Problems Having Matrix Unknowns

Problems in classical system engineering have unknowns which are matrices appearing in a polynomial determined by the system's "signal flow diagram". Recent results show that if such a situation is convex, then there is also an LMI associated to it- a rather negative result to an engineer who is desperate for convexity. The talk will discuss associated topics, eg. , matrix convex hulls and consequences for polynomial inequalities where convexity is involved.

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MS39

Optimizing over Surface Area Measures of Convex Bodies

We are interested in shape optimization problems under convexity constraints. Using the notion of surface area measure introduced by H. Minkowski and refined by A. D. Alexandrov, we show that several well-known problems of this class (constant width body of maximum volume, Newton's body of minimum resistance) can be formulated as linear programming (LP) problems on Radon measures. Then we show that these measure LPs can be solved approximately with a hierarchy of semidefinite programming (SDP) relaxations. The support function of the almost optimal convex body is then recovered from its surface area measure by solving the Minkowski problem with the SDP hierarchy. Joint work with Terence Bayen (University of Montpellier, France).

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MS39

On Level Sets of Polynomials and a Generalization of the Lowner's John Problem

We investigate some properties of level sets of polynomials and solve a generalization of the Lowner's John problem.

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MS40

Hierarchical Cuts to Strengthen Semidefinite Relaxations of NP-hard Graph Problems

The max-cut problem can be closely approximated using the basic semidefinite relaxation iteratively refined by adding valid inequalities. We propose a projection polytope as a new way to improve the relaxations. These cuts are based on requiring the solution to be valid for smaller cut polytopes. Finding new cuts creates a hierarchy that iteratively tightens the semidefinite relaxation in a controlled manner. Theoretical and computational results will be presented.

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MS40

Effective Quadratization of Nonlinear Binary Optimization Problems

We consider large nonlinear binary optimization problems arising in computer vision applications. Numerous recent techniques transform high degree binary functions into equivalent quadratic ones, using additional variables. In this work we study the space of "quadratizations," give sharp lower and upper bounds on the number of additional variables needed, and provide new algorithms to quadratize high degree functions. (Joint work with Martin Anthony (LSE), Yves Crama (University of Liege) and Aritanan Gruber (Rutgers University).)

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MS40

Lower Bounds on the Graver Complexity of M-Fold Matrices

In this talk, we present a construction that turns certain relations on Graver basis elements of an M-fold matrix $A^{(M)}$ into relations on Graver basis elements of $A^{(M+1)}$. In doing so, we give a lower bound on the Graver complexity $g(A^{(M)})$ for general M-fold matrices $A^{(M)}$ and we strengthen the bound on the Graver complexity of $A_{3\times M}$ from $g(A_{3\times M}) \geq 17 \cdot 2^{M-3} - 7$ (Berstein and Onn) to $g(A_{3\times M}) \geq 24 \cdot 2^{M-3} - 21$.

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MS40

BiqCrunch in Action: Solving Difficult Combinatorial Optimization Problems Exactly

We present different combinatorial optimization problems that can be solved by BiqCrunch, a semidefinite-based branch-and-bound solver: MaxCut, Max-k-Cluster, Maximum Independent Set, k-Exact Assignment, and the Quadratic Assignment Problem. With each problem, we describe some of the techniques used in formulating them, such as adding reinforcing constraints, and making special heuristics. We show numerical results that demonstrate the efficiency of BiqCrunch on these problems. Note that N. Krislock's talk "BiqCrunch: a semidefinite branch-and-bound method for solving binary quadratic problems" explains in details the underlying theory of BiqCrunch.

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MS41

An Active Set Strategy for ℓ_1 Regularized Problems

The problem of finding sparse solutions to underdetermined systems of linear equations arises from several application problems (e.g. signal and image processing, compressive sensing, statistical inference). A standard tool for dealing with sparse recovery is the ℓ_1-regularized least-squares approach that has been recently attracting the attention of many researchers. Several ideas for improving the Iterative Shrinkage Thresholding (IST) algorithm have been proposed. We present an active set estimation that can be included within IST-algorithm and its variants. We report numerical results on some test problems showing the efficiency of the proposed strategy.

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MS41

Second Order Methods for Sparse Signal Reconstruction

In this talk we will discuss efficient second order methods for a family of ℓ_1-regularized problems from the field sparse signal reconstruction. The problems include isotropic total-variation, ℓ_1-analysis, the combinations of those two and ℓ_1-regularized least-squares. Although first-order methods have dominated these fields, we will argue that specialized second order methods offer a viable alternative. We will provide theoretical analysis and computational evidence to illustrate our findings.

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MS41

A Stochastic Quasi-Newton Method

We propose a stochastic approximation method based on the BFGS formula. The algorithm is of the type proposed by Robbins-Monro, but scaled by a full quasi-Newton matrix (that is defined implicitly). We show how to control noise in the construction of the curvature correction pairs that determined the BFGS matrix. Results on three large scale learning applications demonstrate the efficiency and robustness of the approach.

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MS41

An Iterative Reweighting Algorithm for Exact Penalty Subproblems

Matrix free alternating direction and reweighting methods are proposed for solving exact penalty subproblems. The methods attain global convergence guarantees under mild assumptions. Complexity analyses for both methods are also discussed. Emphasis is placed on their ability to rapidly find good approximate solutions, and to handle large-scale problems. Numerical results are presented for elastic QP subproblems arising in NLP algorithms and ℓ_1-SVM problems.

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MS42

Optimal Fractionation in Radiotherapy

The prevalent practice in radiotherapy is to first obtain a radiation intensity profile by solving a fluence-map optimization problem and then deliver the resulting dose over a fixed number of equal-dosage treatment sessions. We will present convex programming methods that simultaneously optimize the number of treatment sessions and the intensity profile using the linear-quadratic dose-response model. Our models and methods will also be extended to allow non-stationary dosing schedules.

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MS42

A Stochastic Optimization Approach to Adaptive Lung Radiation Therapy Treatment Planning

Intensity Modulated Radiation Therapy is a common technique used to treat cancer. Treatment planners optimize a physician's treatment planning goals using patient information obtained pre-treatment while remaining within the constraints of the treatment modality. Biomarker data obtained during treatment (post-planning) has been shown to be predictive of a patient's predisposition to radiation-induced toxicity. We develop a two-stage stochastic treatment plan optimization model to explicitly consider future patient-specific biomarker information. Several adaptive treatment strategies are studied.

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MS42

A Mathematical Optimization Approach to the Fractionation Problem in Chemoradiotherapy

In concurrent chemoradiotherapy (CRT) chemotherapeutic agents are administered during the course of radiotherapy to enhance the primary tumor control. That often comes at the expense of increased risk of normal-tissue complications. The additional biological damage is attributed to the drug cytotoxic activity and its interactive cooperation with radiation, which is dose and time dependent. We develop a mathematical optimization framework to determine radiation and drug administration schedules that maximize the therapeutic gain for concurrent CRT.

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MS42

Incorporating Organ Functionality in Radiation Therapy Treatment Planning

Goals of radiotherapy treatment planning include (i) eradicating tumor cells and (ii) sparing critical structures to ultimately preserve functionality. A good indicator of local and global function, perfusion (blood flow) shows that organ function is non-homogenous. Thus, spatial distribution of dose in critical structures matters. We propose an optimization model that explicitly incorporates functionality information from perfusion maps to avoid delivering dose to well-perfused areas. We use liver cancer cases to validate our model.

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MS43

Stochastic Block Mirror Descent Methods for Nonsmooth and Stochastic Optimization

In this paper, we present a new stochastic algorithm, namely the stochastic block mirror descent (SBMD) method for solving large-scale nonsmooth and stochastic optimization problems. The basic idea of this algorithm is to incorporate the block-coordinate decomposition and an incremental block averaging scheme into the classic (stochastic) mirror-descent method, in order to significantly reduce the cost per iteration of the latter algorithm. We establish the rate of convergence of the SBMD method along with its associated large-deviation results for solving general nonsmooth and stochastic optimization problems. We also introduce different variants of this method and establish their rate of convergence for solving strongly convex, smooth, and composite optimization problems, as well as certain nonconvex optimization problems.

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MS43

Universal Coordinate Descent Method

We design and analyze universal coordinate descent methods, that is methods that can efficiently solve smooth as well as nonsmooth problems without knowing the level of smoothness. We propose a line search strategy that does not involve function evaluations and derive iteration complexity bounds. We also study a parallel version of the method. The key technical tool is the introduction of nonquadratic separable overapproximations that allow us to define and compute in parallel the update of each coordinate.

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MS43

Iteration Complexity Analysis of Block Coordinate Descent Methods

We provide a unified iteration complexity analysis for a family of block coordinate descent (BCD)-type algorithms, covering both the classic Gauss-Seidel coordinate update rule and the randomized update rule. We show that for a broad class of nonsmooth convex problems, the BCD-type algorithms, including the classic BCD, the block coordinate gradient descent and the block coordinate proximal gradient methods, have an iteration complexity of $O(1/r)$, where r is the iteration index.

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MS43

On the Complexity Analysis of Randomized Coordinate Descent Methods

We give refined analysis of the randomized block-coordinate descent (RBCD) method proposed by Richtarik and Takac for minimizing the sum of a smooth convex function and a block-separable convex function. We obtain sharper bounds on its convergence rate, both in expected value and in high probability. For unconstrained smooth convex optimization, we develop a randomized estimate sequence technique to establish a sharper expected value type of convergence rate for Nesterov's accelerated RBCD method.

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MS44

Towards a Computable $O(n)$-Self-Concordant Barrier for Polyhedral Sets in $\Re^n$

It is known that for a polyhedral set in $\Re^n$ determined by m linear inequalities, there is a self-concordant barrier (the universal barrier) whose parameter is $O(n)$, as opposed to m for the usual logarithmic barrier. However there is no known *computable* barrier whose parameter is $O(n)$. We describe one possible approach for construcing such a barrier based on maximum volume inscribing ellipsoids.

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MS44

An Efficient Affine-scaling Algorithm for Hyperbolic Programming

Hyperbolic programming (HP) is a generalization of semidefinite programming. Hyperbolicity cones, however, in general are not symmetric, limiting the number of interior-point methods that can be applied. For example, the variants of Dikin's affine-scaling algorithm that have been shown to run in polynomial time depend heavily on the underlying cone being symmetric, and thus do not apply to HP. Until now, that is. We present a natural variant of Dikin's algorithm that applies to HP, and establish a complexity bound that is no worse than the best bound known for interior-point methods ("$O(\sqrt{n})$ iterations to halve the duality gap"). Interestingly, the algorithm is primal, but the analysis is almost entirely dual (and provides new geometric insight into hyperbolicity cones).

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MS44

On the Sonnevend Curvature and the Klee-Walkup Result

We consider Sonnevend's (1991) curvature integral of the central path (CP) of LO. Our main result states that for establishing an upper bound for the total Sonnevend curvature, it is sufficient to consider the case $n = 2m$. Our construction yields an $\Omega(m)$ worst-case lower bound for Sonnevend's curvature. Our results are analogous to Deza et al.' (2008) results for the geometric curvature and to the Klee-Walkup result about a polytope's diameter.

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MS44

On the Curvature of the Central Path for Lp

Similarly to the diameter of a polytope, one may define its curvature based on the worst-case central path associated with solving an LP posed over the polytope. Furthermore, a continuous analogue of the Hirsch conjecture and a discrete analogue of the average curvature result of Dedieu, Malajovich and Shub may be introduced. A continuous analogue of the result of Holt and Klee –a polytope construction that attains a linear order largest total curvature– and a continuous analogue of a d-step equivalence result for the diameter of a polytope may also be proved. We survey the recent progress towards better understanding of the curvature.

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MS45

An Algorithm for Solving Smooth Bilevel Opti-

mization Problems

Our basis is a standard nonsmooth, nonconvex optimistic bilevel programmig problem with the upper level feasible set not depending on the lower level variable. We use the optimal value reformulation and apply partial calmness to the resulting problem which allows us to formulate suitable constraint qualifications. The bundle algorithm by K.C. Kiwiel, *A proximal bundle method with approximate subgradient linearizations*, SIAM Journal on Optimization **16** (2006), 1007–1023 is extended to the nonconvex case.

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MS45

On Regular and Limiting Coderivatives of the Normal Cone Mapping to Inequality Systems

In modern variational analysis, generalized derivatives are the essential ingredients for deriving stability results for solutions maps of generalized equations as well as stating optimality conditions for mathematical programs. For the special case of generalized equations involving the normal cone mapping to a system of C^2 inequalities, we give workable formulas for the graphical derivative and the regular respectively limiting coderivative, when LICQ does not hold at the reference point. We use neighborhood based first order constraint qualifications, which, however, can be characterized by point based second order conditions.

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MS45

A Heuristic Approach to Solve the Bilevel Toll Assignment Problem by Making Use of Sensitivity Analysis

Toll Optimization Problem is considered as a bilevel programming model. At the upper level, a public regulator or a private company manages the toll roads to increase its profit. At the lower level, several users try to satisfy the existing demand for transportation of goods and/or passengers, and simultaneously, to select the routes so as to minimize their travel costs. To solve this bilevel programming problem, a direct algorithm based on sensitivity analysis is proposed.

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MS45

Solving Bilevel Programs by Smoothing Techniques

We propose to solve bilevel programs by reformulating it as a combined program where both the value function constraint and the first order condition are present. Using smoothing technique, we approximate the value function by a smoothing function, use certain penalty based methods to solve the smooth problem and drive the smoothing parameter to infinity. We prove the convergence of the algorithm under a weak extended generalized Mangasarian-Fromovitz constraint qualification.

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MS46

Spectral Bounds and Preconditioners for Unreduced Symmetric Systems Arising from Interior Point Methods

The focus of this talk is on the linear systems that arise from the application of Primal-Dual Interior Point methods to convex quadratic programming problems in standard form. The block structure of the matrices allows for formulations differing in their dimensions and spectral properties. We consider the unreduced symmetric 3x3 block formulation of such systems, provide new spectral bounds and discuss the impact of the formulation used on preconditioning techniques.

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MS46

A General Krylov Subspace Method and its Connection to the Conjugate-gradient Method

Krylov subspace methods are used for solving systems of linear equations $Ax = b$. We present a general Krylov subspace method that can be used when the matrix A is indefinite. We show that the approximate solution in each step, x_k, is given by the chosen scaling of the orthogonal vectors that successively make the Krylov subspaces available. Our framework gives an intuitive way to see the conjugate-gradient method and why it sometimes fails if A is not positive definite.

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MS46

Asqr: Interleaving Lsqr and Craig Krylov Methods for the Solution of Augmented Systems

We consider the solution of standard augmented systems, which can actually be split into the sum of a least-squares solution and a minimum-norm solution. We thus propose to interleave both left and right Krylov sequences from LSQR and Craig methods, with corresponding starting vectors, and to compute at the same time an approximation of the least-squares solution and an approximation of the minimum norm solution, both by means of appropriate restrictions onto these interleaved Krylov basis, and to sum them for an approximation of the solution at each iteration. This interleaving procedure leads to a tridiagonalization procedure of the constraint rectangular sub-matrix, which can be factorized in QR form with Givens rotations. Putting this altogether yields the method that we denote as ASQR, the acronym standing for "*Augmented-system Solution with QR factorization*'. We shall discuss and illustrate numerically the different aspects of this method.

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MS46

Using Partial Spectral Information for Block Diagonal Preconditioning of Saddle-Point Systems

We focus on KKT systems with very badly conditioned symmetric positive definite (1,1) blocks due to few very small eigenvalues. Assuming availability of these eigenvalues and associated eigenvectors, we consider different approximations of the block diagonal preconditioner of Murphy, Golub and Wathen that appropriately recombine the available spectral information through a particular Schur complement approximation built at little extra cost. We also discuss under which circumstances these eigenvalues effectively spoil the convergence of MINRES.

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MS47

Function-Value-Free Continuous Optimization in High Dimension

Information geometric optimization provide a generic framework of function-value-free stochastic search algorithms for arbitrary optimization, including the state-of-the-art stochastic search algorithm for continuous optimization, the CMA-ES. From this framework, we derive a novel algorithm for high dimensional continuous optimization, whose time and space complexity for each iteration is linear in the dimension of the problem.

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MS47

Fifty Years of Randomized Function-Value-Free Algorithms: Where Do We Stand?

The first randomized function-value-free (FVF) or comparison-based algorithms were already introduced in the 60's. There is nowadays a renewal of interests for those algorithms in the context of derivative-free optimization. We will discuss important design principles of randomized FVF algorithms like invariances and emphasize on the theoretical properties that follow from those principles, for example linear convergence or learning of second order information.

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MS47

Evolutionary Multiobjective Optimization and Function-Value-Free Algorithms

Evolutionary Multiobjective Optimization Algorithms (EMOAs) are derivative-free, stochastic optimization algorithms to approximate the Pareto front of multiobjective optimization problems. The approximations are thereby typically of a fixed, pre-determined size, the algorithms' so-called population size. Interestingly, when compared to the single-objective case, all state-of-the-art EMOAs are currently *not* function-value free and this talk discusses the main reasons behind and possible remedies for it.

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MS47

X-NES: Exponential Coordinate System Parameterization for FVF Search

Online adaptation of mean vector and covariance matrix is a key step in randomized FVF optimization with Gaussian search distributions. Adaptation of the covariance matrix must handle the positive definiteness constraint. This talk presents a solution proposed in the exponential natural evolution strategy algorithm, namely a parameterization of the covariance matrix with the exponential map. The resulting multiplicative update blends smoothly with step size adaptation rules. Its tangent space decomposes naturally into meaningful, independent components.

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MS48

Dynamic System Design based on Stochastic Optimization

The common design practice in industry has traditionally been based on steady-state requirement for nominal and fully specified conditions considering economic and various constraints. Afterwards control systems are deisgned to remedify the operability bottlenects and problems caused by the dynamics not considered in the design phase. In this sequential process, overdeign based on engineering insight and knowledge is usually exercised. Nevertheless, it has been realized in many applications that the steady state design may yield systems which are difficult to control due to the lack of consideration of operability, controllability, flexibility and stability in the deisgn phase. In addition, this sequential approach may also lead to more expensive or less efficient design options. With the recent advances in simulation and computational algorithms, design problems include controllability and control system design have emerged in the literature [Flores-Tlacuahuac, A and Biegler, L. Simultaneous control and process design during optimal grade transition operations. Comput. Chem. Eng., 32:2823, 2008]. In addition, stochastic and robust optimization formulations have been proposed to deal with parametric uncertainty and disturbances. However, robust optimization formulation may lead to conservative solutions and the size of the stochastic optimization problem maybe limited due to its sampling nature. This work presents a case study of optimal dynamic system design considering uncertainty based on Generalized Polynomial Chaos. It represents the effects of uncertainties in second order random processes with guarrantted convergence. As a result, a stochastic optimziation problem is formulated considering the economic, design, controllability and flexibility objectives based on a dynamic model of the system of interest, including path constraints, end point constriant, and generalized polynomial chaos model of uncertainty parameters.

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MS48

Enhanced Benders Decomposition for Stochastic Mixed-integer Linear Programs

Stochastic mixed-integer linear programs often hold a decomposable structure that can be exploited by Benders decomposition (BD). However, BD may suffer from the tailing effect, i.e., the lower and upper bounds tend to converge very slowly after the optimal objective value has been reached. We propose to enhance the BD bounds via solving extra subproblems that come from Dantzig-Wolfe decomposition strategy, and case study results demonstrate the advantage of the enhanced BD.

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MS48

Semismooth Equation Approaches to Structured Convex Optimization

Structured convex optimization problems arise in the context of resource allocation problems, network constrained optimization, machine learning, stochastic programming, optimization-based control to name a few. Popular approach to solving structured convex optimization utilizes dual decomposition of complicating constraints to yield smaller subproblems. A subgradient algorithm, which is extremely slow to converge, is typically employed to obtain convergence of dualized constraints. We propose a novel semismooth equation approach to solving the standard dual decomposition formulation. The approach relies on the ability to compute sensitivity of the subproblem solutions to the multipliers of the dualized constraints. We show that under certain assumptions the approach converges locally superlinearly to the solution of the original problem. Globalization of the proposed algorithm using a linesearch is also described. Numerical experiments compare the performance against state-of-the-art nonlinear programming solver.

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MS48

A Scalable Clustering-Based Preconditioning Strategy for Stochastic Programms

We present a scalable implementation of a multi-level clustering-based preconditioning strategy for structured KKT systems arising in stochastic programs. We demonstrate that the strategy can achieve compression rates of over 80% while retaining good spectral properties. Case studies arising from power grid systems are presented.

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MS49

Adaptive and Robust Radiation Therapy in the Presence of Motion Drift

We present an adaptive, multi-stage robust optimization approach to radiation therapy treatment planning for a lung cancer case subject to tumor motion. It was previously shown that this approach is asymptotically optimal if the uncertain tumor motion distribution stabilizes over the treatment course. We show computationally that this approach maintains good performance even if the motion distribution does not stabilize but instead exhibits drifts within the probability simplex.

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MS49

Mathematical Modeling and Optimal Fractionationated Irradiation for Proneural Glioblastomas

Glioblastomas (GBM) are the most common and malignant primary tumors of the brain and are commonly treated with radiation therapy. Despite modest advances in chemotherapy and radiation, survival has changed very little over the last 50 years. Radiation therapy is one of the pillars of adjuvant therapy for GBM but despite treatment, recurrence inevitably occurs. Here we develop a mathematical model for the tumor response to radiation that takes into account the plasticity of the hierarchical structure of the tumor population. Based on this mathematical model we develop an optimized radiation delivery schedule. This strategy was validated to be superior in mice and nearly doubled the efficacy of each Gray of radiation administered. This is based on joint work with Ken Pitter, Eric Holland, and Franziska Michor.**

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MS49

A Column Generation and Routing Approach to 4π Vmat Radiation Therapy Treatment Planning

Volumetric Modulated Arc Therapy (VMAT) is rapidly emerging as a method for delivering radiation therapy treatments to cancer patients that is of comparable quality to IMRT but much more efficient. Since VMAT only uses coplanar beam orientations, the next step is to consider non-coplanar orientations as well. This greatly complicates the radiation therapy treatment plan optimization problem by introducing a routing component. We propose a constructive approach that employs both column generation and routing heuristics.

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MS49

Combined Temporal and Spatial Treatment Optimization

We consider the interdependence of optimal fractionation schemes and the spatial dose distribution in radiotherapy planning. This is approached by simultaneously optimizing multiple distinct treatment plans for different fractions based on the biologically equivalent dose (BED) model. This leads to a large-scale non-convex optimization problem, arising from the quadratic relation of BED and dose. For proton therapy, it is shown that delivering different dose distributions in subsequent fractions may yield a therapeutic advantage.

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MS50

Distributed Optimization over Time-Varying Directed Graphs

We consider distributed optimization by a collection of nodes, each having access to its own convex function, whose collective goal is to minimize the sum of the functions. The communications between nodes are described by a time-varying sequence of directed graphs, which is uniformly strongly connected. For such communications, assuming that every node knows its out-degree, we develop a broadcast-based algorithm, termed the subgradient-push, which steers every node to an optimal value under a standard assumption of subgradient boundedness. The subgradient-push requires no knowledge of either the number of agents or the graph sequence to implement. Our analysis shows that the subgradient-push algorithm converges at a rate of $O(\ln t/t)$, where the constant depends on the initial values at the nodes, the subgradient norms, and, more interestingly, on both the consensus speed and the imbalances of influence among the nodes.

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MS50

On the Solution of Stochastic Variational Problems with Imperfect Information

We consider the solution of a stochastic convex optimization problem $\mathbb{E}[f(x;\theta^*,\omega)]$ over a closed and convex set X in a regime where θ^* is unavailable. Instead, may be learnt by minimizing a suitable stochastic metric in θ over a closed and convex set . We present a coupled stochastic approximation scheme for the associated stochastic optimization problem with imperfect information. It is shown that the resulting schemes are shown to be equipped with almost sure convergence properties in regimes where the function f is both strongly convex as well as merely convex. We show that such schemes display the optimal rate of convergence in convergence and quantify the degradation in convex regimes by a modest amount. We examine extensions to variational regimes and provide some numerics to illustrate the workings of the scheme.

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MS50

Stochastic Methods for Convex Optimization with "Difficult" Constraints

Convex optimization problems involving large-scale data or expected values are challenging, especially when these difficulties are associated with the constraint set. We propose random algorithms for such problems, and focus on special structures that lend themselves to sampling, such as when the constraint is the intersection of many simpler sets, involves a system of inequalities, or involves expected values, and/or the objective function is an expected value, etc. We propose a class of new methods that combine elements of successive projection, stochastic gradient descent and proximal point algorithm. This class of methods also contain as special cases many known algorithms. We use a unified analytic framework to prove their almost sure convergence and the rate of convergence. Our framework allows the random algorithms to be applied with various sampling schemes (e.g., i.i.d., Markov, sequential, etc), which are suitable for applications involving distributed implementation, large data set, computing equilibriums, or statistical learning.

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MS50

On Decentralized Gradient Descent

Consider the consensus problem of minimizing $\sum_{i=1}^{n} f_i(x)$ where each f_i is only known to one individual agent in a connected network of many agents. All the agents shall collaboratively solve this problem subject to data exchange restriction to between neighbor agents. Such algorithms avoids the need of a fusion center and long-distance communication. It offers better network load balance and improves data privacy. We study the decentralized gradient method in which each agent i updates its copy of variable $x_{(i)}$ by averaging of its neighbors' variables $x_{(j)}$ and moving along the negative gradient $-\alpha\nabla f_i(x_{(i)}$. That is, $x_{(i)} \leftarrow \sum_{(i,j)\in E} w_{ij}x_{(j)} - \alpha\nabla f_i(x_{(i)})$. We show that if the problem has a solution x^* and all f_i's are proper closed convex with Lipschitz continuous gradients, then provided stepsize $\alpha < (1 + \lambda_{\min} W)/2$, the function value at the average, $f(\bar{x}(k)) - f^*$, reduces at a speed of $O(1/k)$ until it reaches $O(1/\alpha)$. If f_i are further (restricted) strongly convex, then each $x_{(i)}(k)$ converges to the global minimizer at a linear rate until reaching an $O(1/\alpha)$-neighborhood of x^*.

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MS51

Constructive Approximation Approach to Polynomial Optimization

In this talk we explore the links between some constructive approximation approaches and polynomial optimization. In particular, we revisit some approximation results for polynomial optimization over a simplex by exploring the links with Bernstein approximation and other constructive approximation schemes.

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MS51

Polynomial Optimization in Biology

The problem of inferring the phylogenic tree of n extant species from their genome is treated via mainly two approaches, the maximum parsimony and the maximum likelihood approach. While the latter is thought to produce more meaningful results, it is harder to solve computationally.We show that under a molecular clock assumption, the maximum likelihood model has a natural formulation that can be approached via branch-and-bound and polynomial optimization. Using this approach, we produce a counterexample to a conjecture relating to the reconstruction of an ancestral genome under the maximum parsimony and maximum likelihood approaches.

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MS51

Noncommutative Polynomials

Abstract not available.

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MS51

The Hierarchy of Local Minimums in Polynomial Optimization

This paper studies the hierarchy of local minimums of a polynomial in the space. For this purpose, we first compute H-minimums, for which the first and second order optimality conditions are satisfied. To compute each H-minimum, we construct a sequence of semidefinite relaxations, based on optimality conditions. We prove that each constructed sequence has finite convergence, under some generic conditions. A procedure for computing all local minimums is given. When there are equality constraints, we have similar results for computing the hierarchy of critical values and the hierarchy of local minimums. Several extensions are discussed.

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MS52

Alternating Direction Methods for Penalized Classification

Fisher Linear Discriminant Analysis is a classical technique for feature reduction in supervised classification. However, this technique relies on the fact that the data being processed contains fewer features than observations, which typically fails to hold in a high-dimensional setting. In this talk, we present a modification, based on ℓ_1-regularization and the alternating direction method of multipliers, for performing Fisher Linear Discriminant Analysis in the high-dimensional setting.

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MS52

Statistical-Computational Tradeoffs in Planted Models

We study the statistical-computational tradeoffs in the planted clustering model, where edges are randomly placed between nodes according to their cluster memberships and the goal is to recover the clusters. When the number of clusters grows, we show that the space of model parameters can be partitioned into four regions: impossible, where all algorithms fail; hard, where an exponential-time algorithm succeeds; easy, where a polynomial-time algorithm succeeds; simple, where a simple counting algorithm succeeds.

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MS52

Regularized Spectral Clustering under the Degree-Corrected Stochastic Blockmodel

Spectral clustering is a fast and popular algorithm for finding clusters in networks. Recently, Chaudhuri et al. and Amini et al. proposed inspired variations on the algorithm that artificially inflate the node degrees for improved statistical performance. The current paper extends the previous statistical estimation results to the more canonical spectral clustering algorithm in a way that removes any assumption on the minimum degree and provides guidance on the choice of the tuning parameter. Moreover, our results show how the “star shape” in the eigenvectors–a common feature of empirical networks–can be explained by the Degree-Corrected Stochastic Blockmodel and the Extended Planted Partition model, two statistical models that allow for highly heterogeneous degrees. Throughout, the paper characterizes and justifies several of the variations of the spectral clustering algorithm in terms of these models.

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MS52

Statistical and Computational Tradeoffs in Hierarchical Clustering

Recursive spectral clustering is robust to noise in similarities between the objects to be clustered, however it has cubic computational complexity. I will present an active spectral clustering algorithm that uses selective similarities, allowing one to trade off noise tolerance for computational efficiency. For one setting, it reduces to spectral clustering and for another it yields nearly linear computational complexity while being more robust than greedy hierarchical clustering methods such as single linkage.

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MS53

Alternative Quadratic Models for Minimization Without Derivatives

Let quadratic models be updated by an algorithm for derivative-free optimization, using a number of values of the objective function that is fewer than the amount of freedom in each model. The freedom may be taken up by minimizing the Frobenius norm of either the change to or the new second derivative matrix of the model. An automatic way of choosing between these alternatives is described. Its advantages are illustrated by two numerical examples.

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MS53

The Spectral Cauchy-Akaike Method

We introduce a variation of Cauchy method to minimize a convex quadratic function. It explores the fact, proved by Akaike, that the steepest descent method will be trapped in a two dimensional subspace associated to extreme eigenvalues. The algorithm then estimates the largest eigenvalue and performs a spectral step to scape this subspace. We will compare the new algorithm to the Barzilai-Borwein and Cauchy-Barzilai-Bowein methods and discuss its extensions to box constrained problems.

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MS53

On the Convergence and Worst-Case Complexity of Trust-Region and Regularization Methods for Unconstrained Optimization

A nonlinear stepsize control framework for unconstrained optimization was recently proposed by Toint (2013), providing a unified setting in which the global convergence can be proved for trust-region algorithms and regularization schemes. The original analysis assumes that the Hessians of the models are uniformly bounded. In this paper, the global convergence of the nonlinear stepsize control algorithm is proved under the assumption that the norm of the Hessians can grow by a constant amount at each iteration. The worst-case complexity is also investigated. The results obtained for unconstrained smooth optimization are extended to some algorithms for composite nonsmooth optimization and unconstrained multiobjective optimization as well.

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MS53

A Nonmonotone Approximate Sequence Algorithm for Unconstrained Optimization

A new nonmonotone algorithm will be presented for unconstrained nonlinear optimization. Under proper searching direction assumptions, this algorithm has global convergence for minimizing general nonlinear objective function with Lipschitz continuous derivatives. For convex objective function, this algorithm would maintain the optimal convergence rate of convex optimization. Some preliminary numerical results will be also presented.

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MS54

Integer Programs with Exactly K Solutions

In this work we study a generalization of the classical feasibility problem in integer linear programming, where an ILP needs to have a prescribed number of solutions to be considered solved. (e.g., exactly k-solutions). We developed the structure theory of such problems and prove some generalization of known results: E.g., we provide a generalization of the famous Doignon-Bell-Scarf theorem: Given an integer k, we prove that there exists a constant $c(k, n)$, depending only on the dimension n and k, such that if a polyhedron $\{x : Ax \leq b\}$ contains exactly k integer solutions, then there exists a subset of the rows of cardinality no more than $c(k, n)$, defining a polyhedron that contains exactly the same k integer solutions.

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MS54

Cutting Planes for a Multi-Stage Stochastic Unit Commitment Problem

Motivated by the intermittency of renewable energy, we propose a multi-stage stochastic integer programming model in this talk to address unit commitment problems under uncertainty, for which we construct several classes of strong inequalities by lifting procedures to strengthen the original formulation. Our preliminary computational experiments show encouraging results.

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MS54

A Tighter Formulation of a Mixed-Integer Program with Powerflow Equations

We consider a problem arising in power systems where a distribution network operator needs to decide on the activation of a set of load modulations in order to avoid congestion in its network. The problem can be modeled as a mixed-integer nonlinear program where the nonconvex nonlinearities come from the powerflow equations. We first show that the Lagrangian and the SDP relaxation provide loose lower bounds for such a problem. We propose a formulation based on a linear network flow strengthened by the presence of loss variables. We show with computational experiments that we can provide tighter dual bounds with our formulation if we add some lower and upper bounds on the loss variables.

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MS54

Pushing the Frontier (literally) with the Alpha Alignment Factor

Construction of optimized portfolios entails complex interaction between three key entities, namely, the risk factors, the alpha factors and the constraints. The problems that arise due to mutual misalignment between these three entities are collectively referred to as Factor Alignment Problems (FAP). Examples of FAP include risk-underestimation of optimized portfolios, undesirable exposures to factors with hidden and unaccounted systematic risk, consistent failure in achieving ex-ante performance targets, and inability to harvest high quality alphas into above-average IR. In this paper, we give a detailed analysis of FAP and discuss solution approaches based on augmenting the user risk model with a single additional factor y. For the case of unconstrained MVO problems, we develop a parametric non-linear optimization model to analyze the ex-post utility function of the corresponding optimal portfolios, derive a closed form expression of the optimal factor volatility value and compare the solutions for various choices of y culminating with a closed form expression for the optimal choice of y. Ultimately, we show how the Alpha Alignment Factor (AAF) approach emerges as a natural and effective remedy to FAP. AAF not only corrects for risk underestimation bias of optimal portfolios but also pushes the ex-post efficient frontier upwards thereby empowering a PM to access portfolios that lie above the traditional risk-return frontier. We provide extensive computational results to corroborate our theoretical findings.

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MS55

Parallel Coordinate Descent for Sparse Regression

This talk discusses parallelization of coordinate descent-based methods, targeted at sparse regression. Several works have demonstrated theoretical and empirical speedups from parallelizing coordinate descent, in both the multicore and distributed settings. We examine these works, highlighting properties of sparse regression problems which permit effective parallel coordinate descent. We then generalize this discussion by asking: How well can a local solution (single or block coordinate descent updates) approximate a global solution? Exploring this question leads to new parallel block coordinate descent-based algorithms which are well-suited for the distributed setting and use limited communication.

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MS55

An Asynchronous Parallel Stochastic Coordinate Descent Algorithm

We describe an asynchronous parallel stochastic coordinate descent algorithm for minimizing smooth unconstrained or separably constrained functions. The method achieves a linear convergence rate on functions that satisfy an essential strong convexity property and a sublinear rate ($1/K$) on general convex functions. Near-linear speedup on a multicore system can be expected if the number of processors is $O(n^{1/2})$ in unconstrained optimization and $O(n^{1/4})$ in the separable-constrained case, where n is the number of variables. We describe results from implementation on 40-core processors.

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MS55

Hydra: Distributed Coordinate Descent for Big Data Optimization

Hydra: HYbriD cooRdinAte descent method for solving loss minimization problems with big data. We initially partition the coordinates and assign each partition to a different node of a cluster. At every iteration, each node picks a random subset of the coordinates from those it owns, independently from the other computers, and in parallel computes and applies updates to the selected coordinates based on a simple closed-form formula. We give bounds on the number of iterations sufficient to approximately solve the problem with high probability, and show how it depends on the data and on the partitioning. We perform numerical experiments with a LASSO instance described by a 3TB matrix.

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MS55

The Rich Landscape of Parallel Coordinate Descent Algorithms

Large-scale ℓ_1-regularized loss minimization problems arise in high-dimensional applications such as compressed sensing and high-dimensional supervised learning, including classification and regression problems. High-performance algorithms and implementations are critical to efficiently solving these problems. Building upon previous work on coordinate descent algorithms for ℓ_1-regularized problems, we introduce a novel family of algorithms that includes, as special cases, several existing algorithms such as SCD, Greedy CD, Shotgun, and Thread-Greedy. We give a unified convergence analysis for the family of block-greedy algorithms. We hope that algorithmic approaches and convergence analysis we provide will not only advance the field, but will also encourage researchers to systematically explore the design space of parallel coordinate descent algorithms for solving large-scale ℓ_1-regularization problems.

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MS56

Augmentation Algorithms for Linear and Integer Linear Programming

Separable convex IPs can be solved via polynomially many augmentation steps if best augmenting steps along Graver basis directions are performed. Using instead augmentation along directions with best ratio of cost improvement/unit length, we show that for linear objectives the number of augmentation steps is bounded by the number of elements in the Graver basis of the problem matrix, giving strongly polynomial-time algorithms for the solution of N-fold LPs and ILPs.

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MS56

Colorful Linear Programming: Complexity and Algorithms

Let $S_1, \ldots, S_k$ be k sets of points in $\mathbb{Q}^d$. The *colorful linear programming problem*, defined by Bárány and Onn (*Mathematics of Operations Research*, **22** (1997), 550–567) aims at deciding whether there exists a $T \subseteq \bigcup_{i=1}^{k} S_i$ such that $|T \cap S_i| \leq 1$ for $i = 1, \ldots, k$ and $\mathbf{0} \in \mathrm{conv}(T)$. They proved in their paper that this problem is NP-complete when $k = d$. They leave as an open question the complexity status of the problem when $k = d + 1$. Contrary to the case $k = d$, this latter case still makes sense when the points are in a generic position. We solve the question by proving its NP-completeness while exhibiting some relationships between colorful linear programming and complementarity programming. In particular, we prove that any polynomial time algorithm solving the case with $k = d+1$ and $|S_i| \leq 2$ for $i = 1, \ldots, d+1$ allows to compute easily Nash equilibrium in bimatrix games in polynomial time. On our track, we found a new way to prove that a complementarity problem belongs to the PPAD class with the help of Sperner's lemma. We also show that the algorithm proposed by Bárány and Onn for computing a feasible solution T in a special case can be interpreted as a "Phase I" simplex method, without any projection or distance computation. This is joint work with Pauline Sarrabezolles.

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MS56

An LP-Newton method for a standard form Linear Programming Problem

Fujishige et al. propose the LP-Newton method, a new algorithm for solving linear programming problems (LPs). They address LPs which have a lower and an upper bound for each variable. They reformulate the problem by introducing a related zonotope. Their algorithm solves the problem by repeating projections to the zonotope. In this paper, we develop the LP-Newton method for solving standard form LPs. We recast the LP by introducing a related convex cone. Our algorithm solves the problem by iterating projections to the convex cone.

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MS56

Performance of the Simplex Method on Markov Decision Processes

Markov decision processes (MDPs) are a particularly interesting class of linear programs that lie just beyond the point where our ability to solve LPs in strongly polynomial time stops, and number of recent results have studied the performance of the simplex method on MDPs and proven both upper and lower bounds, most famously Friedmann, Hansen, and Zwick's sub-exponential lower bound for randomized pivoting rules [STOC 2011]. This talk will discuss the known upper bounds for solving MDPs using the simplex method.

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MS57

Metric Regularity of Stochastic Dominance Constraints Induced by Linear Recourse

The introduction of stochastic dominance constraints is one option of handling risk aversion in linear programming under (stochastic) uncertainty. This approach leads to an optimization problem with infinitely many probabilistic constraints. Metric regularity is of crucial importance, e.g. for optimality conditions and stability of optimal solutions when the underlying probability measure is subjected to perturbations. The talk addresses sufficient conditions for metric regularity including their verification.

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MS57

Two-Stage meets Two-Scale in Stochastic Shape Optimization

In structural elastic shape optimization one faces the problem of distributing a given solid material over a working domain exposed to volume and surface loads. The resulting structure should be as rigid as possible while meeting a constraint on the volume spent. Without any further regularization the problem is ill-posed and on a minimizing sequence the onset of microstructures can be observed. We are interested in approximating these optimal microstructures by simple, constructible geometries within a two-scale model based on boundary elements for the elastic problem on the microscale and finite elements on the macroscale. Geometric details described by a small set of parameters thereby enter the macroscopic scale via effective material properties and lead to a finite dimensional constraint optimization problem. The performance of resulting shapes in the presence of uncertain loading will be compared to the one of classical single scale designs by applying stochastic dominance constraints.

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MS57

SOCP Approach for Joint Probabilistic Constraints

In this talk, we investigate the problem of linear joint probabilistic constraints. We assume that the rows of the constraint matrix are dependent. Furthermore, we assume the distribution of the constraint rows to be elliptically distributed. Under some conditions, we prove the convexity of the investigated set of feasible solutions. We also develop an approximation scheme for this class of stochastic programming problems based on SOCP. Numerical results are presented.

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MS57

Unit Commitment Under Uncertainty in AC Transmission Systems - a Risk Averse Two-Stage Stochastic SDP Approach

The talk addresses unit commitment under uncertainty of load and power infeed from renewables in alternating-current (AC) power systems. Beside traditional unit-commitment constraints, the physics of power flow are included. This leads to risk averse two-stage stochastic semidefinite programs whose structure is analyzed, and for which a decomposition algorithm is presented.

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MS58

A Primal-Dual Interior Point Solver for Conic Problems with the Exponential Cone

Primal-dual interior point methods for linear programming have been successfully extended to the realm of conic programming with self-dual cones. However, other useful and interesting conic constraints are ?not self-dual and the extensions cannot be used. The exponential cone is one such non-self-dual cone that can be used to define geometric programming problems in the language of conic programming. We describe the development and implementation of a predictor-corrector algorithm suitable for linear, second-order cone, and exponential cone problems.

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MS58

The Merits of Keeping It Smooth

For optimization problems with general nonlinear constraints, exact merit functions, which are used to ensure convergence from arbitrary starting points, typically come in two varieties: primal-dual merit functions that are smooth, and primal-only merit functions that are nonsmooth. Primal-only smooth merit functions for equality constraints have been proposed, though they are generally considered too expensive to be practical. We describe the properties of a smooth exact merit function first proposed by Fletcher (1970), extensions that can handle inequality constraints, and our efforts to use it efficiently.

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MS58

Block Preconditioners for Saddle-Point Linear Systems

Symmetric indefinite 2x2 block matrices of the form

$$\begin{pmatrix} A & B^T \\ B & 0 \end{pmatrix}$$

feature prominently in the solution of constrained optimization problems, and in the solution of partial differential equations with constraints. When the systems are large and sparse, modern iterative methods are often very effective. These methods require the use of preconditioners, and for block-structured matrices of the above form it is often desirable to design block diagonal preconditioners, based primarily on the primal or the dual Schur complement. In this talk we present a few block preconditioning approaches and discuss the spectral properties of the associated preconditioned matrices. We are particularly interested in situations where the leading block (typically representing the Hessian) is singular and has a high nullity. In such situations one often has to resort to Schur complements of a regularized version of the block matrix, and the resulting preconditioners have interesting spectral properties. In particular, the high nullity seems to promote clustering of the eigenvalues, which in turn may accelerate the convergence of a typical minimum residual Krylov subspace solver. The analytical results are accompanied by numerical illustrations.

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MS58

Numerical Methods for Symmetric Quasi-Definite Linear Systems

Abstract not available.

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MS59

On the Convergence of the Self-Consistent Field Iteration in Kohn-Sham Density Functional Theory

We view the SCF iteration as a fixed point iteration with respect to the potential and formulate the simple mixing schemes accordingly. The convergence of the simple mixing schemes are established. A class of approximate Newton approaches and their convergence properties are presented and discussed respectively. Preliminary numerical experimentations show the efficiency of our proposed approximate Newton approaches.

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MS59

Gradient Type Optimization Methods for Electronic Structure Calculations

We present gradient type methods for electronic structure calculations by constructing new iterations along the gradient on the Stiefel manifold. The main costs of our approaches arise from the assembling of the total energy functional and its gradient and the projection onto the manifold. These tasks are cheaper than eigenvalue computation and they are often more suitable for parallelization as long as the evaluation of the total energy functional and its gradient is efficient.

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MS59

A Projected Gradient Algorithm for Large-scale Eigenvalue Calculation

We examine a projected gradient algorithm for computing a relatively large number of lowest eigenvalues of a Hermitian matrix. The algorithm performs fewer Rayleigh-Ritz calculations than some of the existing algorithms, thus has better parallel scalability. It is relatively easy to implement. We will discuss a number of practical issues for implementing this algorithm, and demonstrate its performance in an electronic structure application.

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MS59

Symmetric Low-Rank Product Optimization: Gauss-Newton Method

Emerging applications demand higher capacities in large-scale eigenspace computation, among which are higher parallel scalability and better warm-start ability that many existing eigensolvers often lack. We propose to study a nonlinear least squares formulation for symmetric matrix eigenspace calculation. We derive a class of Guass-Newton type algorithms from this formulation, and present convergence and numerical results.

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MS60

Accounting for Uncertainty in Complex System Design Optimization

Uncertainty manifests itself in complex systems in a variety of ways. In airspace traffic, a major source of uncertainty

is the potential inability to compute a safe trajectory in real time, i.e., to solve a large nonlinear optimization problem. One way to mitigate the uncertainty is to evaluate the airspace and anticipate approach to phase transitions from controllable (where trajectory computation is feasible) to uncontrollable (where trajectories cannot be computed). We discuss such an approach.

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MS60

Beyond Variance-based Robust Optimization

In optimization under uncertainty of a wing, maximization of aerodynamic performance (in expectation) is complemented by minimization of the variance induced by manufacturing tolerances. This typically leads to stiff multi-objective optimization; moreover, the variance is a symmetric measure and therefore penalizes both better- and worse-than-average designs. We propose to use the overall probability density of the wing performance and define the optimization goal as the minimization of the "distance" between this and a target distribution.

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MS60

Quasi-Newton Methods for Stochastic Optimization

We describe a class of algorithms for stochastic optimization, i.e., for problems in which repeated attempts to evaluate the objective function generate a random sample from a probability distribution. These algorithms exploit a connection between *ridge analysis* in response surface methodology and trust-region methods for numerical optimization. First-order information is obtained by designed regression experiments; second-order information is obtained by secant updates. A convergence analysis is borrowed from stochastic approximation.

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MS60

Multi-Information Source Optimization: Beyond Mfo

Conventional optimization concerns finding the extremizer of a function f(x). However often one has several information sources concerning the relation between x and f(x) that can be sampled, each with a different sampling cost. Multi-Information Source Optimization is the problem of optimally choosing which information source to sample during the overall optimization of f, by trading off information the samples of the different sources could provide with the cost of generating those samples.

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MS61

A Relaxed Projection Splitting Algorithm for Nonsmooth Variational Inequalities in Hilbert Spaces

We introduce a relaxed-projection splitting algorithm for solving variational inequalities in Hilbert spaces for the sum of nonsmooth maximal monotone operators, where the feasible set is defined by a nonlinear and nonsmooth continuous convex function inequality. In our scheme, the orthogonal projections onto the feasible set are replaced by projections onto separating hyperplanes. Furthermore, each iteration of the proposed method consists of simple subgradient-like steps, which does not demand the solution of a nontrivial subproblem, using only individual operators, which explores the structure of the problem. Assuming monotonicity of the individual operators and the existence of solutions, we prove that the generated sequence converges weakly to a solution.

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MS61

Forward-Backward and Tseng's Type Penalty Schemes for Monotone Inclusion Problems

We propose a forward-backward penalty algorithm for monotone inclusion problems of the form $0 \in Ax + Dx + N_C(x)$ in real Hilbert spaces, where A is a maximally monotone operator, D a cocoercive operator and C the nonempty set of zeros of another cocoercive operator. Weak ergodic convergence is shown under the use of the Fitzpatrick function associated to the operator that describes the set C. A forward-backard-forward penalty algorithm is also proposed by relaxing the cocoercivity assumptions to monotonicity and Lipschtz continuity.

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MS61

The Douglas-Rachford Algorithm for Nonconvex Feasibility Problems

Projection algorithms for solving (nonconvex) feasibility problems in Euclidean spaces are considered. Of special interest is the Douglas-Rachford or Averaged Alternating Reflection Algorithm (AAR). In the case of convex feasibility, firm nonexpansiveness of projection mappings is a global property that yields global convergence. A relaxed local version of firm nonexpansiveness is introduced. Together with a coercivity condition that relates to the regularity of the intersection, this yields local linear convergence for a wide class of nonconvex problems for consistent feasibility problems.

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MS61

Linear Convergence of the Douglas-Rachford Method for Two Nonconvex Sets

In this talk, we study the Douglas-Rachford method for two closed (possibly nonconvex) sets in Euclidean spaces. In particular, we show that under suitable assumptions, the method converges locally with linear rate. In convex settings, we prove that the linear convergence is global. Our study recovers recent results on the same topic.

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MS62

Globalized Robust Optimization for Nonlinear Uncertain Inequalities

Globalized Robust Optimization (GRO) is an extension of Robust Optimization (RO) where controlled constraint violations are allowed outside the primary uncertainty region. The traditional GRO approach only deals with linear inequalities and a secondary uncertainty region that is restricted to a special form. We extend GRO to nonlinear inequalities and secondary regions that are general convex regions. Furthermore, we propose a method to optimize the controlled violation outside the primary region based on intuitive criteria.

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MS62

Adjustable Robust Optimization with Decision Rules Based on Inexact Information

Adjustable robust optimization, a powerful technique to solve multistage optimization problems, assumes that the revealed information on uncertain parameters is exact. However, in practice such information often contain inaccuracies. We therefore extend the adjustable robust optimization approach to the more practical situation that the revealed information is inexact. We construct a new model, and develop a computationally tractable robust counterpart. Examples show that this new approach yields much better solutions than using the existing approach.

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MS62

Robust Growth-Optimal Portfolios

The log-optimal portfolio is known to outperform any other portfolio in the long run if stock returns are i.i.d. and follow a known distribution. In this talk, we establish similar guarantees for finite investment horizons where the distribution of stock returns is ambiguous. By focusing on fixed-mix portfolios, we exploit temporal symmetries to formulate the emerging distributionally robust optimization problems as tractable conic programs whose sizes are independent of the investment horizon.

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MS62

Routing Optimization with Deadlines under Uncertainty

We consider a class of routing optimization problems on networks with deadlines imposed at a subset of nodes, and with uncertain arc travel times. The problems are static in the sense that routing decisions are made prior to the realization of uncertain travel times. The goal is to find optimal routing solution such that arrival times at nodes respect deadlines “as much as possible’.

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MS63

Computing Generalized Tensor Eigenpairs

Several tensor eigenpair definitions have been put forth in the past decade which can be unified under the generalized tensor eigenpair framework introduced by Chang, Pearson, and Zhang (2009). Given an mth-order, n-dimensional real-valued symmetric tensors $\mathcal{A}$ and $\mathcal{B}$, the goal is to find a real-valued scalar λ and a real-valued n-vector $\mathbf{x}$ with $\mathbf{x} \neq 0$ such that $\mathcal{A}\mathbf{x}^{m-1} = \lambda\mathcal{B}\mathbf{x}^{m-1}$. To solve the problem, we present our generalized eigenproblem adaptive power method (GEAP) method, which uses interesting properties of convex optimization on a sphere, even though our objective function is not convex.

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MS63

Square Deal: Lower Bounds and Improved Relaxations for Tensor Recovery

Recovering a low-rank tensor from incomplete information is a recurring problem in signal processing and machine learning. The most popular convex relaxation of this problem minimizes the sum of the nuclear norms of the unfoldings of the tensor. We show that this approach can be substantially suboptimal: reliably recovering a K-way tensor of length n and Tucker rank r from Gaussian measurements requires $\Omega(rn^{K-1})$ observations. In contrast, a certain (intractable) nonconvex formulation needs only $O(r^K + nrK)$ observations. We introduce a simple, new convex relaxation, which partially bridges this gap. Our new formulation succeeds with $O(r^{\lfloor K/2 \rfloor} n^{\lceil K/2 \rceil})$ observations. While these results pertain to Gaussian measurements, numerical experiments on both synthetic and real data sets strongly suggest that the new convex regularizer also outperforms the sum of nuclear norms for tensor completion from a random subset of entries. The lower bound for the sum-of-nuclear-norms model follows from our new result on recovering signals with multiple sparse structures (e.g. sparse, low rank), which demonstrates the significant suboptimality of the commonly used recovery approach via minimizing the sum of individual sparsity inducing norms (e.g. l_1, nuclear norm). Our new formulation for low-rank tensor recovery however opens the possibility in reducing the sample complexity by exploiting several structures jointly.

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MS63

Robust Nonnegative Matrix/Tensor Factorization with Asymmetric Soft Regularization

In this talk, we introduce ℓ_∞-norm based new low rank promoting regularization framework, that is, soft asymmetric regularization (SAR) framework for robust nonnegative matrix factorization (NMF). The main advantage of the proposed low rank enforcing SAR framework is that it is less sensitive to the rank selecting regularization parameters since we use soft regularization framework, instead of using the conventional hard constraints such as nuclear norm, γ_2-norm, or rank itself in matrix factorization. The numerical results show that, although we fixed all parameters of the proposed SAR framework for robust NMF, the proposed method recover low-rank structure better than that of the state-of-the-art nuclear norm based robust principal component analysis (PCA) and other robust NMF models. Moreover, the basis generated by the proposed method is more interpretable than that of the robust PCA.

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MS63

Inverse Scale Space: New Regularization Path for Sparse Regression

The mostly used regularization path for sparse regression is minimizing an ℓ_1-regularization term. However it has many disadvantages such as bias and introducing more features. We introduce inverse scale space (ISS)-a new regularization path for sparse regression, which is unbiased and can remove unrelated features quickly. We show why ISS is better than ℓ_1 minimization, and the comparison of both methods is done on synthetic and real data. In addition, we develop a fast algorithm for ISS.

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MS64

A Nonlinear Semidefinite Approximation for Copositive Optimisation

Copositive optimisation has numerous applications, e.g. an exact formulation of the stability number. Due to the difficulty of copositive optimisation, we often consider approximations, e.g. the Parrilo-cones. The Parrilo-cones are not invariant under scaling, but in this talk a method is presented to optimise over all scalings at once. This is through nonlinear semidefinite optimisation, which is in general intractable. However for some problems, including the stability number, quasiconvexity in our method makes it tractable.

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MS64

Optimal Solutions to a Root Minimization Problem over a Polynomial Family with Affine Constraints

Consider the system $y' = A(x)y$, where A is a depending on a parameter $x \in \Omega \subset \mathbb{C}^k$. This system is Hurwitz-stable if the eigenvalues of $A(x)$ lie in the left half of the complex plane and Schur-stable if the eigenvalues of $A(x)$ lie in the unit disk. A related topic is to consider polynomials whose coefficients lie in a parameter set. In 2012, Blondel, Gürbüzbalaban, Megretski and Overton investigate the Schur and Hurwitz stability of monic polynomials whose coefficients lie in an affine hyperplane of dimension $n-1$ in $\mathbb{R}$ and $\mathbb{C}$, respectively. They provide explicit global solutions to the radius minimization problem and closely related results for the abscissa minimization problem for a family of polynomials with one affine constraint. In addition to their theoretical results, the authors provide Matlab implementations of the algorithms they derive. A major question that is left open is: suppose there are $\nu \in \{2, \ldots, n-1\}$ constraints on the coefficients, not just one. Our current work is to extend results on the polynomial radius and abscissa minimization problems to this more general case.

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MS64

Narrowing the Difficulty Gap for the Celis-Dennis-Tapia Problem

We study the Celis-Dennis-Tapia problem: minimize a nonconvex quadratic function over the intersection of two ellipsoids, a generalization of the well-known trust region problem. Our main objective is to narrow the difficulty gap that occurs when the Hessian of the Lagrangian is indefinite at Karush-Kuhn-Tucker points. We prove new sufficient and necessary conditions both for local and global optimality, based on copositivity, giving a complete characterization in the degenerate case.

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MS64

Real PSD Ternary Forms with Many Zeros

We are concerned with real psd ternary forms $p(x, y, z)$ of degree $2d$. Choi, Lam and Reznick proved in 1980 that a psd ternary sextic with more than 10 zeros has infinitely many zeros and is sos. We will discuss the situation for ternary octics, in which 10 must be replaced by at least 17. This is, in part, joint work with Greg Blekherman.

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MS65

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Abstract Not Available

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MS65

Constrained Best Euclidean Distance Embedding on a Sphere: a Matrix Optimization Approach

The problem of data representation on a sphere of unknown radius arises from various disciplines. The best representation often needs to minimize a distance function of the data on a sphere as well as to satisfy some Euclidean distance constraints. In this paper, we reformulate the problem as an Euclidean distance matrix optimization problem with a low rank constraint. We then propose an iterative algorithm that uses a quadratically convergent Newton method at its each step. We use some classic examples from the spherical multidimensional scaling to demonstrate the flexibility of the algorithm in incorporating various constraints.

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MS65

Inexact Proximal Point and Augmented Lagrangian Methods for Solving Convex Matrix Optimization Problems

Convex matrix optimization problems (MOPs) arise in a wide variety of applications. In this talk, we present the framework of designing algorithms based on the inexact proximal point and augmented Lagrangian methods for solving MOPs. In order to solve the subproblem in each iteration efficiently and robustly, we propose an inexact block coordinate descent method coupled with a semismooth Newton-CG method for the purpose. A concrete illustration of the methodology is given to solve the class of linearly constrained semidefinite matrix least squares problems with nuclear norm regularization.

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MS65

SDPNAL+: A Majorized Semismooth Newton-CG Augmented Lagrangian Method for Semidefinite Programming with Nonnegative Constraints

We present a majorized semismooth Newton-CG augmented Lagrangian method, called SDPNAL+, for semidefinite programming (SDP) with partial or full nonnegative constraints on the matrix variable. SDPNAL+ is a much enhanced version of SDPNAL introduced by Zhao, Sun and Toh [SIAM Journal on Optimization, 20 (2010), pp. 1737–1765] for solving generic SDPs. SDPNAL works very efficiently for nondegenerate SDPs and may encounter numerical difficulty for degenerate ones. Here we tackle this numerical difficulty by employing a majorized semismooth Newton-CG method coupled with a block coordinate descent method to solve the inner problems. Numerical results for various large scale SDPs with or without nonnegative constraints show that the proposed method is not only fast but also robust in achieving accurate solutions. It outperforms, by a significant margin, two other competitive codes: (1) an alternating direction based solver called SDPAD by Wen et al. [Mathematical Programming Computation, 2 (2010), pp. 203–230] and (2) a two-easy-block-decomposition hybrid proximal extragradient method called 2EBD-HPE by Monteiro et al. [Mathematical Programming Computation, (2013), pp. 1–48]. In contrast to these two codes, we are able to solve all the 95 difficult SDP problems arising from QAP problems tested in SDPNAL to an accuracy of 10^{-6} efficiently, while SDPAD and 2EBD-HPE successfully solve 30 and 16 problems, respectively. It is also noted that SDPNAL+ appears to be the only viable method currently available to solve large scale SDPs arising from rank-1 tensor approximation problems constructed by Nie and Li [arXiv preprint arXiv:1308.6562, (2013)]. The largest rank-1 tensor approximation problem solved is `nonsym(21,4)`, in which its resulting SDP problem has matrix dimension $n = 9,261$ and the number of equality constraints $m = 12,326,390$.

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MS66

An Acceleration Procedure for Optimal First-order Methods

We introduce a first-order method for smooth convex problems that allows an easy evaluation of the optimal value of the local Lipschitz constant of the objective's gradient, without even using any backtracking strategies. We show that our method is optimal. Numerical experiments on very large-scale eigenvalue minimization problems show that our method reduces computation times by orders of magnitude over standard optimal first-order methods.

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MS66

Decompose Composite Problems for Big-data Optimization

Composite problems play an important role in analyzing big datasets. This talk presents new optimization procedures that can benifit from the decoupling of data fidelity components from regularization terms constituting these data analysis models.

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MS66

An Adaptive Accelerated Proximal Gradient Method and Its Homotopy Continuation for Sparse Optimization

We first propose an adaptive accelerated proximal gradient (APG) method for minimizing strongly convex composite functions with unknown convexity parameters. This method incorporates a restarting scheme to automatically estimate the strong convexity parameter and achieves a nearly optimal iteration complexity. Then we consider the l1- regularized least-squares (l1-LS) problem in the high-dimensional setting. Although such an objective function is not strongly convex, it has restricted strong convexity over sparse vectors. We exploit this property by combining the adaptive APG method with a homotopy continuation scheme, which generates a sparse solution path towards optimality. This method obtains a global linear rate of convergence and its complexity is the best among known results for solving the l1-LS problem in the high-dimensional setting.

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MS66

An Extragradient-Based Alternating Direction Method for Convex Minimization

In this talk, we consider the problem of minimizing the sum of two convex functions subject to linear linking constraints. The classical alternating direction type methods usually assume that the two convex functions have relatively easy proximal mappings. However, many problems arising from statistics, image processing and other fields have the structure that only one of the two functions has easy proximal mapping, and the other one is smoothly convex but does not have an easy proximal mapping. Therefore, the classical alternating direction methods cannot be applied. For solving this kind of problems, we propose in this paper an alternating direction method based on extragradients. Under the assumption that the smooth function has a Lipschitz continuous gradient, we prove that the proposed method returns an eps-optimal solution within O(1/eps) iterations. We test the performance of different variants of the proposed method through solving the basis pursuit problem arising from compressed sensing. We then apply the proposed method to solve a new statistical model called fused logistic regression. Our numerical experiments show that the proposed method performs very well when solving the test problems.

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MS67

Support Vector Machines Based on Convex Risk Functionals and General Norms

This paper studies unified formulations of support vector machines (SVMs) for binary classification on the basis of convex analysis. Using the notion of convex risk functionals, a pair of primal and dual formulations of the SVMs are described in a general manner, and duality results and optimality conditions are established. The formulation uses arbitrary norms for regularizers and incorporates new families of norms (in place of ℓ_p-norms) into SVM formulations.

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MS67

The Fundamental Quadrangle of Risk in Optimization and Statistics

Measures of risk, which assign a numerical risk value to random variable representing loss, are well recognized as a basic tool in financial management. But they also fit into a larger scheme in which they are complemented by measures of deviation, error and regret. The interactions among these four different quantifications of loss, as corner points of a quadrangle of relationships, provide rich modeling opportunities for risk management, not only in finance. Furthermore they reveal surprising connections between the ways an optimization problem is set up and how the data associated with it ought to be handled statistically.

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MS67

Superquantile Regression: Theory and Applications

The presentation presents a generalized regression technique centered on a superquantile (also called conditional value-at-risk) that is consistent with that coherent measure of risk and yields more conservatively fitted curves than classical least-squares and quantile regression. In contrast to other generalized regression techniques that approximate conditional superquantiles by various combinations of conditional quantiles, we directly and in perfect analog to classical regression obtain superquantile regression functions as optimal solutions of certain error minimization problems. We discuss properties of this new regression technique, computational methods, and applications.

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MS67

Cvar Norm in Deterministic and Stochastic Case: Applications in Statistics

CVaR norm for a random variable is CVaR of absolute value of this random variable. L1 and L-infinity norms are limiting cases of the CVaR norm. Several properties for CVaR norm, as a function of confidence level were proved. CVaR norm, as a Measure of Error, generates a Regular Risk Quadrangle. We discuss several statistical applications of CVaR norm: 1) Robust linear regression disregarding some percentage of outliers; 2) Estimation of probabilistic distributions.

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MS68

Stochastic Predictive Control for Energy Efficient Buildings

We present a stochastic model predictive control (SMPC) approach to building heating, ventilation, and air conditioning (HVAC) systems. The building uncertain load is described by finitely supported probability density functions identified from historical data. The SMPC is designed with the goal of minimizing expected energy consumption while bounding thermal comfort violations at each time instance. The SMPC uses the predictive knowledge of building loads described by stochastic models. The presentation focuses on the trade off between the computational tractability and the conservatism of the resulting SMPC scheme. The large number of zones in a commercial building requires proper handling of system nonlinearities, chance constraints, and robust constraints in order to allow real-time computation. We will present an approach which combines feedback linearization, tailored tightening offset for chance constraints, and tailored sequential quadratic programming. The proposed SMPC approach, existing SMPC approaches and current industrial control logics are compared to demonstrate the link between controller complexity, energy savings and comfort violations.

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MS68

Pde-Ode Modeling, Inversion and Optimal Control for Building Energy Demand

Development of an accurate heat transfer model of buildings is of high importance. Such a model can be used for analyzing energy efficiency of buildings, predicting energy consumption and providing decision support for energy efficient operation of buildings. In this talk, we will present the proposed PDE-ODE hybrid model to describe heat transfer through building envelope as well as heat evolution inside building. A inversion procedure is presented to recover parameters of equations from sensor data and building characteristic so that the model represents a specific building with current physical condition. We will present how this model is being used in MPC for building heating, ventilation, and air conditioning (HVAC) systems.

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MS68

Performance Optimization of Hvac Systems

Performance of an HVAC system installed in a multi-story office building is studied. A model minimizing the energy consumption and room temperature ramp rate of is presented. The relationship between the input and output parameters, energy consumption, and temperature of five rooms is developed based on data. As the energy optimization model includes nonparametric component models, computational intelligence algorithms are applied to solve it. Experiments are designed to analyze performance of the computational intelligence algorithms. The computational experiments have confirmed significant energy savings.

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MS68

Development of Control-Oriented Models for Model Predictive Control in Buildings

Model Predictive Control (MPC) has gained attention in recent years for application to building automation and controls because of significant potential for energy cost. MPC utilizes dynamic building and HVAC equipment models and input forecasts to estimate future energy usage and employs optimization to determine control inputs that minimize an integrated cost function or a specified prediction horizon. A dynamic model with reasonable prediction performance (e.g., accuracy and simulation speed) is crucial for a practical implementation of MPC. One modeling approach is to use whole-building energy simulation programs such as EnergyPlus, TRNSYS and ESP-r etc. However, the computational and set up costs for these models are significant and they do not appear to be suitable for on-line implementation. This talk will present the development of control-oriented models for the thermal zones in buildings. A simple linear ARX (Auto-Regressive with exogenous input) model and a low-order state-space model are identified from the designed input-output responses of thermal zones with disturbances from ambient conditions and internal heat gains. A high-fidelity TRNSYS model of an office building was used as a virtual testbed to generate data for system identification, parameter estimation and validation of the two model structures. This talk will be concluded with comparisons of the ARX model and the state-space model in terms of model accuracy for a predictive control design and the results of applying MPC.

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MS69

Learning Near-Optimal Linear Embeddings

We introduce a new framework for the deterministic construction of linear, near-isometric embeddings of a finite set of data points. Our formulation is based on an affine rank minimization problem that we relax into a tractable semidefinite program (SDP). The resulting Nuclear norm minimization with Max-norm constraints (NuMax) framework outperforms both principal components analysis (PCA) and random projections in a range of applications in machine learning and signal processing, which we demonstrate via a range of experiments on large-scale datasets.

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MS69

Convex Relaxation of Optimal Power Flow

The optimal power flow (OPF) problem is fundamental in power systems as it underlies many applications such as economic dispatch, unit commitment, state estimation, stability and reliability assessment, volt/var control, demand response, etc. OPF seeks to optimize a certain objective function, such as power loss, generation cost and/or user utilities, subject to Kirchhoff's laws, power balance as well as capacity, stability and security constraints on the voltages and power flows. It is a nonconvex quadratically constrained quadratic program. This is a short survey of recent advances in the convex relaxation of OPF.

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MS69

Using Regularization for Design: Applications in Distributed Control

Both distributed optimal control and sparse reconstruction have seen tremendous success recently. Although the objectives of these fields are very different – the former is concerned with the synthesis and design of controllers, the latter with recovering some underlying signal – they are united through their quest for structure. We show that ideas from sparse approximation can be used for the codesign of communication networks that are well-suited for distributed optimal control.

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MS69

Covariance Sketching

Learning covariance matrices from high-dimensional data is an important problem that has received a lot of attention recently. For example, network links can be detected by identifying strongly correlated variables. We are particularly interested in the high-dimensional setting, where the number of samples one has access to is much fewer than the number of variates. Fortunately, in many applications of interest, the underlying covariance matrix is sparse and hence has limited degrees of freedom. In most existing work however, it is assumed that one can obtain samples of all the variates simultaneously. This could be very expensive or physically infeasible in some applications. As a means of overcoming this limitation, we propose a new framework whereby: (a) one can pool information about the covariates by forming sketches of the samples and (b) reconstruct the original covariance matrix from just these sample sketches. We show theoretically that this is indeed possible and we discuss efficient algorithms to solve this problem.

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MS70

Piecewise Linear Multicommodity Flow Problems

Abstract Not Available

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MS70

Fixed-Charge Multicommodity Flow Problems

Abstract Not Available

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MS70

Piecewise Convex Multicommodity Flow Problems

Abstract Not Available

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MS71

Denoising for Simultaneously Structured Signals

Signals or models exhibiting low dimensional behavior play an important role in statistical signal processing and system identification. We focus on signals that have multiple structures simultaneously; e.g., matrices that are both low rank and sparse, arising in phase retrieval, sparse PCA, and cluster detection in social networks. We consider the estimation of such signals when corrupted by additive Gaussian noise, and provide tight upper and lower bounds on the mean squared error (MSE) of a denoising program that uses a combination of convex regularizers to induce multiple structures. In the case of low rank and sparse matrices, we quantify the gap between the error of this convex program and the best achievable error.

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MS71

Algorithmic Blessings of High Dimensional Problems

The curse of dimensionality is a phrase used by scientists to indicate the following observation: as the dimension of the data exceeds the number of observations, many inference tasks become seemingly more complicated. The last decade has witnessed the efforts of many researchers who proposed a variety of algorithms that can cope with the high-dimensionality of the data. In this line of work, high-dimension is often viewed as a curse and the effort is to propose schemes that work well even when this curse happens. In this talk, I take a different approach and show the algorithmic blessings of high dimensions. As a concrete example, I discuss the iterative thresholding algorithms for solving the ℓ_1-regularized least squares problem. Then, I show that the high dimensionality of the data enables us to obtain the optimal value of parameters and linear convergence. These goals cannot be achieved for low-dimensional problems. This is based on a joint work with Ali Mousavi and Richard Baraniuk.

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MS71

Learning from Heterogenous Observations

The aggregation of various sources of data to construct massive databases does not always come as a benefit to statistical methods. We study a canonical model: sparse linear regression when the observed sample may come from different, unidentified models. This question raises not only statistical but also algorithmic questions.

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MS71

An Enhanced Conditional Gradient Algorithm for Atomic-Norm Regularization

In many applications in signal and image processing, communications, system identification, one aims to recover a signal that has a simple representation, as a linear combination of a modest number of elements from a certain basis. Atoms and atomic norms are key devices for finding and expressing such representations. Fast and efficient algorithms have been proposed to solve reconstruction problems in important special cases (such as compressed sensing), but a framework that handles the general atomic-norm setting would be a further contribution to unifying the area. We propose a method that combines greedy selection of atoms with occasional reduction of the basis. Without the reduction step, the approach reduces to the conditional gradient or "Frank-Wolfe' scheme for constrained convex optimization.

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MS74

Threshold Risk Measures: Dynamic Infinite Horizon and Approximations

Threshold risk measures is a class of non-coherent risk measures that quantifies the risk of being above fixed thresholds. These measures appear naturally in the dynamic optimization of energy systems where crucial economic thresholds are set. In this talk we introduce the infinite horizon risk-averse dynamic optimization method with threshold risk measures. Tho solve these, we develop variants of the policy and value iteration algorithms, and an approximate dynamic programming algorithm with performance guarantees.

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MS74

Statistical Estimation of Composite Risk Measures and Risk Optimization Problems

Motivated by estimation of law-invariant coherent measures of risk, we deal with statistical estimation of composite functionals. Additionally, the optimal values of composite risk functionals are analysed when they are parametrized by vectors from a deterministic convex set. We establish central limit formulae and characterize the limiting distribution of the corresponding empirical estimators. The results are applied to characterize the asymptotic distribution of estimators for the mean-semi-deviation risk measures and higher order inverse risk measures. Central limit formulae for the optimal value function of problems with these risk measures in the objective are established as well.

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MS74

Multilevel Optimization Modeling for Stochastic Programming with Coherent Risk Measures

Although there is only one decision maker, we propose a multilevel optimization modeling scheme that allows simple, law-invariant coherent risk measures to be used in stochastic programs with more than two stages without running afoul of time inconsistency. We motivate the needs for such an approach, but also show that the resulting models are NP-hard even in the simplest cases. On the other hand, we also present empirical evidence that some nontrivial practical instances may not be difficult to solve.

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MS74

Challenges in Dynamic Risk-Averse Optimization

We shall discuss modern challenges in dynamic risk-averse optimization. In particular, we shall address the issue of time-consistency and its relations to the dynamic programming principle. We shall consider time-consistent approximations of time-inconsistent models. Next, we shall discuss Markov consistency, which determines the usefulness of a dynamic risk measure for as an objective functional in control of Markov models. We shall derive dynamic programming equations for Markov decision problems with Markov consistent measures, and discuss methods for their solution.

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MS75

Identifying K Largest Submatrices Using Ky Fan Matrix Norms

We propose a convex relaxation using Ky Fan matrix norms for the problem of identifying k largest approximately rank-one submatrices of a nonnegative data matrix. This problem is related to nonnegative matrix factorization and has important applications in data mining. We show that under some certain randomized model, then the k largest blocks can be recovered via the proposed convex relaxation.

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MS75

Convex Lower Bounds for Atomic Cone Ranks with Applications to Nonnegative Rank and cp-rank

We propose new lower bounds using semidefinite programming on a class of atomic rank functions defined on a convex cone. We focus on two important special cases which are the nonnegative rank and the cp-rank and we show that our lower bound has interesting connections with existing combinatorial bounds. Our lower bound also inherits many of the structural properties satisfied by these rank functions such as invariance under diagonal scaling and subadditivity.

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MS75

Provable and Practical Topic Modeling Using NMF

Topic modeling is a classical application of NMF. Recently, [Arora et al.] showed NMF can be solved in polynomial time under separability. This assumption naturally translates to anchor-words assumption for topic modeling. In this talk I will address some problems that arise when applying NMF to topic modeling, and how to redesign NMF algorithms to solve those problems. The final algorithm has performance close to classical Gibbs sampling algorithms but is much faster.

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MS75

Semidefinite Programming Based Preconditioning for More Robust Near-Separable Nonnegative Matrix Factorization

Nonnegative matrix factorization under the separability assumption can be solved efficiently, even in the presence of noise. This problem is referred to as near-separable NMF and requires that there exists a cone spanned by a subset of the columns of the input matrix containing all columns. In this talk, we propose a preconditioning based on semidefinite programming which can improve significantly the performance of near-separable NMF algorithms. We illustrate our result on some hyperspectral images.

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MS76

Dsos and Sdsos: More Tractable Alternatives to Sum of Squares Programming

We present linear and second order inner approximations to the sum of squares cone and new hierarchies for polynomial optimization problems that are amenable to LP and SOCP and considerably more scalable than the SDP-based sum of squares approaches.

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MS76

Lower Bounds for a Polynomial on a basic Closed Semialgebraic Set using Geometric Programming

Let $f, g_1, \ldots, g_m$ be polynomials in $\mathbb{R}[x_1, \ldots, x_n]$. We deal with the general problem of computing a lower bound for f on the subset of $\mathbb{R}^n$ defined by the inequalities $g_i \geq 0$, $i = 1, \ldots, m$. We show that there is an algorithm for computing such a lower bound, based on geometric programming, which applies in a large number of cases. The bound obtained is typically not as good as the bound obtained using semidefinite programming, but it has the advantage that it is computable rapidly, even in cases where the bound obtained by semidefinite programming is not computable.

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MS76

Approximation Quality of SOS Relaxations

Sums of squares (SOS) relaxations provide efficiently computable lower bounds for minimization of multivariate polynomials. Practical experience has shown that these bounds usually outperform most other available techniques, but a fully satisfactory theoretical justification is still lacking. In this talk, we discuss several results (new and old) about the approximation quality of these SOS bounds, focusing on the case of polynomial optimization on the sphere.

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MS76

An Alternative Proof of a PTAS for Fixed-degree Polynomial Optimization over the Simplex

The problem of minimizing a polynomial over the standard simplex is a well-known NP-hard nonlinear optimization problem. It is known that the problem allows a polynomial-time approximation scheme (PTAS) for polynomials of fixed degree. We provide an alternative proof of the PTAS property for one simple scheme that only evaluates the polynomial on a regular grid, and the proof relies on the properties of Bernstein approximation on the simplex.

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MS77

On Universal Rigidity of Tensegrity Frameworks, a Gram Matrix Approach

A tensegrity framework (G, p) in R^r is a graph G, where each edge is labeled as either a bar, a cable, or a strut; and where each node i is mapped to a pint p^i in R^r. Connelly proved that if an r-dimensional tensegrity framework (G, p) on n vertices in R^r admits a proper semidefinite stress matrix of rank $n - r - 1$, and if configuration $p = (p^1, \ldots, p^n)$ is generic, then (G, p) is universally rigid. In this talk, we show that this result continues to hold under the much weaker assumption that in configuration p, each point and its neighbors in G affinely span R^r.

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MS77

On the Sensitivity of Semidefinite Programs and Second Order Cone Programs

Given a feasible conic program with finite optimal value that does not satisfy strong duality, a small feasible perturbation of the problem data may lead to a relatively big change in the optimal value. We quantify the notion of big change in the cases of semidefinite programs and of second order cone programs. If there is a nonzero duality gap, then one can always find an arbitrarily small feasible perturbation so that the change in optimal value is no less than the duality gap. If there is a zero duality gap, then the change in optimal value due to any sufficiently small and feasible right-hand side perturbation S is bounded above by $\kappa\|S\|^{1/2^d}$, where κ is a fixed constant and d is the degree of singularity of the optimization problem, i.e., the number of facial reduction iterations required to find the minimal face of the optimization problem. We will also discuss some applications of these results to the solution of semidefinite and second order cone programs in the absence of strictly complementary solutions.

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MS77

Combinatorial Certificates in Semidefinite Duality

A semidefinite system is called *badly behaved*, if for some objective function the dual does not attain, or has a positive gap with the primal; *well-behaved*, if not badly behaved. We show that combinatorial type certificates exist to easily verify the badly/well behaved nature of a semidefinite system, using only elementary linear algebra. This work continues the work presented in *Bad semidefinite programs: they all look the same.*

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MS77

Efficient Use of Semidefinite Programming for Selection of Rotamers in Protein Conformations

In this paper we study a semidefinite programming relaxation of the (NP-hard) side chain positioning problem. We show that the Slater constraint qualification (strict feasibility) fails for the SDP relaxation. We then show the advantages of using facial reduction to regularize the SDP. In fact, after applying facial reduction, we have a *smaller* problem that is *more stable* both in theory and in practice.

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MS78

Frank-Wolfe-like Methods for Large-scale Convex Optimization

We develop and analyze variants of the Frank-Wolfe method, particularly designed to be mindful of large-scale problems over domains with favorable sparsity properties. We analyze the methods presented in terms of the trade-offs between solution accuracy and sparsity guarantees. We also adapt our methods and analysis to large-scale parallel and/or distributed computing environments.

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MS78

Frank-Wolfe and Greedy Algorithms in Optimization and Signal Processing

The Frank-Wolfe algorithm is one of the earliest first-order optimization algorithms, and has recently seen a late revival in several large-scale machine learning and signal processing applications. We discuss some recent new insights for such methods, highlighting in particular the close connection to popular sparse greedy methods in signal processing, and sparse optimization over arbitrary atomic norms.

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MS78

Statistical Properties for Computation

Abstract Not Available

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MS78

Minimizing Finite Sums with the Stochastic Average Gradient Algorithm

We propose the stochastic average gradient (SAG) method for optimizing the sum of a finite number of smooth convex functions. Like stochastic gradient (SG) methods, the SAG method's iteration cost is independent of the number of terms in the sum. However, by incorporating a memory of previous gradient values the SAG method achieves a faster convergence rate than black-box SG methods. The convergence rate is improved from $O(1/\sqrt{k})$ to $O(1/k)$ in general, and when the sum is strongly-convex the convergence rate is improved from the sub-linear $O(1/k)$ to a linear convergence rate of the form $O(\rho^k)$ for $\rho < 1$. Further, in many cases the convergence rate of the new method is also faster than black-box deterministic gradient methods, in terms of the number of gradient evaluations. Numerical experiments indicate that the new algorithm often dramatically outperforms existing SG and deterministic gradient methods. Further, we argue that the performance may be further improved through the use non-uniform sampling strategies.

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MS79

Sensitivity Analysis of Markov Decision Processes and Policy Convergence Rate of Model-Based Reinforcement Learning

Consider a finite-state discounted Markov Decision Problem (MDP) where the transition probabilities have to be statistically estimated through observations, as is done, e.g., in reinforcement learning. We analyze the MDP through its linear programming (LP) representation. This allows us to use old-fashioned LP post-optimality sensitivity analysis to provide sufficient conditions on the difference between the true and estimated transition probabilities that ensure that the optimal policy can be discovered by solving the approximate MDP.

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MS79

Partially Observable Markov Decision Processes with General State and Action Spaces

For Partially Observable Markov Decision Processes (POMDPs) with Borel state, observation, and action sets and with the expected total costs, this paper provides sufficient conditions for the existence of optimal policies and validity of other optimality properties including that optimal policies satisfy optimality equations and value iterations converge to optimal values. Action sets may not be compact and one-step functions may not be bounded. Since POMDPs can be reduced to Completely Observable Markov Decision Processes (COMDPs), whose states are posterior state distributions, this paper focuses on the validity of the above mentioned optimality properties for COMDPs.

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MS79

Dantzig's Pivoting Rule for Shortest Paths, Deterministic Markov Decision Processes, and Minimum Cost to Time Ratio Cycles

Orlin showed that the simplex algorithm with Dantzig's pivoting rule solves the shortest paths problem using at most $O(mn^2 \log n)$ pivoting steps for graphs with m edges and n vertices. Post and Ye recently showed that $O(m^2n^3 \log^2 n)$ and $O(m^3n^5 \log^2 n)$ steps suffice to solve deterministic Markov decision processes with uniform and varying discount factors, respectively. We improve these bounds by a factor of n, assuming in the last case that the discounts are close to 1.

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MS79

On the Use of Non-Stationary Policies for Stationary Infinite-Horizon Markov Decision Processes

I will consider infinite-horizon stationary γ-discounted Markov Decision Processes, for which it is known that there exists a stationary optimal policy. Using Value and Policy Iteration with some error ϵ at each iteration, it is well-known that one can compute stationary policies that are $\frac{2\gamma}{(1-\gamma)^2}\epsilon$-optimal. After arguing that this guarantee is tight, I will describe variations of Value and Policy Iteration for computing non-stationary policies that can be up to $\frac{2\gamma}{1-\gamma}\epsilon$-optimal, which constitutes a significant improvement in the usual situation when γ is close to 1. Surprisingly, this shows that the problem of "computing near-optimal non-stationary policies' is much simpler than that of "computing near-optimal stationary policies'.

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MS80

Polyhedral Projection

A fast algorithm is developed for computing the projection onto a polyhedron. The algorithm solves the dual projection problem in two phases. In one phase a nonmonotone SpaRSA algorithm is used to handle nonsmoothness in the dual problem, while the second phase uses active set techniques. The second phase could be implemented with a sparse linear solver and update/downdate techniques or with the conjugate gradient method. The projection algorithm can exploit a warm starting point.

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MS80

A Filter Method with Unified Step Computation

We will present a new filter line search method for solving general nonlinear nonconvex optimization problems. This filter method avoids the restoration phase required in traditional filter methods by using a penalty mode instead. The same step computation procedure is used at each iteration, and the generated trial step always incorporates information from both the objective function and constraint violation. We will present convergence results and report on numerical experiments.

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MS80

An Interior-Point Trust-Funnel Algorithm for Nonlinear Optimization

We present an inexact barrier-SQP trust-funnel algorithm for solving large-scale nonlinear optimization problems. Our method, which is designed to solve problems with both equality and inequality constraints, achieves global convergence guarantees by combining a trust-region methodology with a funnel mechanism. The prominent features of our algorithm are that (i) the subproblems that define each search direction may be solved approximately, (ii) criticality measures for feasibility and optimality aid in determining which subset of computations will be performed during each iteration, (iii) no merit function or filter is used, (iv) inexact sequential quadratic optimization steps may be computed when advantageous, and (v) it may be implemented matrix-free so that derivative matrices need not be formed or factorized so long as matrix-vector products with them can be performed. Preliminary numerical tests will be given.

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MS80

Globalizing Stabilized SQP with a Smooth Exact Penalty Function

Identifying a suitable merit/penalty function for which the direction given by the so-called stabilized sequencial programming algorithm is that of descent, proved to be quite a challenge. In this work, for an equality-contrained problem, we propose for the task a smooth two-parameter exact penalty function consisting of the the augmented Lagrangian plus a penalty for violating Lagrangian stationarity.

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MS81

Network Design under Compression and Caching Rates Uncertainty

Energy-aware routing can significantly reduce energy consumption in a communication network. Compression and caching techniques can be activated at the nodes to reduce the required bandwidths further. Given demands and compression rates, our aim is to find a minimum energy network configuration. In this talk, we discuss the generalization where the compression rates are uncertain. We derive a robust formulation and cutting planes to speed-up the computations of MIP solvers.

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MS81

Solving Network Design Problems Via Iterative Aggregation

We present an exact approach for solving network design problems (NDP). Motivated by applications in transportation and energy optimization, the instances may contain preexisting capacities such that some percentage of the demand can already be routed. Starting with an initial network aggregation, we solve a sequence of NDP over increasingly fine-grained representations until a globally optimum solution is determined. Computational results on realistic networks show a drastic improvement over solving the original problem from scratch.

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MS81

The Recoverable Robust Two-Level Network Design Problem

We consider a network design application which is modeled as the two level network design problem under uncertainty. In this problem, one of the two available technologies can be installed on each edge and all customers of the network need to be served by at least the lower level (*secondary*) technology. The decision maker is confronted with uncertainty regarding the set of *primary* customers, i.e., the set of nodes that need to be served by the higher level (*primary*) technology. A set of discrete scenarios associated to the possible realizations of primary customers is available. The network is built in two stages. In the first-stage the network topology must be determined. One may decide to install the primary technology on some of the edges in the first stage, or one can wait to see which scenario will be realized, in which case, edges with the installed secondary technology may be upgraded, if necessary to primary technology, but at higher *recovery* cost. The overall goal then is to build a spanning tree in the first stage that serves all customers by at least the lower level technology, and that minimizes the first stage installation cost plus the worst-case cost needed to upgrade the edges of the selected tree, so that the primary customers of each scenario can be served using the primary technology. Using the recently introduced concept of recoverable robustness, we address this problem of importance in the design of telecommunication and distribution networks, and provide mixed integer programming models and a branch-and-cut algorithm to solve it.

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MS81

Robust Network Design for Simple Polyhedral Demand Uncertainties

We consider a basic network design problem. Given a network (V, E) and a set $\mathcal{D}$ of supply/demand vectors, find minium cost capacities such that any $d \in \mathcal{D}$ can be balanced. We extend an exact approach by [Buchheim, Liers and Sanit, INOC 2011]. The uncertainty set $\mathcal{D}$ can be a finite set or a specific polyhedron and we give an integer programming formulation with $O(|E|)$ variables and a separation algorithm for both cases.

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MS82

Regularization Methods for Variational Inequalties

In this paper we study regularization methods for the general varia- tional inequality problem. Based of the D-gap function, we propose se- quential inexact method for solving the the general variational inequality and discuss the convergence properties. We extend the concept of exact regularization to generalized variational inequality problems and establish error bounds to the solution sets of the regularized problems. In the case when exact regularization fails to exist, we give an estimate for the distance between the solution sets of regularized and original problems.

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MS82

Convergence, Robustness, and Set-Valued Lyapunov Functions

Every optimization algorithm leads to a discrete-time dynamical system, which can be analyzed through control theory tools. Minimizers correspond to equilibria, convergence and robustness can be studied through Lyapunov techniques. This talk presents a robustness result applicable to a class of algorithms, obtained through the use of a set-valued Lyapunov mapping. The technique is motivated by problems of convergence to a consensus in a multi-agent system and applies to systems with a continuum of equilibria.

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MS82

Global and Local Linear Convergence of Projection-Based Algorithms for Sparse Affine Feasibility

The problem of finding a vector with the fewest nonzero elements that satisfies an underdetermined system of linear equations is an NP-complete problem that is typically solved numerically via convex heuristics or nicely-behaved nonconvex relaxations. In this work we consider elementary methods based on projections for solving a sparse feasibility problem without employing convex heuristics. In a recent paper Bauschke, Luke, Phan and Wang (2013) showed that, locally, the fundamental method of alternating projections (AP) must converge linearly to a solution to the sparse feasibility problem with an affine constraint. In this paper we apply different analytical tools that allow us to show global linear convergence of AP and a relaxation thereof under familiar constraint qualifications. These analytical tools can also be applied to other algorithms. This is demonstrated with the prominent DouglasRachford algorithm where we establish local linear convergence of this method applied to the sparse affine feasibility problem.

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MS82

Generalized Solutions for the Sum of Two Maximally Monotone Operators

A common theme in mathematics is to define generalized solutions to deal with problems that potentially do not have solutions. A classical example is the introduction of least squares solutions via the normal equations associated with a possibly infeasible system of linear equations. In this talk, we introduce a 'normal problem" associated with finding a zero of the sum of two maximally monotone operators. If the original problem admits solutions, then the normal problem returns this same set of solutions. The normal problem may yield solutions when the original problem does not admit any; furthermore, it has attractive variational and duality properties. Several examples illustrate our theory.

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MS83

A Primal-Dual Active-Set Method for Convex Quadratic Programming

We discuss active-set methods for convex quadratic program with general equality constraints and simple lower bounds on the variables. In the first part of the talk, two methods are proposed, one primal and one dual. In the second part of the talk, a primal-dual method is proposed that solves a sequence of quadratic programs created from the original by simultaneously shifting the simple bound constraints and adding a penalty term to the objective function.

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MS83

Regularized Sequential Quadratic Programming Methods

Regularized and stabilized sequential quadratic programming (SQP) methods are two classes of methods designed to resolve the numerical and theoretical difficulties associated with ill-posed or degenerate nonlinear optimization problems. Recently, a regularized SQP method has been proposed that provides a strong connection between augmented Lagrangian methods and stabilized SQP methods. The method is formulated as a regularized SQP method with an implicit safeguarding strategy based on minimizing a bound-constrained primal-dual augmented Lagrangian. Each iteration involves the solution of a regularized quadratic program (QP) that is equivalent to a strictly convex bound-constrained QP based on minimizing a quadratic model of the augmented Lagrangian. The solution of the QP subproblem will be discussed in the context of applying active-set and interior methods that are themselves regularized versions of conventional methods.

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MS83

Steering Augmented Lagrangian Methods

We propose an enhanced augmented Lagrangian algorithm for solving large-scale optimization problems with both equality and inequality constraints. The novel feature of the algorithm is an adaptive update for the penalty parameter motivated by recently proposed techniques for exact penalty methods. We provide convergence results from remote starting points and illustrate by a set of numerical experiments that our method outperforms traditional augmented Lagrangian methods in terms of critical performance measures.

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MS83

Recent Developments in the SNOPT and NPOPT Packages for Sequential Quadratic Programming

We discuss recent developments in the nonlinear optimization packages SNOPT and NPOPT. Both packages are designed to solve nonlinear programming problems. SNOPT is best suited for sparse large-scale problem, while NPOPT is best suited for dense medium-scale problems. New developments include the incorporation of second derivatives and the implementation of a new quadratic solver. Numerical results will be presented.

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MS84

Improved Mixed Integer Linear Optimization Formulations for Unit Commitment

We present two ways to improve the mixed-integer linear optimization formulation for the unit commitment problem. The first is a new class of inequalities that give a tighter description of the feasible generator schedules. The second is a modified orbital branching technique that exploits the symmetry created by identical generators. Computational results show that these approaches can significantly reduce overall solution times for realistic instances of unit commitment.

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MS84

Efficient Solution of Problems with Probabilistic Constraints Arising in the Energy Sector

For problems with constraints involving random parameters due to (market, weather) uncertainty, if a decision x has to be taken "here and now", no matter how carefully x is chosen, there is no guarantee that the random constraint will be satisfied for all possible realizations of the uncertain parameters. A chance-constrained model declares x feasible if the constraint probability is higher than certain safety level. To solve this type of problems a dual approach was recently proposed by D. Dentcheva and M. G. Martínez, using the so-called p-efficient points. We discuss the benefits of applying an inexact bundle algorithm in such a setting and assess the interest of the proposal on a problem arising in unit-commitment to optimally manage a hydrovalley, with several hydropower plants cascaded along the same basin.

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MS84

Large Scale 2-Stage Unit-Commitment: A Tractable Approach

In energy management, generation companies have to submit a generation schedule to the grid operator for the coming day. Computing such an optimal schedule is known as the "unit-commitment" problem. In electrical systems wherein renewable generation has overall high generation capacity, uncertainty is strongly present. Generation companies can therefore occasionally submit a change to the originally submitted schedule. These changes can be seen as intra-daily recourse actions. Recourse is incomplete because of technical constraints on generation. It is of interest to investigate the impact of uncertainty and recourse on the originally submitted schedule. In this work we will investigate a two stage formulation of unit-commitment wherein both the first and second stage problems are full unit-commitment problems. We propose a primal-dual decomposition approach, whose computational core makes extensive use of warmstarted bundle methods. Results are demonstrated on typical unit-commitment problems.

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MS84

Fast Algorithms for Two-Stage Robust Unit Commitment Problem

To hedge against randomness in power systems, we employ robust optimization method to construct two-stage robust unit commitment models. To solve those challenging problems, we investigate their structural properties and develop advanced algorithm strategies for fast computation. Numerical results on typical IEEE testbeds will be presented.

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MS85

The DouglasRachford Algorithm for Two Subspaces

I will report on recent joint work (with J.Y. Bello Cruz, H.M. Phan, and X. Wang) on the DouglasRachford algorithm for finding a point in the intersection of two subspaces. We prove that the method converges strongly to the projection of the starting point onto the intersection. Moreover, if the sum of the two subspaces is closed, then the convergence is linear with the rate being the cosine of the Friedrichs angle between the subspaces. Our results improve upon existing results in three ways: First, we identify the location of the limit and thus reveal the method as a best approximation algorithm; second, we quantify the rate of convergence, and third, we carry out our analysis in general (possibly infinite-dimensional) Hilbert space. We also provide various examples as well as a comparison with the classical method of alternating projections. Reference: http://arxiv.org/pdf/1309.4709v1.pdf

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MS85

Inheritance of Properties of the Resolvent Average

Maximally monotone operators play a key role in many optimization problems. It is well known that the sum of two maximally monotone operators is not always maximally monotone; however the resolvent average always maintains maximal monotonicity. In this talk, we discuss which other desirable properties the resolvent average inherits from its component operators, including rectangularity and paramonotonicity.

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MS85

Full Stability in Mathematical Programming

The talk is devoted to the study of fully stable local minimizers of general optimization problems in finite-dimensional spaces and its applications to classical nonlinear programs with twice continuously differentiable data. The importance of full stability has been well recognized from both theoretical and numerical aspects of optimization, and this notion has been extensively studied in the literature. Based on advanced tools of second-order variational analysis and generalized differentiation, we develop a new approach to full stability, which allows us to derive not only qualitative but also quantitative characterizations of fully stable minimizers with calculating the corresponding moduli. The implementation of this approach and general results in the classical framework of nonlinear programming provides complete characterizations of fully stable minimizers under new second-order qualification and optimality conditions.

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MS85

Finite Convergence of a Subgradient Projections Algorithm

This research focuses on finite convergence of a subgradient projections algorithm for solving convex feasibility problem in the Euclidean space. I will present properties of cutters and subgradient projections and applications to subgradient projection algorithms. Our convergence results relate to previous work by Crombez and by Polyak.

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MS86

On Cones of Nonnegative Quartic Forms

In this talk we study the class of nonnegative polynomials. Six fundamentally important convex cones of nonnegative quartic functions will be presented. It turns out that these convex cones coagulate into a chain in decreasing order. The complexity status of these cones is sorted out as well. We further consider the polynomial sized representation of a very specific nonnegative polynomial, and this representation enables us to address an open question asserting that the computation of the matrix $2 \mapsto 4$ norm is NP-hard in general.

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MS86

Tensor Methods in Control Optimization

We present some tensor based methods for solving optimal control problems. In particular, we formulate high-dimensional nonlinear optimal control problems in a tensor framework and compute polynomial solutions using tensor based approach. In addition, we look at stability and controllability of ensemble control in the tensor framework.

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MS86

Eigenvectors of Tensors and Waring Decomposition

In recent work with Ottaviani, we have developed algorithms for symmetric tensor decomposition. I will explain these algorithms, their connection to algebraic geometry, and possible applications.

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MS86

Structured Data Fusion

We present structured data fusion (SDF) as a framework for the rapid prototyping of coupled tensor factorizations. In SDF, each data set—stored as a dense, sparse or incomplete multiway array—is factorized with a tensor decomposition. Factorizations can be coupled with each other by indicating which factors should be shared between data sets. At the same time, factors may be imposed to have any type of structure that can be constructed as an explicit function of some underlying variables. The scope of SDF reaches far beyond factor analysis alone, encompassing nearly the full breadth of applications resulting from matrix factorizations and tensor decompositions. It subsumes, for example, tasks based on dimensionality reduction such as feature extraction, subspace learning and model order reduction and tasks related to machine learning such as regression, classification, clustering, and imputation of missing data. Tensorlab v2.0 offers a domain specific language (DSL) for modelling SDF problems. The three key ingredients of an SDF model are (1) defining variables, (2) defining factors as transformed variables and (3) defining the data sets and their factorizations based on these factors. Tensor decompositions and factor structure may be chosen in a modular way. Currently, Tensorlab comes with the choice of the canonical polyadic decomposition (CPD), low multilinear rank approximation (LMLRA) and block term decomposition (BTD) and ships with a library of 32 predefined factor structures such as nonnegativity, orthogonality, Hankel, Toeplitz, Vandermonde and the matrix inverse. By selecting the right combination of tensor decompositions and factor structures, even classical matrix factorizations such as the eigenvalue decomposition, singular value decomposition and QR factorization can be computed with SDF.

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MS87

Supermodular Inequalities for Mixed Integer Bilinear Knapsacks

We address the problem of developing new valid inequalities for $S = \{(x, y) : \sum_{i,j} a_{ij}x_iy_j + \sum_i a_{0i}x_i + \sum_j b_jy_j \leq r, x_i \in [0, u_i], y_j \in \{0, 1\}\ \forall i, j\}$ in the (x, y)-space. We study the convex hull of $X = \{(x, y) : \sum_j a_jxy_j + a_0x + \sum_j b_jy_j \leq r, x \in [0, u], y_j \in \{0, 1\}\ \forall j\}$, which is a relaxation of S upon aggregation of variables. The set X also appears when maximizing hyperbolic functions and discretizing variables in a single bilinear term. Exploiting the supermodular structure in X and using disjunctive programming techniques leads to an exponential family of inequalities, which define conv$X$ for certain values of a, b, u. These valid inequalities from X can be strengthened when the coefficient matrix in S has rank one and/or x is discrete. Computational results with a branch-and-cut algorithm will also be discussed.

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MS87

Convex Quadratic Programming with Variable Bounds

We aim to obtain a strong relaxation for the convex hull of a mixed binary set defined by convex non-separable quadratic functions that appears in many important applications. Our approach starts by reformulation through Cholesky factorization. Several classes of linear and nonlinear valid inequalities are derived. Computational results on different formulations are compared, and we demonstrate that the derived inequalities are helpful in the solution process of the application problems.

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MS87

Strong Convex Nonlinear Relaxations of the Pooling Problem

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

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MS87

Cuts for Quadratic and Conic Quadratic Mixed Integer Programming

We study algorithms and formulas for constructing the convex hull of the sets defined by two quadratic inequalities. We also study the generalization of split and intersection cuts from Mixed Integer Linear Programming to Mixed Integer Conic Quadratic Programming. Constructing such cuts requires characterizing the convex hull of the difference of two convex sets with specific geometric structures.

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MS88

A Lagrangian-Dnn Relaxation: a Fast Method for Computing Tight Lower Bounds for a Class of Quadratic Optimization Problems

We propose an efficient computational method for linearly constrained quadratic optimization problems (QOPs) with complementarity constraints based on their Lagrangian and doubly nonnegative (DNN) relaxation and first-order algorithms. The simplified Lagrangian-CPP relaxation of such QOPs proposed by Arima, Kim, and Kojima in 2012 takes one of the simplest forms, an unconstrained conic linear optimization problem with a single Lagrangian parameter in a completely positive (CPP) matrix variable with its upper-left element fixed to 1. Replacing the CPP matrix variable by a DNN matrix variable, we derive the Lagrangian-DNN relaxation, and establish the equivalence between the optimal value of the DNN relaxation of the original QOP and that of the Lagrangian-DNN relaxation. We then propose an efficient numerical method for the Lagrangian-DNN relaxation using a bisection method combined with the proximal alternating direction multiplier and the accelerated proximal gradient methods. Numerical results on binary QOPs, quadratic multiple knapsack problems, maximum stable set problems, and quadratic assignment problems illustrate the superior performance of the proposed method for attaining tight lower bounds in shorter computational time.

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MS88

Mixed Integer Second-Order Cone Programming Formulations for Variable Selection

Variable selection is to select the best subset of explanatory variables in a multiple linear regression model. To evaluate a subset regression model, some goodness-of-fit measures, such as AIC, BIC and $\bar{R}^2$, are generally employed. A stepwise regression method, which is frequently used, does not always provide the best subset of variables according to these measures. In this talk, we introduce mixed integer second-order cone programming formulations for selecting the best subset of variables.

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MS88

Improved Implementation of Positive Matrix Completion Interior-Point Method for Semidefinite Programs

Exploiting sparsity is the key to solving SDPs in a short time. An important feature of the completion method in SDPA-C is that it decomposes the variable matrices to reveal the structural sparsity. We implement a new decomposition formula focusing the inverse of variable matrices. Numerical results show that this new formula and multiple-threaded parallel computing reduce the computation time for some SDPs that have structural sparsity.

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MS88

Dual Approach Based on Spectral Projected Gradient Method for Log-Det Sdp with L_1 Norm

An SDP problem combined with log-determinant and L_1 norm terms in its objective function has attracted more attention by a connection to the sparse covariance selection. Lu adapted an adaptive spectral projected gradient method to this SDP. To apply this method to the SDP with linear constraints, we focus its dual formulation and develop the dual method. Numerical results indicate that the dual method is more efficient than the primal method.

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MS89

A Criterion for Sums of Squares on the Hypercube

Optimizing a polynomial over the $\{0,1\}$-cube by sums of squares is a standard problem in combinatorial optimization. We will present a criterion showing the limitations of this approach, even when a weaker version of the certificates is considered, improving results of Laurent on the strength of Lassere's hierarchy for maxcut. As a byproduct, we construct a family of globally nonnegative polynomials that need an increasing degree of sums of squares multipliers to be certified nonnegative.

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MS89

Partial Facial Reduction: Simplified, Equivalent SDPs via Inner Approximations of the PSD Cone

We develop practical semidefinite programming (SDP) facial reduction procedures that utilize computationally efficient inner approximations of the positive semidefinite cone. The proposed methods simplify SDPs with no strictly feasible solution by solving a sequence of easier optimization problems. We relate our techniques to parsing algorithms for polynomial nonnegativity decision problems, demonstrate their effectiveness on SDPs arising in practice, and describe our publicly-available software implementation.

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MS89

Polytopes with Minimal Positive Semidefinite Rank

We define the positive semidefinite (PSD) rank of a polytope P to be the size of the smallest cone of psd matrices that admits a lift of P. PSD minimal polytopes have PSD rank equal to $\dim(P)+1$. We will discuss characterizations and properties of these polytopes.

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MS89

Semidefinite Representations of the Convex Hull of Rotation Matrices

The convex hull of $SO(n)$, the set of $n \times n$ orthogonal matrices with determinant one, arises naturally when dealing with optimization problems over rotations, e.g. in satellite attitude estimation. In this talk we describe explicit constructions showing that the convex hull of $SO(n)$ is doubly spectrahedral, i.e. both it and its polar have a description as the intersection of a cone of positive semidefinite matrices with an affine subspace. This allows us to solve certain problems involving rotations using semidefinite programming.

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MS90

Iteration Complexity of Feasible Descent Methods for Convex Optimization

Abstract Not Available

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MS90

Randomized Block Coordinate Non-Monotone Gradient Method for a Class of Nonlinear Programming

We propose a randomized block coordinate non-monotone gradient (RBCNMG) method for minimizing the sum of a smooth (possibly nonconvex) function and a block-separable (possibly nonconvex nonsmooth) function. We show that the solution sequence generated by this method is arbitrarily close to an approximate stationary point with high probability. When the problem under consideration is convex, we further establish that the sequence of expected values generated converges to the optimal value of the problem.

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MS90

Efficient Random Coordinate Descent Algorithms for Large-Scale Structured Nonconvex Optimiza-

tion

We analyze several new methods for solving nonconvex optimization problems with the objective function formed as a sum of two terms: one is nonconvex and smooth, and another is convex but simple and its structure is known. Further, we consider both cases: unconstrained and linearly constrained nonconvex problems. For optimization problems of the above structure, we propose random coordinate descent algorithms and analyze their convergence properties. For the general case, when the objective function is nonconvex and composite we prove asymptotic convergence for the sequences generated by our algorithms to stationary points and sublinear rate of convergence in expectation for some optimality measure. We also present extensive numerical experiments for evaluating the performance of our algorithms in comparison with state-of-the-art methods.

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MS90

Efficient Coordinate-minimization for Orthogonal Matrices through Givens Rotations

Optimizing over the orthogonal-matrices set is central to many problems including eigenvalue problems, sparse-PCA, and tensor decomposition. Such optimization is hard since operations on orthogonal matrices easily break orthogonality, and reorthogonalization is usually costly. We propose a framework for orthogonal matrix optimization that is parallel to coordinate-minimization in Euclidean spaces. It is based on Givens-rotations, fast-to-compute linear operations that modify few matrix entries and preserve orthogonality. We apply it to orthogonal tensor decomposition and sparse-PCA.

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MS91

NOWPAC - A Provably Convergent Derivative Free Optimization Algorithm for Nonlinear Programming

We present the derivative free trust-region algorithm NOWPAC for computing local solutions of nonlinear constrained optimization problems. NOWPAC is designed to work solely with black box evaluations of the objective and the constraints, a setting which is of particular interest, for example, in robust optimization with chance constraints. Constraints are handled using a path-augmented inner boundary of the feasible domain, guaranteeing strict feasibility of all intermediate designs as well as convergence to a first order critical point.

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MS91

Optimal Design and Model Re-specification

Improved characterization and assimilation of prior information is essential in the context of large-scale inverse problems, yet, for realistic problems, the ability to do so is rather limited. Complementary to such endeavors; it is instrumental to attempt to maximize the extraction of measureable information. This can be performed through improved prescription of experiments, or through improved specification of the observation model. Conventionally, the latter is achieved through first principles approaches, yet, in many situations, it is possible to learn a supplement for the observation operator from the data. Such an approach may be advantageous when the modeler is agnostic to the principle sources of model-misspecification as well as when the development effort of revising the observation model explicitly is not cost-effective.

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MS91

Approximation Methods for Robust Optimization and Optimal Control Problems for Dynamic Systems with Uncertainties

All models contain systematic errors such as statistical uncertainties of state and parameter estimates, model plant mismatch and discretization errors provided by simulation methods. That is why application of optimization to real-life processes demands taking into account model and data uncertainties. One of the possibilities is robust optimization which leads to problems with extremely high degree of computational complexity. The talk discusses efficient approximative robust optimization methods and their application in optimal control problems.

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MS91

Improved Bounds on Sample Size for Implicit Matrix Trace Estimators

This talk is concerned with Monte-Carlo methods for the estimation of the trace of an implicitly given matrix A whose information is only available through matrix-vector products. Such a method approximates the trace by an average of N expressions of the form $w^t\ (Aw)$, with random vectors w drawn from an appropriate distribution. We prove, discuss and experiment with bounds on the number of realizations N required in order to guarantee a probabilistic bound on the relative error of the trace estimation upon employing Rademacher (Hutchinson), Gaussian and uniform unit vector (with and without replacement) probability distributions. In total, one necessary and six sufficient bounds are proved, improving upon and extending similar estimates obtained in the seminal work of Avron and Toledo (2011) in several dimensions. We first improve their bound on N for the Hutchinson method, dropping a term that relates to rank(A) and making the bound comparable with that for the Gaussian estimator. We further prove new sufficient bounds for the Hutchinson, Gaussian and the unit vector estimators, as well as a necessary bound for the Gaussian estimator, which depend more specifically on properties of the matrix A. As such they may suggest for what type of matrices one distribution or another provides a particularly effective or relatively ineffective stochastic estimation method.

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MS92

A Geometric Theory of Phase Transitions in Convex Optimization

Convex regularization has become a popular approach to solve large scale inverse or data separation problems. A prominent example is the problem of identifying a sparse signal from linear samples my minimizing the l_1 norm under linear constraints. Recent empirical research indicates that many convex regularization problems on random data exhibit a phase transition phenomenon: the probability of successfully recovering a signal changes abruptly from zero to one as the number of constraints increases past a certain threshold. We present a rigorous analysis that explains why phase transitions are ubiquitous in convex optimization. It also describes tools for making reliable predictions about the quantitative aspects of the transition, including the location and the width of the transition region. These techniques apply to regularized linear inverse problems, to demixing problems, and to cone programs with random affine constraints. These applications depend on a new summary parameter, the statistical dimension of cones, that canonically extends the dimension of a linear subspace to the class of convex cones. Joint work with Dennis Amelunxen, Mike McCoy and Joel Tropp.

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MS92

Preconditioners for Systems of Linear Inequalities

We show that a combination of two simple preprocessing steps improves the conditioning of a system of linear inequalities. Our approach is based on a comparison among three different but related notions of conditioning due to Renegar, Goffin-Cheung-Cucker, and Amelunxen-Burgisser.

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MS92

On a Four-dimensional Cone that is Facially Exposed but Not Nice

A closed convex cone is nice if the Minkowski sum of its dual with the orthogonal complement of each of its faces is a closed set. This property is useful in the analysis of a range of conic problems. We show that while all three-dimensional facially exposed cones are nice, there exists a four-dimensional cone that is facially exposed but is not nice. We will also demonstrate some tricks that allow dealing with 4D objects using lower-dimensional argument and 3D graphics.

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MS92

A Deterministic Rescaled Perceptron Algorithm

The classical perceptron algorithm is a separation-based algorithm for solving conic-convex feasibility problems in a number of iterations that is bounded by the reciprocal of the square of the cone thickness. We propose a modified perceptron algorithm that leverages periodic rescaling for exponentially faster convergence, where the iteration bound is proportional to the logarithm of the reciprocal of the cone thickness and another factor that is polynomial in the problem dimension.

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MS93

Online Algorithms for Ad Allocation

As an important component of any ad serving system, online capacity (or budget) planning is a central problem in online ad allocation. Various models are used to formally capture these problems and various algorithmic techniques such as primal-dual and sampling based algorithms have been applied to these problems. The talk will survey the different models and techniques, theoretical guarantees and practical evaluations of these algorithms on real data sets.

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MS93
Distributed Learning on Dynamic Networks

In this talk, I will explore a data-driven online optimization framework for the synthesis of certain classes of networks that are resistive to an external influence. The setup is in line with performance measures often adopted in control theory, tailored for diffusion-type protocols. The approach provides means of embedding a distributed adaptive mechanism on networks that modify the way the network collectively responds to an external input. Along the way, we will explore connections between online distributed optimization, limits of influence on diffusion-type networks, spectral graph theory, electrical networks, and linear equation solving on graphs.

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MS93
Online Algorithms for Node-Weighted Network Design

In recent years, an online adaptation of the classical primal-dual paradigm has been successfully used to obtain new online algorithms for node-weighted network design problems, and simplify existing ones for their edge-weighted counterparts. In this talk, I will give an outline of this emerging toolbox using three fundamental problems in this category for illustration: the Steiner tree (Naor-P.-Singh, 2011) and Steiner forest (Hajiaghayi-Liaghat- P., 2013) problems, and their prize-collecting versions (Hajiaghayi-Liaghat-P., 2014).

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MS93
A Dynamic Near-Optimal Algorithm for Online Linear Programming

A natural optimization model that formulates many online resource allocation and revenue management problems is the online linear program (LP) where the constraint matrix is revealed column by column along with the objective function. We provide a near-optimal algorithm for this surprisingly general class of online problems under the assumption of random order of arrival and some mild conditions on the size of the LP right-hand-side input. Our algorithm has a feature of "learning while doing" by dynamically updating a threshold price vector at geometric time intervals, where the dual prices learned from revealed columns in the previous period are used to determine the sequential decisions in the current period. In particular, our algorithm doesn't assume any distribution information on the input itself, thus is robust to data uncertainty and variations due to its dynamic learning capability. Applications of our algorithm include many online multi-resource allocation and multi-product revenue management problems such as online routing and packing, online combinatorial auctions, adwords matching, inventory control and yield management.

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MS94
Linear Scalarizations for Vector Optimization Problems with a Variable Ordering Structure

In recent applications the preferences in the considered multi-objective optimization problems turned out to be variable and to depend on the current function values. This is modeled by a vector optimization problem with an ordering structure defined by a cone-valued map. We discuss in this talk how the well-known linear scalarizations based on elements from the dual cone can be generalized to variable orderings. We present characterization results for optimal elements including proper optimal elements.

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MS94
Comparison of Different Scalarization Methods in Multi-objective Optimization

This talk presents the comparison of different scalarization methods in multi-objective optimization. The methods are compared with respect to the ability to consider the preferences of decision maker, the ability to generate different kinds of efficient solutions such as weak efficient, efficient and proper efficient solutions. Theorems establishing relations between different scalarization methods are presented. The computational skills and dependence on the parameters sets for different scalarization methods are discussed and demonstrative examples are presented.

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MS94
Variational Analysis in Psychological Modeling

This talk presents some mathematical models arising in psychology and some other areas of behavioral sciences that are formalized via general variable preferences. In the mathematical framework, we derive a new extension of the Ekeland variational principle to the case of set-valued mappings with variable cone-valued ordering structures. Such a general setting provides an answer to the striking question: in the world, where all things change what can stay fixed for a while?

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MS94

Robust Multiobjective Optimization

We consider multiobjective programs (MOPs) with uncertainty in objective and constraint functions, and in the parameters converting MOPs into single-objective programs (SOPs). We propose several types of robust counterpart problems (RCs) that involve infinitely many MOPs, infinitely many objective functions in a single MOP, and MOPs or SOPs with infinitely many constraints. In each case, we reduce the RC into a computationally tractable deterministic MOP (or SOP) and examine the relationship between their efficient sets.

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MS95

Finding Low-Rank Solutions to Qcqps

We describe continuing work to find low-rank solutions to QCQPs, especially as they arise in optimal power flow (OPF) problems.

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MS95

Global Optimization with Non-Convex Quadratics

We present results on a new spatial B&B solver, iquad, for optimization problems in which all of the non-convexity is quadratic. Our approach emphasizes pre-processing to effectively exploit any convexity.

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MS95

On the Separation of Split Inequalities for Non-Convex Quadratic Integer Programming

We investigate the computational potential of split inequalities for non-convex quadratic integer programming, first introduced by Letchford and further examined by Burer and Letchford. These inequalities can be separated by solving convex quadratic integer minimization problems. For small instances with box-constraints, we show that the resulting dual bounds are very tight; they can close a large percentage of the gap left open by both the RLT- and the SDP-relaxations of the problem. The gap can be further decreased by separating so-called non-standard split inequalities, which we examine in the case of ternary variables.

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MS95

Extended Formulations for Quadratic Mixed Integer Programming

An extended formulation for Mixed Integer Programming (MIP) is a formulation that uses a number of auxiliary variables in addition to the original or natural variables of a MIP. Extended formulations for linear MIP have been extensively used to construct small, but strong formulations for a wide range of problems. In this talk we consider the use of extended formulations in quadratic MIP and show how they can be used to improve the strength cutting plane procedures.

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MS96

Numerical Methods for Stochastic Multistage Optimization Problems Applied to the European Electricity Market

Abstract Not Available

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MS96

Risk in Capacity Energy Equilibria

We look at a risky investment equilibrium that combines a game of investments by risk averse firms in electricity plants, a risk market in financial products, and a stochastic electricity market. In a complete risk market, all risks can be priced and the equilibrium model collapses, eg, to convex optimization problem when the energy market is perfectly competitive. We also look at equilibria in incomplete markets which are computationally and theoretically more challenging.

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MS96

Computing Closed Loop Equilibria of Electricity Capacity Expansion Models

We propose a methodology to compute closed loop capacity equilibria using only open loop capacity equilibrium models and apply this approximation scheme to large-scale generation expansion planning models in liberalized electricity markets. This approximation scheme allows us to solve the closed loop model reasonably well by smartly employing open loop models which reduces the computational time by two orders of magnitude. These results are confirmed in a large-scale, multi-year, multi-load period and multi-technology numerical example.

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MS96

Optimization (and Maybe Game Theory) of Demand Response

In this talk we will briefly outline the market clearing mechanism for the NZ electricity market (NZEM) which co-optimizes energy and reserve simultaneously. We will then present a tool designed for the demand response of major users of electricity. This tool embeds the change to the distribution of future prices as a function of the actions of the major electricity users and optimizes the consumption level as well as the reserve offer for a major user of electricity. We will also discuss extensions of this to schedules for longer time horizons.

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MS97

Fast Variational Methods for Matrix Completion and Robust PCA

We present a general variational framework that allows efficient algorithms for denoising problems (where a functional is minimized subject to a constraint on fitting the observed data). This framework is useful for both vector recovery (sparse optimization) and matrix recovery (matrix completion and robust principle component analysis). While very general in principle, the efficacy of the approach relies on efficient first order solvers. For matrix completion and robust PCA, we incorporate new ideas in factorized and accelerated first order methods into the variational framework to develop state of the art approaches for large scale applications, and illustrate with both synthetic and real examples.

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MS97

ϵ-Subgradient Methods for Bilevel Convex Optimization

Existing techniques used in the solution of the convex bilevel optimization problem include Cabot's idea of using the proximal method applied to a varying objective function and Solodov's bundle variation of the same technique. Continuing this trend we introduce an ϵ-subgradient method for the bilevel problem. Our algorithm presents two main advantages over current technique: cheap iteration cost and ease of implementation. The main drawback is slow asymptotic convergence rate.

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MS97

An Algorithm for Convex Feasibility Problems Using Supporting Halfspaces and Dual Quadratic Programming

A basic idea of finding a point in the intersection of convex sets is to project iterates onto these convex sets to obtain halfspaces containing the intersection, and then to project the iterates onto the polyhedron generated. We discuss theoretical issues and implementation strategies.

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MS97

A First Order Algorithm for a Class of Nonconvex-nonsmooth Minimization

We introduce a new first order algorithm for solving a broad class of nonconvex and nonsmooth problems. The resulting scheme involves simple iterations and is particularly adequate for solving large scale nonsmooth and nonconvex problems arising in a wide variety of fundamental applications. We outline a self contained convergence analysis framework describing the main tools and methodology to prove that the sequence generated by the proposed scheme globally converges to a critical point. Our results are illustrated on challenging sparse optimization models arising in data analysis applications. This is a joint work with Jerome Bolte and Marc Teboulle.

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MS98

On Symmetric Rank and Approximation of Symmetric Tensors

In this talk we will discuss two problems: The first one is when the rank of real symmetric tensor is equal to its symmetric rank. The second problem is when a best k-border rank approximation can be chosen symmetric. Some partial results are given in a joint paper with M. Stawiska: arXiv:1311.1561.

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MS98

Some Extensions of Theorems of the Alternative

In this talk, some extensions of theorems of the alternative to the tensor setting will be discussed. We will talk about the difficulties and impossibility of the general case. Nevertheless, there are classes of structured tensors which have suitable generalisations. Specially, we will present a tractable extension of Yuan's theorem of the alternative with application to a class of nonconvex polynomial optimisation problems. The optimal solution of this class problems can be recovered from the corresponding solution of the convex conic programming problem.

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MS98

Algorithms for Decomposition

We present an algorithm for decomposing a symmetric tensor, of dimension n and order d, as a sum of rank-1 symmetric tensors, based on an extension of Sylvester's algorithm for binary forms. We also present an efficient variant for the case where the factor matrices enjoy some structure, such as block-Hankel, triangular, band, etc. Finally, we sketch the bit complexity analysis for the case of binary forms. The talk is based on common works with J. Brachat, P. Comon, P. Hubáček, B. Mourrain, V. Pastro, S. K. Stiil Frederiksen, and M. Sorensen.

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MS98

Semidefinite Relaxations for Best Rank-1 Tensor Approximations

We study the problem of finding best rank-1 approximations for both symmetric and nonsymmetric tensors. For symmetric tensors, this is equivalent to optimizing homogeneous polynomials over unit spheres; for nonsymmetric tensors, this is equivalent to optimizing multi-quadratic forms over multi-spheres. We propose semidefinite relaxations, based on sum of squares representations, to solve these polynomial optimization problems. Their properties and structures are studied. In applications, the resulting semidefinite programs are often large scale. The recent Newton-CG augmented Lagrangian method by Zhao, Sun and Toh is suitable for solving these semidefinite relaxations. Extensive numerical experiments are presented to show that this approach is practical in getting best rank-1 approximations.

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MS99

An Inexact Sequential Quadratic Optimization Method for Nonlinear Optimization

We present a sequential quadratic optimization algorithm for solving nonlinear constrained optimization problems. The unique feature of the algorithm is that inexactness is allowed when solving the arising quadratic subproblems. Easily implementable inexactness criteria for the subproblem solver are established that ensure global convergence guarantees for the overall algorithm. This work represents a step toward a scalable active-set method for large-scale nonlinear optimization.

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MS99

A BFGS-Based SQP Method for Constrained Nonsmooth, Nonconvex Optimization

We consider constrained optimization problems where both the objective and constraints may be nonsmooth and nonconvex. In 2012, Curtis and Overton presented a gradient-sampling-based SQP method, proving convergence results, but in the unconstrained nonsmooth case, Lewis and Overton contrastingly argue that BFGS is a far more efficient approach than gradient-sampling. We extend BFGS using SQP to dynamically adapt to nonsmooth objectives and constraint violations and show promising results on challenging applied problems from feedback control.

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MS99

A Two-phase SQO Method for Solving Sequences of NLPs

SQO methods are fundamental tools while solving more complex problems. Usually the problem one wants to solve adopts the form of a sequence of closely related nonlinear programming problems. Therefore, warm starts an inexact solutions, among other desirable features, play an important role in the overall performance of the final method. In this talk we explore the potential of SQP+ for solving sequences of NLPs. SQP+ is a two phase method that combines an inequality QP step for detecting the active set, followed by an equality QP phase that promotes fast convergence.

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MS99

An Inexact Trust-Region Algorithm for Nonlinear Programming Problems with Expensive General Constraints

This talk presents an inexact SQP algorithm for nonlinear optimization problems with equality and inequality constraints. The proposed method does not require the exact evaluation of the constraint Jacobian. Instead, only approximations of these Jacobians are required. Corresponding accuracy requirements for the presented first-order global convergence result can be verified easily during the optimization process to adjust the approximation quality of the constraint Jacobian. First numerical results for this new approach are discussed.

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Larry Biegler
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MS100

A Geometrical Analysis of Weak Infeasibility in Semidefinite Programming and Related Issues

In this talk, we present a geometrical analysis of Semidefinite Feasibility Problems (SDFPs). We show how to divide an SDFP into smaller subproblems in a way that the feasibility properties are mostly preserved. This is accomplished by introducing an object called "hyper feasible partition". We use our techniques to study weakly infeasible problems in a systematic way and to provide some insight into how weakly infeasibility arises in semidefinite programming.

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MS100

Gauge optimization, duality and applications

Gauge optimization seeks the element of a convex set that is minimal with respect to a gauge function. It can be used to model a large class of useful problems, including a special case of conic optimization, and various problems that arise in machine learning and signal processing. In this talk, we explore the duality framework proposed by Freund, and discuss a particular form of the problem that exposes some useful properties of the gauge optimization framework.

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MS100

On the rolls of optimality conditions for polynomial optimization

A polynomial optimization problem is a problem to find a minimum of a polynomial function over the set defined by polynomial equations and inequalities. There is an algorithm which obtains the *global minimum*, by solving a sequence of semidefinite programming. We study how optimality conditions, or other preferable properties of polynomial optimization problems affect the generated semidefinite programming. This involves attainability of semidefinite programming, finite convergence properties of Lasserre's hierarchy and representability of nonnegative polynomials.

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MS100

An LP-based Algorithm to Test Copositivity

A symmetric matrix is called copositive if it generates a quadratic form taking no negative values over the positive orthant, and the linear optimization problem over the set of copositive matrices is called the copositive programming problem. Recently, many studies have been done on the copositive programming problem which (cf, Dur (2010)). Among others, several blanch and bound type algorithms have been provided to test copositivity since it is known that the problem for deciding whether a given matrix is copositive is co-NP-complete (cf. Murty and Kabadi (1987)). In this talk, we propose a new blanch and bound type algorithm for this testing problem. Our algorithm is based on solving linear optimization problems over the nonnegative orthant, repeatedly. Numerical experiments suggest that our algorithm is promising for determining upper bounds of the maximum clique problem.

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MS101

Building Large-scale Conic Optimization Models using MOSEK Fusion

A modern trend in convex optimization is to pose convex problem in conic form, which is a surprisingly versatile and expressive description. MOSEK Fusion is an object orientated tool for building conic optimization models. In this talk we present Fusion with an emphasis on techniques that can be used to vectorize the model construction. When applicable such vectorization techniques can speed up the model construction by more than one order of magnitude.

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MS101

Quadratic Cone Modeling Language

The quadratic cone modeling language (QCML) is a lightweight convex optimization modeling language implemented in Python. It is a code generator that produces lightweight Python, Matlab, or C code for *matrix stuffing*. This resulting code can then be called to solve a particular problem instance, in which the parameters and dimensions of the original description are fixed to given values. The resulting cone program is solved with an external solver.

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MS101

The Cvx Modeling Framework: New Development

CVX is a well known modeling framework for convex optimization. Initially targeting just MATLAB, CVX is now available on Octave, and work is actively ongoing in bringing CVX to other computational platforms as well. In this talk, we will provide an overview of CVX and provide an update on the status of these recent developments.

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MS101

Recent Devlopments in Picos

PICOS is a user-friendly modelling language written in python which interfaces several conic and integer programming solvers, similarly to YALMIP or CVX under MATLAB. In this talk we will present some recent developments of PICOS, in particular concerning **complex semidefinite programming** (with Hermitian matrices) and **robust optimization**.

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MS102

Coordinate Descent Type Methods for Solving Sparsity Constrained Problems

We consider the problem of minimizing a smooth function over the intersection of a closed convex set and a sparsity constraint. We begin by showing how the orthogonal projection operator can be computed efficiently when the underlying convex set has certain symmetry properties. A hierarchy of optimality conditions for the problem is presented, and the theoretical superiority of coordinate-wise type conditions is established. Finally, based on the derived optimality conditions, we present several coordinate descent type algorithms for solving the sparsity constrained problem, and illustrate their performance on several numerical examples. This is joint work with Nadav Hallak.

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MS102

GAMSEL: A Penalized Likelihood Approach to Model Selection for Generalized Additive Models

We introduce GAMSEL (Generalized Additive Model SELection), a method for fitting generalized additive models in high dimensions. Our method borrows ideas from the overlap group lasso of Jacob et al (2009) to retain, when possible, the interpretability advantages of a simple linear fit while allowing a more flexible additive fit when necessitated by the data. We present a blockwise coordinate descent procedure for optimizing the penalized likelihood objective.

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MS102

Coordinate descent methods for ℓ_0-regularized optimization problems

The recent interest in sparse optimization represents a strong motivation for deriving complexity results for ℓ_0-regularized problems. We present new results regarding the classification and quality of local optimal points for ℓ_0-regularized problems. In order to provide efficient algorithms that converge to particular classes of optimal points, we combine coordinate descent framework with iterative hard thresholding methods. For all the new algorithms we provide estimates on the convergence rate that are superior to the existing results.

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MS102

Efficient Randomized Coordinate Descent for Large Scale Sparse Optimization

Recently several methods were proposed for sparse optimization which make careful use of second-order information to improve local convergence rates. These methods construct a composite quadratic approximation using Hessian information, optimize this approximation using a first-order method, such as coordinate descent and employ a line search to ensure sufficient descent. Here we propose a general method, which improves upon these ideas to improve the practical performance and prove a global convergence analysis in the spirit of proximal gradient methods.

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MS103

Efficient Estimation of Selecting and Locating Actuators and Sensors for Controlling Compressible, Viscous Flows

A new method is developed to estimate optimal actuator types and locations for controlling compressible, viscous flows using linear feedback. Based on an analysis of the structural sensitivity of the linearized compressible Navier-Stokes operator about a time-steady baseflow, the forward and adjoint global modes are used to optimize eigenvalue placement which leads to an estimate of where the controller should be placed, and what type of controller (mass, momentum, energy, etc.) it should be. The method is demonstrated using direct numerical simulations of a separated boundary layer in a Mach 0.65 diffuser at different Reynolds numbers and whether the baseflow is taken as the true steady solution or the time-averaged flow. For sufficiently low Reynolds numbers global stabilization of the flow is achieved; only partial stabilization is achieved at higher Reynolds numbers. Preliminary results for controlling supersonic jet noise will also be given.

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MS103

New Trends in Aerodynamic Shape Optimization using the Continuous Adjoint Method

In this presentation, the authors will review their research on high-fidelity Computational Fluid Dynamics (CFD) tools and continuous adjoint-based techniques for the optimal aerodynamic shape design. While there is a well-consolidated theory for the application of adjoint methods to optimal shape design, the use of these techniques in realistic industrial problems is challenging due to a range of technical and mathematical issues that will be discussed in this presentation. In particular, different examples (rotorcraft, free-surface, or supersonic) will be used to introduce original contributions to the state-of-the-art in CFD-based optimal shape design: a systematic approach to shape design, ALE formulation using continuous adjoint, design with discontinuities, and robust grid adaptation, among other topics.

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MS103

Shape Analysis for Maxwell's Equations

In the context of the project HPC-FLiS, we formulate the problem of identifying unknown objects in predefined domains as an inverse electromagnetic scattering problem. Here, we consider it as a shape optimization problem. A typical design cycle consists of a forward simulation, adjoint solution, shape gradient calculation and shape&grid modification. This talk will cover the theoretical derivation of the shape derivatives, the realization using the tool FEniCS and results obtained for various test configurations.

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MS103

Optimization in Chaos

Turbulent flow is chaotic. So can be flow-structure coupled oscillations. High fidelity simulations of both systems often inherit their chaotic dynamics, which brings fascinating mathematical questions into their optimization. What is butterfly effect? How does it affect gradient computation? What is sampling error? How does it affect gradient-based and gradient-free optimization? Can ideas in stochastic programming apply to optimization in chaos? What if our problem is both chaotic and uncertain?

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MS104

Equitable Division of a Geographic Region

In many practical problems, a geographic region must be subdivided into smaller regions in a fair or balanced fashion. Partitioning a region is generally a difficult problem because the underlying optimization variables are infinite-dimensional and because shape constraints may be difficult to impose from within a standard optimization context. Here we present several natural formulations of region partitioning problems and discuss how to solve them, with applications to vehicle routing and facility location.

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MS104

Structured Convex Infinite-dimensional Optimization with Double Smoothing and Chebfun

We propose an efficient approach to minimize a convex function over a simple infinite-dimensional convex set under an additional constraint $\mathcal{A}(x) \in T$ where $\mathcal{A}(\cdot)$ is linear and T finite-dimensional. We apply a fast gradient method to a doubly smoothed dualized problem, while relying on the chebfun toolbox to perform numerical computations on the primal side. We present results for optimal control problems where the trajectory is forced to visit some sets at certain moments in time.

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MS104

Global Optimization in Infinite Dimensional Hilbert Spaces

This talk is about complete search methods for solving non-convex infinite-dimensional optimization problems to global optimality. The optimization variables are assumed to be bounded and in a given Hilbert space. We present an algorithm and analyze its convergence under certain regularity conditions for the objective and constraint functions, which hold for a large class of practically-relevant optimization problems. We also discuss best- and worst-case run-time bounds for this algorithm.

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MS104

The Slater Conundrum: Duality and Pricing in Infinite Dimensional Optimization

In convex optimization, the Slater constraint qualification is perhaps the most well known interior point condition that ensures a zero duality gap. Using an algebraic approach, we examine the infinite dimensional vector spaces that admit Slater points and show that the resulting dual variable space contains singular functionals. These dual variables lack the standard pricing interpretation desired for many modeling applications. We then present sufficient conditions that ensure these functionals are not optimal solutions to the dual program.

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MS105

Analysis and Design of Fast Graph Based Algorithms for High Dimensional Data

Geometric methods have revolutionized the field of image processing and image analysis. Recently some of these concepts have shown promise for problems in high dimensional data analysis and machine learning on graphs. I will briefly review the methods from imaging and then focus on the new methods for high dimensional data and network data. These ideas include diffuse interface methods and threshold dynamics for total variation minimization.

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MS105

Fast Algorithms for Multichannel Compressed Sensing with Forest Sparsity

In this paper, we propose a new model called *forest sparsity* for multichannel compressive sensing. It is an extension of standard sparsity when the support set of the data is consisted of a series of mutually correlated trees. Forest sparsity exists in many practical applications such as multi-contrast MRI, parallel MRI, multispectral image and color image recovery. We theoretically prove its benefit, that much less measurements are required for successful recovery in compressive sensing. Moreover, efficient algorithms are proposed and applied on several applications with forest sparsity. All experimental results validate the superiority of forest sparsity.

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MS105

GRock: Greedy Coordinate-Block Descent Method for Sparse Optimization

Modern datasets usually have a large number of features or training samples, and stored in a distributed manner. Motivated by the need of solving sparse optimization problems with large datasets, we propose GRock, a parallel greedy coordinate-block descent method. We also establish the asymptotic linear convergence of GRock and explain why it often performs exceptionally well for sparse optimization. Numerical results on a computer cluster and Amazon EC2 demonstrate the efficiency and elasticity of our algorithms.

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MS105

Adaptive BOSVS Algorithm for Ill-Conditioned Linear Inversion with Application to Partially Parallel Imaging

This paper proposes a new adaptive Bregman operator splitting algorithm with variable stepsize (Adaptive BOSVS) for solving large scale and ill-conditioned inverse problems that arise in partially parallel magnetic resonance imaging. The original BOSVS algorithm uses a line search to achieve efficiency, while a proximal parameter is adjusted to ensure global convergence whenever a monotonicity condition is violated. The new Adaptive BOSVS uses a simpler line search than that used by BOSVS, and the monotonicity test can be skipped. Numerical experiments based on partially parallel image reconstruction compare the performance of BOSVS and Adaptive BOSVS scheme.

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MS106

Optimal Control of Free Boundary Problems with Surface Tension Effects

We will give a novel proof for the second order order sufficient conditions for an optimal control problem where the state system is composed of Laplace equation in the bulk and Young-Laplace on the free boundary. We will use piecewise linear finite elements to discretize the control problem and prove the optimal a priori error estimates. Finally, we will discuss a novel analysis for an extrusion process where the bulk equations are Stokes equations.

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MS106

Fast and Sparse Noise Learning via Nonsmooth PDE-constrained Optimization

We consider a nonlinear PDE constrained optimization approach to learn the optimal weights for a generic TV-denoising model featuring different noise distributions possibly present in the data. To overcome the high computational costs needed to compute the numerical solution, we use dynamical sampling schemes. We will consider also spatially dependent weights combined with a sparse regularisation on the parameter vector. This is joint work with J. C. De Los Reyes and C.-B. Schoenlieb.

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MS106

Multibang Control of Elliptic Equations

Multi-bang control refers to pde-constrained optimization problems where a distributed control should only take on values from a given discrete set, which can be promoted by a combination of L^2 and L^0-type control costs. Although the resulting functional is nonconvex and lacks weak lower-semicontinuity, application of Fenchel duality yields a formal primal-dual optimality system that admits a unique solution and can be solved numerically via a regularized semismooth Newton method.

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MS106

A Primal-dual Active Set Algorithm for a Class of Nonconvex Sparsity Optimization

We develop an algorithm of primal-dual active set type for a class of nonconvex sparsity-promoting penalties.

We derive a novel necessary optimality condition for the global minimizer using the associated thresholding operator. The solutions to the optimality system are necessarily coordinate-wise minimizers, and under minor conditions, they are also local minimizers. Upon introducing the dual variable, the active set can be determined from the primal and dual variables. This relation lends itself to an iterative algorithm of active set type which at each step involves updating the primal variable only on the active set and then updating the dual variable explicitly. Numerical experiments demonstrate its efficiency and accuracy.

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MS107

Conic Geometric Programming

We introduce conic geometric programs (CGPs), which are convex optimization problems that unify geometric programs (GPs) and conic optimization problems such as semidefinite programs (SDPs). Computing global optima of CGPs is not much harder than solving GPs and SDPs. The CGP framework facilitates a range of new applications that fall outside the scope of SDPs and GPs: permanent maximization, hitting-time estimation in dynamical systems, computation of quantum capacity, and robust optimization formulations of GPs.

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MS107

Sketching the Data Matrix of Large Linear and Convex Quadratic Programs

Abstract Not Available

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MS107

Convex Programming for Continuous Sparse Optimization

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MS107

Multi-Stage Convex Relaxation Approach for Low-Rank Structured Psd Optimization Problems

This work is concerned with low-rank structured positive semidefinite (PSD) matrix optimization problems. We start from reformulating them as mathematical programs with PSD equilibrium constraints and their exact penalty forms. Then, we propose a multi-stage convex relaxation approach that solves at each iteration a weighted trace semi-norm minimization problem. Under conditions weaker than the RIP, we establish an error bound for the optimal solution of the kth sub-problem, and show that the error bound in the second stage is strictly less than that of the first stage with the reduction rate explicitly quantifiable. Numerical results are provided to verify the efficiency of the proposed approach. [Joint work with Shujun Bi and Shaohua Pan]

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MS108

A Strong Relaxation for the Alternating Current Optimal Power Flow (acopf) Problem

ACOPF is an electric generation dispatch problem that is nonlinear and nonconvex. Fortunately, its Lagrangian dual can be solved with Semidefinite Programming; the problem can thus be solved in polynomial time when zero duality gap occurs. Establishing global optimality with duality gap can be problematic; in this case we strengthen the dual relaxation by adding valid inequalities based on a convex envelope. Our relaxation motivates a globally convergent algorithm that exploits sparse network topology.

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MS108

Islanding of Power Networks

In the past there have been multiple high-profile cases of cascading blackouts of power systems. In this talk we will present a MINLP model for optimal islanding of a power system network in order to prevent an imminent cascading blackout. We give a tractable reformulation of the original problem based on a new linear approximation of the

transmission constraints. We give computational results on networks of various sizes and show that our method scales well.

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MS108

Real-Time Pricing in Smart Grid: An ADP Approach

To realize real-time pricing (RTP) of electricity, demand-level control automation devices are essential. Aided by such devices, we propose an approximate dynamic programming (ADP)-based modeling and algorithm framework to integrate wholesale markets dispatch operation with demand response under RTP. With controllable charging/discharging of plug-in electric vehicles, our numerical results show that RTP can lower the expected values of wholesale electricity prices, increase capacity factors of renewable resources, and reduce system-wide CO_2 emissions.

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MS108

Topology Control for Economic Dispatch and Reliability in Electric Power Systems

Transmission topology control through line switching has been recognized as a valuable mechanism that can produce economic and reliability benefits through reduced congestion cost and corrective actions in response to contingencies. Such benefits are due to the inherent physical laws, known as Kirchhoffs Laws, governing the flow of power in electricity networks. This paper provides an overview describing the underlying motivation, current industry practices and the computational challenges associated with topology control in power systems.

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MS109

Some Variational Properties of Regularization Value Functions

Regularization plays a key role in a variety of optimization formulations of inverse problems. A recurring theme in regularization approaches is the selection of regularization parameters, and their effect on the solution and on the optimal value of the optimization problem. The sensitivity of the value function to the regularization parameter can be linked directly to the Lagrange multipliers. In this talk we show how to characterize the variational properties of the value functions for a broad class of convex formulations. An inverse function theorem is given that links the value functions of different regularization formulations (not necessarily convex). These results have implications for the selection of regularization parameters, and the development of specialized algorithms. Numerical examples illustrate the theoretical results.

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MS109

Optimization and Intrinsic Geometry

Modern optimization - both in its driving theory and in its classical and contemporary algorithms - is illuminated by geometry. I will present two case studies of this approach. The first example - seeking a common point of two convex sets by alternately projecting onto each - is classical and intuitive, and widely applied (even without convexity) in applications like image processing and low-order control. I will sketch some nonconvex cases, and relate the algorithm's convergence to the intrinsic geometry of the two sets. The second case study revolves around "partly smooth manifolds" - a geometric generalization of the active set notion fundamental to classical Nonlinear optimization. I emphasize examples from eigenvalue optimization. Partly smooth geometry opens the door to acceleration strategies for first-order methods, and is central to sensitivity analysis. Reassuringly, given its power as a tool, this geometry is present generically in semi-algebraic optimization problems.

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MS109

Epi-Convergent Smoothing with Applications to Convex Composite Functions

In this talk we synthesize and extend recent results due to Beck and Teboulle on infimal convolution smoothing for convex functions with those of X. Chen on gradient consistency for nonconvex functions. We use epi-convergence techniques to define a notion of epi-smoothing that allows us to tap into the rich variational structure of the subdifferential calculus for nonsmooth, nonconvex, and nonfinite-valued functions. As an illustration of the versatility of epi-smoothing techniques, the results are applied to the general constrained optimization problem.

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MS109

Epi-splines and Exponential Epi-splines: Pliable Approximation Tools

Epi-splines are primordially approximation tools rather than their splines 'cousins' which are mostly interpolation (or smoothing) tools. This allows them to accommodate more easily a richer class of information about the function, or system, that we are trying to approximate yielding in some instances stunning results. The theory that supports their properties is to a large extent anchored in the up-to-date version of Variational Analysis and implementations rely almost always on the availability of optimization routines that have been so successfully developed in the last half century. Exponential epi-spline are composition of the exponential function with an epi-spline and are particularly well suited to specific types of applications. This lecture will provide a quick overview of the basic framework and describe a few applications.

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MS110

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Abstract Not Available

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MS110

On Generic Nonexistence of the Schmidt-Eckart-Young Decomposition for Tensors

The Schmidt-Eckart-Young theorem for matrices states that the optimal rank-r approximation to a matrix in the Euclidean topology is obtained by retaining the first r terms from the singular value decomposition of that matrix. In this talk, we consider a generalization of this optimal truncation property to the CANDECOMP/PARAFAC decomposition of tensors and establish a necessary orthogonality condition. We prove that this condition is not satisfied at least by an open set of positive Lebesgue measure. We prove, moreover, that for tensors of small rank this orthogonality condition can be satisfied on only a set of tensors of Lebesgue measure zero.

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MS110

On Low-Complexity Tensor Approximation and Optimization

In this talk we shall discuss the issues related to the low-rank approximation for general tensors. Attention will be paid to the relationships between the classical CANDECOMP/PARAFAC (abbreviated as CP) rank, the multilinear (or Tucker) rank, the n-mode rank, and a newly introduced matrix rank. We then discuss the solution methods for the optimal rank-1 approximation model, which leads to the so-called tensor PCA problem. Finally, we introduce the notion of low-order robust co-clustering for tensors, and discuss its applications in bioinformatics.

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MS110

The Rank Decomposition and the Symmetric Rank Decomposition of a Symmetric Tensor

For a symmetric tensor, we show that its rank decomposition must be its symmetric rank decomposition when its rank is less than its order. Furthermore, for a symmetric tensor whose rank is equal to its order, we have that its symmetric rank is equal to its order. As a corollary, for a symmetric tensor, its rank is equal to its symmetric rank when its rank is not greater than its order. This partially gives a positive answer to the conjecture proposed in [Comon, Golub, Lim and Murrain, Symmetric tensors and symmetric tensor rank, SIAM Journal on Matrix Analysis and Applications, 30 (2008) pp. 1254-1279].

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MS111

Recent Advances in Branch-and-Bound Methods for MINLP

We present recent advances in the solution of mixed integer quadratically constrained quadratic programming (MIQCQP) problems. This very general class of problems comprises several practical applications in Finance and Chemical Engineering. We describe a solution technique that is currently implemented in Xpress and that allows for efficiently solving various types of MIQCQP, including problems whose quadratic constraints are Lorentz (or second-order) cones.

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MS111

Computing Strong Bounds for Convex Optimization with Indicator Variables

We propose an iterative procedure for computing strong relaxations of convex quadratic programming with indicator variables. An SDP relaxation that is equivalent to the optimal perspective relaxation is approximately solved by a sequence of quadratic subprograms and "simple" SDPs. Each subproblem is solved by tailored first order methods. Our algorithm readily extends to general strongly convex case. Numerical experiments and comparisons are reported.

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MS111

A Hybrid Lp/nlp Paradigm for Global Optimization

After their introduction in global optimization by Tawarmalani and Sahinidis over a decade ago, polyhedral relaxations have been incorporated in a variety of solvers for the global optimization of nonconvex NLPs and MINLPs. In this talk, we introduce a new relaxation paradigm for global optimization. The proposed framework combines polyhedral and convex nonlinear relaxations, along with fail-safe techniques, convexity identification at each node of the search tree, and learning heuristics for automatic sub-problem algorithm selection. We report computational experiments on widely-used test problem collections, including 369 problems from GlobalLib, 250 problems from MINLPLib and 980 problems from PrincetonLib. Results show that incorporating the proposed techniques in the BARON software leads to significant improvements in execution time, and increases the number of problems that are solvable to global optimality by 30%.

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MS111

Decomposition Techniques in Global Optimization

In this paper, we develop new decomposition techniques for convexification of constraints. First, we provide conditions under which convex hull of an equality constraint is obtained by convexifying inequality constraints. Second, we discuss situations where the convex hull can be written as a disjunctive hull of orthogonal sets. Third, we show that positively-homogenous functions can often be replaced with a new variable. Finally, we apply these techniques to develop closed-form expressions and optimization formulations.

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MS112

Robust Formulation for Online Decision Making on Graphs

We consider the problem of routing in a stochastic network with a probabilistic objective function when knowledge on arc cost distributions is restricted to low-order statistics. A stochastic dynamic programming equation with an inner Moment Problem is developed to simultaneously capture the randomness of arc costs and cope with limited information on their distributions. We design algorithms with an emphasis on tractability and run numerical experiments to illustrate the benefits of a robust strategy.

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MS112

Stochastic Route Planning in Public Transport

There are plenty of public transport planners that help passangers to find a route satisfying their needs, most of them assuming a deterministic environment. However, vehicles in public transport are typically behind or before time, hence making the availability of a given journey in real life questionable. We present an algorithm that overcomes this uncertainty by using a stochastic model for departure and travel times. The output of the algorithm is not a single route but a policy for each node that defines which services to take at a given time.

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MS112

Speed-Up Algorithms for the Stochastic on-Time Arrival Problem

We consider the stochastic on-time arrival (SOTA) problem of finding a routing strategy that maximizes the probability of reaching a destination within a pre-specified time budget in a road network with probabilistic link travel-times. In this work, we provide a theoretical understanding of the SOTA problem and present efficient computational techniques that can enable practical stochastic routing applications. Experimental speedups achieved by these techniques are demonstrated via numerical results on real and synthetic networks.

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MS112

Risk-averse Routing

We consider a routing problem in a transportation network, where historical delay information is available for various road segments. We model future delays as random variables whose distribution can be estimated. Given a source, a destination, and a functional, we optimize the functional of the delay distributions along routes. This allows us to minimize risk measures of the total delay and the probability of missing a deadline, instead of the expected total delay.

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MS113

A Quasi-Newton Proximal Splitting Method

Projected and proximal quasi-Newton methods occasionally resurface in the literature as an elegant and natural method to handle constraints and non-smooth terms, but these methods rarely become popular because the projection step needs to be solved by an iterative non-linear solver. We show that with the correct choice of quasi-Newton scheme and for special classes of problems (notably, those with non-negativity constraints, l1 penalties or hinge-loss penalties), the projection/proximal step can be performed almost for free. This leads to a method that has very few parameters and is robust, and is consistently faster than most state-of-the-art alternatives. The second part of the talk discusses extending this approach to solve general non-linear programs. Joint work with Jalal Fadili.

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MS113

Composite Self-Concordant Minimization

We propose a variable metric framework for minimizing the sum of a self-concordant function and a possibly non-smooth convex function endowed with a computable proximal operator. We theoretically establish the convergence of our framework without relying on the usual Lipschitz gradient assumption on the smooth part. An important highlight of our work is a new set of analytic step-size selection and correction procedures based on the structure of the problem. We describe concrete algorithmic instances of our framework for several interesting large-scale applications and demonstrate them numerically on both synthetic and real data.

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MS113

Mixed Optimization: On the Interplay between Deterministic and Stochastic Optimization

Many machine learning algorithms follow the framework of empirical risk minimization which involve optimizing an objective which is in most cases a convex function or replaced by a convex surrogate. This formulation makes an intimate connection between learning and convex optimization. In optimization for empirical risk minimization method, there exist three regimes in which popular algorithms tend to operate: *deterministic* (full gradient oracle) in which whole training data are used to compute the gradient at each iteration, *stochastic* (stochastic oracle) which samples a small data set per iteration to perform descent towards the optimum, and more recently *hybrid* regime which is a combination of stochastic and deterministic regimes. We introduced a new setup for optimization termed as **mixed optimization**, which allows to access both a stochastic oracle and a full gradient oracle. The proposed setup is an *alternation* between stochastic and deterministic steps while trying to minimize the number of calls to the full gradient oracle. In minimizing smooth functions, we propose the MixedGrad algorithm which has an $O(\ln T)$ calls to the full gradient oracle and an $O(T)$ calls to the stochastic oracle, and is able to achieve an optimization error of $O(1/T)$ which is significantly improves on the known $O(1/\sqrt{T})$ rate. This result shows an intricate interplay between stochastic and deterministic convex optimization.

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MS113

Incremental and Stochastic Majorization-Minimization Algorithms for Large-Scale Optimization

Majorization-minimization algorithms consist of iteratively minimizing a majorizing surrogate of an objective function. Because of its simplicity and its wide applicability, this principle has been very popular in statistics and in signal processing. In this paper, we intend to make this principle scalable. We introduce incremental and stochastic majorization-minimization schemes that are able to deal with large-scale data sets. We compute convergence rates of our methods for convex and strongly-convex problems, and show convergence to stationary points for non-convex ones. We develop several efficient algorithms based on our framework. First, we propose new incremental and stochastic proximal gradient methods, which experimentally matches state-of-the-art solvers for large-scale l1 and l2 logistic regression. Second, we develop an online DC programming algorithm for non-convex sparse estimation. Finally, we demonstrate the effectiveness of our approach for solving large-scale non-convex structured matrix factorization problems.

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MS114

Applications of Coordinate Descent in Combinatorial Prediction Markets

The motivating application of my talk is the problem of pricing of interrelated securities in a prediction market. The key step is the Bregman projection on a convex set, which lends itself naturally to a solution by the coordinate descent. I will discuss the application domain and highlight some of the specifics, which require modifications of existing coordinate descent algorithms.

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MS114

Efficient Accelerated Coordinate Descent Methods and Faster Algorithms for Solving Linear Systems

In this paper we show how to accelerate randomized coordinate descent methods and achieve faster convergence rates without paying per-iteration costs in asymptotic running time. To highlight the computational power of this algorithm, - We show how this method achieves a faster asymptotic runtime than conjugate gradient. - We give an $\tilde{O}\left(m\log^{3/2}(n)\log(\varepsilon^{-1})\right)$ time algorithm for solving Symmetric Diagonally Dominant (SDD) system. - We improve the best known asymptotic convergence guarantees for Kaczmarz methods.

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MS114

A Comparison of PCDM and DQAM for Big Data Problems

In this talk we study and compare two algorithms for big data problems: the Diagonal Quadratic Approximation method (DQAM) of Mulvey and Ruszczyński and the Parallel Coordinate Descent method (PCDM) of Richtárik and Takáč. These algorithms are applied to optimization problems with a convex composite objective. We demonstrate that PCDM has better theoretical guarantees (iteration complexity results) than DQAM, and performs better in practice than DQAM.

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MS114

Direct Search Based on Probabilistic Descent

Direct-search methods are a class of derivative-free algorithms based on evaluating the objective function along directions in positive spanning sets. We study a more general framework where the directions are only required to be probabilistic descent, meaning that with a significantly positive probability at least one of them is descent. This framework enjoys almost-sure global convergence and a global rate of 1/sqrt(k) (like in gradient methods) with overwhelmingly high probability.

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MS115

Gradient Projection Type Methods for Multi-material Structural Topology Optimization using a Phase Field Ansatz

A phase field approach for structural topology optimization with multiple materials is numerically considered. First the problem formulation is introduced and the choice of the involved potential is discussed. This reasons our choice of the obstacle potential and leads to an optimization problem with mass constraints and inequality constraints. Moreover we motivate the choice of the interpolation of the elasticity tensor on the interface. Then, an H^1-gradient projection type method in function spaces is deduced, where we can prove global convergence. The gradient is not required but only far less expensive directional derivatives. In addition it turns out that the scaling of the H1-gradient with respect to the interface thickness is important to obtain a drastic speed up of the method. With computational experiments we demonstrate the independence of the mesh size and of the interface thickness in the number of iterations as well as its efficency in time.

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MS115

Efficient Techniques for Optimal Active Flow Control

For efficient optimal active control of unsteady flows, the use of adjoint approaches is a first essential ingredient. We compare continuous and discrete adjoint approaches in terms of accuracy, efficiency and robustness. For the generation of discrete adjoint solvers, we discuss the use of Automatic Differentiation (AD) and its combination with checkpointing techniques. Furthermore, we discuss so-called one-shot methods. Here, one achieves simultaneously convergence of the primal state equation, the adjoint state equation as well as the design equation. The direction and size of the one-shot optimization steps are determined by a carefully selected design space preconditioner. The one-shot method has proven to be very efficient in optimization with steady partial differential equations (PDEs). Applications of the one-shot method in the field of aerodynamic shape optimization with steady Navier-Stokes equations have shown, that the computational cost for an optimization, measured in runtime as well as iteration counts, is only 2 to 8 times the cost of a single simulation of the governing PDE. We present a framework for applying the one-shot approach also to optimal control problems with unsteady Navier-Stokes equations. Straight forward applications of the one-shot method to unsteady problems have shown, that its efficiency depends on the resolution of the physical time domain. In order to dissolve this dependency, we consider unsteady model problems and investigate an adaptive time scaling approach.

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MS115

Improved Monte-Carlo Methods for Optimization Problem

The class of problems dealt with here is a (time dependent) parameter identification calibration problem with SDE constraints. As known, Monte-Carlo method is used to solve such problems. Nevertheless this method is very costly and may be inefficient for large-scale problems. Therefore some improved Monte-Carlo Techniques are presented to significantly enhance the computational efficiency of an optimization algorithm. Also an adjoint approach for the Monte-Carlo method is also presented. Since this approach is even successful for more sophisticated discretization schemes, like Milstein scheme and stochastic predictor-corrector schemes, we present an extended version with this schemes of higher order of convergence. Finally numerical results are presented and discussed.

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MS115

Time-dependent Shape Derivative in Moving Domains Morphing Wings Adjoint Gradient-based Aerodynamic Optimisation

In the field of aerodynamics the focus is partly put on reducing drag and making the airplanes greener and economically efficient. Nowadays the developments reached a point where highly-detailed shape control is needed to obtain further improvements. In this talk, we explain a methodology that can be used to design an airplane with morphing wings. Such aircraft has the capability to adapt and optimize its shape in real time in order to achieve multi-objective mission roles efficiently and effectively. We present the general approach of this methodology which can be applied to a number of time-dependent PDE-constrained optimisation problems. Special attention is given to the derivation of the shape derivative in moving domains. For primal and adjoint flow solution we used an in-house flow solver built in FEniCS environment. We illustrate the effectiveness of this approach using numerical results.

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MS116

On the Sufficiency of Finite Support Duals in Semi-infinite Linear Programming

We consider semi-infinite linear programs with countably many constraints indexed by the natural numbers. When the constraint space is the vector space of all real valued sequences, we show that the finite support (Haar) dual is equivalent to the algebraic Lagrangian dual of the linear program. This settles a question left open by Anderson and Nash. This result implies that if there is a duality gap between the primal linear program and its finite support dual, then this duality gap cannot be closed by considering the larger space of dual variables that define the algebraic Lagrangian dual. However, if the constraint space corresponds to certain subspaces of all real-valued sequences, there may be a strictly positive duality gap with the finite support dual, but a zero duality gap with the algebraic Lagrangian dual.

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MS116

Countably Infinite Linear Programs and Their Application to Nonstationary MDPs

Well-known results in finite-dimensional linear programs do not extend in general to countably infinite linear programs (CILPs). We will discuss conditions under which a basic feasible characterization of extreme points, weak duality, complementary slackness, and strong duality hold in CILPs. We will also present simplex-type algorithms for CILPs. Nonstationary Markov decision processes and their variants will be used to illustrate our results.

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MS116

A Linear Programming Approach to Markov Decision Processes with Countably Infinite State Space

We consider Markov Decision Processes (MDPs) with countably infinite state spaces. Previous solution methods were limited to solving finite-state truncations, or estimating the reward function for a finite subset of states. Our proposed approach considers the countably-infinite linear programming (CILP) formulations of MDPs (both the number of variables and constraints are countably infinite). We extend the theoretical results for finite LPs such as duality to the resulting CILPs and suggest ideas for a simplex-like algorithm.

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MS116

Projection: A Unified Approach to Semi-Infinite Linear Programs

We extend Fourier-Motzkin elimination to semi-infinite linear programs. Applying projection leads to new characterizations of important properties for primal-dual pairs of semi-infinite programs such as zero duality gap. Our approach yields a new classification of variables that is used to determine the existence of duality gaps. Our approach has interesting applications in finite-dimensional convex optimization.

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MS117

A Convex Optimization Approach for Computing Correlated Choice Probabilities

The recently proposed Cross Moment Model (CMM) by Mishra, Natarajan and Teo (IEEE Transactions and Automatic Control, 2012) utilize a semidefinite programming approach to compute choice probabilities for the joint distribution of the random utilities that maximizes expected agent utility given only the mean, variance and covariance information. We develop an efficient first order method to compute choice probabilities in the CMM model. Numerical results demonstrate that the new approach can calculate choice probabilities of a large number of alternatives. We also discuss an application related to route choice in transportation networks.

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MS117

Modeling Dynamic Choice Behavior of Customers

Traditionally, choice-based demand models in operations used transaction data to learn aggregate user preferences. However, there is now an abundance of panel data: transaction data tagged with customer ids, which is obtained by tracking customers through credit cards, loyalty cards, etc. Given this, we consider the problem of constructing individual user preferences from their purchase paths in order to predict demand, and personalize recommendations and promotions. We do not assume access to demographic information about the customers or any attribute information about the products. In order to accomplish this, we propose a dynamic model for how customers construct preference lists over time as a function of all products that were purchased and were on offer in the past. The model accounts for several "behavioral" biases in choice that have been empirically established. Due to scarcity of data, the individual preference lists we construct are often sparse. Hence, we "cluster" the constructed preference lists in order to make demand predictions. Our methods were tested on real-world IRI dataset. We also provide statistical and computational guarantees for our methods, in the process of which we make important theoretical contributions to the study of preference theory in statistics and computer science.

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MS117

A New Compact Lp for Network Revenue Management with Customer Choice

The choice network revenue management model incorporates customer purchase behavior as a function of the offered products. We derive a new compact LP formulation for the choice network RM problem. Our LP gives an upper bound that is provably between the choice LP value and the affine relaxation, and often coming close to the latter in numerical experiments.

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MS117

On Theoretical and Empirical Aspects of Marginal Distribution Choice Models

In this paper, we study the properties of a recently proposed class of semiparametric discrete choice models (referred to as the Marginal Distribution Model), by optimizing over a family of joint error distributions with prescribed marginal distributions. Surprisingly, the choice probabilities arising from the family of Generalized Extreme Value models can be obtained from this approach, despite the difference in assumptions on the underlying probability distributions. We use this connection to develop flexible and general choice models to incorporate respondent and product/attribute level heterogeneity in both partworths and scale parameters in the choice model. Furthermore, the extremal distributions obtained from the MDM can be used to approximate the Fisher's Information Matrix to obtain reliable standard error estimates of the partworth parameters, without having to bootstrap the method. We use various simulated and empirical datasets to test the performance of this approach. We evaluate the performance against the classical Multinomial Logit, Mixed Logit, and a machine learning approach developed by Evgeniou et al. (2007) (for partworth heterogeneity). Our numerical results indicate that MDM provides a practical semiparametric alternative to choice modeling.

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MS118

On the Use of Second Order Information for the Numerical Solution of L1-Pde-Constrained Optimization Problems

We present a family of algorithms for the numerical solution of PDE-constrained optimization problems, which involve an L^1-cost of the design variable in the objective functional. It is well-known that this non-differentiable term leads to a sparse structure of the optimal control, which acts on "small" regions of the domain. In order to cope with the non-differentiability, we consider a Huber regularization of the L^1-term, which approximates the original problem by a family of parameterized differentiable problems. The main idea of our method consists in computing descent directions by incorporating second order information. An orthantwise-direction strategy is also used in the spirit of OW-algorithms in order to obtain a fast identification of the active sets. We present several experiments to illustrate the efficiency of our approach.

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MS118

Finite Element Error Estimates for Elliptic Optimal Control Problems with Varying Number of Finitely Many Inequality Constraints

We derive a priori error estimates for the finite element discretization of an elliptic optimal control problem with finitely many pointwise inequality constraints on the state. In particular, following ideas of Leykekhman, Meidner, and

Vexler, who considered a similar problem with equality constraints, we obtain an optimal rate of convergence for the state variable. In contrast to earlier works, the number of inequality constraints may vary on refined meshes.

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MS118

PDE Constrained Optimization with Pointwise Gradient-State Constraints

In this talk, we will review several recent result in PDE constrained optimization with pointwise constraints on the gradient of the state. This includes barrier and penalty methods in a function space setting to eliminate the constraint on the gradient. Convergence of such methods is discussed. Further, we will consider the discretization of such problems in particular for non smooth domains, where the control to state mapping does not assert the gradient to be Lipschitz.

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MS118

Boundary Concentrated Finite Elements for Optimal Control Problems and Application to Bang-Bang Controls

We consider the discretization of an optimal boundary control problem with distributed observation by the boundary concentrated finite element method. With an $H^{1+\delta}(\Omega)$ regular elliptic PDE on two-dimensional domains as constraint, we prove that the discretization error $\|u^* - u_h^*\|_{L_2(\Gamma)}$ decreases like $N^{-\delta}$, where N denotes the total number of unknowns. We discuss the application to problems whose optimal control displays bang-bang character.

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MS119

Funding Opportunities at NSF

This session discusses funding opportunities at the National Science Foundation.

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MS119

Funding Opportunities in the Service and Manufacturing Enterprise Systems Programs

We provide an overview of the MES and SES programs, which support research on strategic decision making, design, planning, and operation of manufacturing and service enterprises, that is both grounded in an interesting and relevant application and requires the development of novel methodologies.

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PP1

Design of a Continuous Bioreactor Via Multiobjective Optimization Coupled with Cfd Modeling

In this paper a multiobjective design optimization was applied in a continuous bioreactor. The aim of the procedure is to find the geometry most favorable to simultaneously optimize the fluid dynamics parameters that can influence the biochemical process involved in the bioreactor, such as shear stress and residence time distribution. An open source computer package,called pyCFD-O, was developed to perform the CFD and the optimizations processes in a fully automatic manner.

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PP1

Interior Point Algorithm As Applied to the Transmission Network Expansion Planning Problem

The main purpose of this poster is to study the long term transmission network expansion planning problem, which consists in finding an optimal synthesis of a power network that minimizes the capital cost of circuits construction under some technical restrictions. Regarding the robustness and efficiency when solving large scale real-world problems, we use the IP algorithm proposed by [Vanderbei & Shanno, 1999] to the IEEE-118 nodes test systems to get the optimum cost of construction.

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PP1

Meshless Approximation Minimizing Divergence-free Energy

In this work, we propose a meshless approximation of a vector field in multidimensional space minimizing quadratic forms related to the divergence of a vector field. Our approach guarantees the conservation of the divergence-free, which is of great importance in applications. For instance, divergence-free vector fields correspond to incompressible fluid flows. Our construction is based on the meshless approximation by the pseudo-polyharmonic functions which are a class of radial basis functions minimizing an appropriate energy in an adequate functional space. We provide an HelmholtzHodge decomposition of the used native functional space. Numerical examples are included to illustrate our approach.

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PP1

Robust Security-Constrained Unit Commitment with Dynamic Ratings

The actual capacity of overhead transmission lines and gas generators vary by their ambient temperatures. To provide efficient and also reliable generation and dispatch decisions, we develop a two stage robust unit commitment formulation considering both dynamic line and generation ratings, subject to the uncertainty in weather conditions. Our model is demonstrated on standard IEEE testbeds as well as real industrial data.

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PP1

Preventive Maintenance Scheduling of Multi-Component Systems with Interval Costs

We consider the preventive maintenance scheduling of a multi-component system with economic dependencies. The corresponding decision problem is modeled as an integer linear program (ILP) where maintenance of a set of components are to be scheduled over a discretized time horizon. The main contributions are a theoretical analysis of the properties of the ILP model and three case studies demonstrating the usefulness of the model.

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PP1

A Minimization Based Krylov Method for Ill-Posed Problems and Image Restoration

We are concerned with the computation of accurate approximate solutions of linear discrete ill-posed problems. These are systems of equations with a very ill-conditioned matrix and an error-contaminated right-hand side vector. Their solution requires regularization such as a Tikhonov regularization or other regularization techniques based on Krylov subspace methods such as conjugate gradient- or GMRES-type methods. It can be difficult to determine when to truncate. We will be interested in a minimization method namely the reduced rank extrapolation. The present work describes a novel approach to determine a suitable truncation index by comparing the original and extrapolated vector sequences. Applications to image restoration is presented.

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PP1

Introducing Penlab, a Matlab Code for Nonlinear (and) Semidefinite Optimization

We will introduce a new code PENLAB, an open Matlab implementation and extension of our older code PENNON. PENLAB can solve problems of nonconvex nonlinear optimization with standard (vector) variables and constraints, as well as matrix variables and constraints. We will demonstrate its functionality using several nonlinear semidefinite examples.

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PP1

Aircraft Structure Design Optimization Via a Matrix-Free Approach

When applying gradient-based optimization algorithms to structural optimization problems, it is the computation of the constraint gradients that requires the most effort because repeated calls to the finite element solver are needed. We aim to reduce this effort by using a matrix-free optimizer that estimates the gradient information based on quasi-Newton methods. We demonstrate our approach using two problems arising from aircraft design. We show that our method can result in many fewer calls to the expensive finite element solver.

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PP1

Damage Detection Using a Hybrid Optimization Algorithm

This paper presents a hybrid stochastic/deterministic optimization algorithm to solve the target optimization problem of vibration-based damage detection. It employs the representation formula of Pincus to locate the region of the optimum and the Nelder-Mead algorithm as the local optimizer. A series of numerical examples with different damage scenarios and noise levels was performed under impact and ambient vibrations. The proposed algorithm was more accurate and efficient than well-known heuristic algorithms.

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PP1

Social Welfare Comparisons with Fourth-Order Utility Derivatives

In this paper, we provide intuitive justifications of normative restrictions based on the signs of fourth-order derivatives of utilities in the context of multidimensional welfare analysis. For this, we develop a new notion of welfare shock sharing. This allows us to derive new characterizations for symmetric and asymmetric conditions on the signs of fourth-order derivatives of utility functions. Then, we use these restrictions to derive new stochastic dominance criteria for multidimensional welfare comparisons.

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PP1

The Mesh Adaptive Direct Search Algorithm for Blackbox Optimization with Linear Equalities

The Mesh Adaptive Direct Search (MADS) algorithm is designed to solve blackbox optimization problems with bounds under general inequality constraints. Currently the MADS theory does not support equality constraints other than transforming each equality into two inequalities, which does not work very well in practice. We present various extensions to solve problems with linear equality constraints. Strategies combining these extensions are presented. The convergence properties of MADS are maintained. Numerical results on a subset of CUTEr problems are reported.

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PP1

Nonlinear Model Reduction in Optimization with Implicit Constraints

We consider nonlinear optimization problems in which the evaluation of the objective function requires the solution of time-dependent PDEs of large dimension. We design a surrogate management framework that relies on the POD and DEIM nonlinear model reduction techniques to construct surrogates for the constraints. We present results for two case studies: an optimal control problem with a simplified flow equation (Burgers' equation), and model calibration (history matching) of an oil reservoir model. This work is the result of collaborations with Manuel Baumann, Sławomir Szklarz, and Martin van Gijzen.

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PP1

An Optimization Model for Truck Tyres' Selection

To improve the truck tyre selection process at Volvo Group Trucks Technology an optimization model has been developed to determine an optimal set of tyres for each vehicle and operating environment specification. The overall purpose is to reduce the fuel consumption while preserving the levels of other tyre dependent features. The model - currently being improved with respect to accuracy - is based on vehicle dynamics equations and surrogate models of expensive simulation based functions.

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PP1

Analysis of Gmres Convergence Via Convex Optimization

In this poster, we will give new bounds for the GMRES method of Saad and Schultz, for solving linear system. The explicit formula of the residual norm of the GMRES when applied to normal matrix, which is a rational function, is given in terms of eigenvalues and of the components of the eigenvector decomposition of the initial residual. By minimizing this rational function over a convex subset, we ob-

tain the sharp bound of the residual norm of the GMRES method applied to normal matrix, even if the spectrum contains complex eigenvalues. Hence we completely characterize the worst case GMRES for normal matrices. We use techniques from constrained optimization rather than solving the classical min-max problem (problem in polynomial approximation theory)

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PP1

In-Flight Trajectory Redesign Using Sequential Convex Programming

Onboard trajectory redesign capabilities for autonomous orbiters is being explored as part of the NASA Space Technology Research Fellowship. Development has combined system discretization, heuristic search, sequential convex programming, and software architecture. The onboard system focus has motivated the use of techniques with provable convergence properties and feasible iterations in case of system interrupts or time constraints. Examples of local correction and full replanning will be shown for the case of an orbiter at Phobos.

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PP1

Riemannian Pursuit for Big Matrix Recovery

Low rank matrix recovery (MR) is a fundamental task in many real-world applications. We propose a new model for the MR problem and then relax it as a convex quadratically constrained quadratic program (QCQP) problem. To solve this problem, we propose an efficient Convex Riemannian Pursuit (CRP) method which addresses the MR problem by iteratively solving a series of fixed-rank problems. Experimental results on matrix completion tasks show that, compared with state-of-the-art methods, the proposed method can achieve superior scalability and maintain comparable or even better performance in terms of recovery error on both large-scale synthetic and real-world datasets.

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PP1

Stochastic Optimization of the Topology of a Combustion-based Power Plant for Maximum Energy Efficiency

Much research has been done to improve the efficiency of internal combustion-based power plants. These plants are not limited by the Carnot efficiency and the topology of the optimal power plant using existing technologies is unknown. This work uses genetic algorithms to determine the optimal structure and parameters of such a plant. With no presumption of device ordering, we calculate maximally efficient designs for wet cycles and integrated solid-oxide fuel cell, gas turbine systems.

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