Banff International Research Station

for Mathematical Innovation and Discovery

Workshop on Robust Optimization
May 25-27, 2012

MEALS

Coffee Breaks: As per daily schedule, in the foyer of the TransCanada Pipeline Pavilion (TCPL) *(included in workshop)*

For meal options at the Banff Centre, there are food outlets on The Banff Centre campus such as Vistas Main Dining Room on the 4th floor of Sally Borden Building (breakfast: 7:00-9:30am; lunch: 11:30am-1:30pm; dinner: 5:30-7:30pm), Le Cafe (ground floor, Sally Borden Building) and the Maclab Bistro (Kinnear Centre). You will also find a good selection of restaurants in the town of Banff which is a 10-15 minute walk from Corbett Hall.

MEETING ROOMS

All lectures will be held in the new lecture theater in the TransCanada Pipelines Pavilion (TCPL). LCD projector and blackboards are available for presentations.

SCHEDULE

Friday

16:00 Check-in begins (Front Desk – Professional Development Centre - open 24 hours)
19:30 Informal gathering in 2nd floor lounge, Corbett Hall.
Beverages and a small assortment of snacks are available in the lounge on a cash honor system.

Saturday

7:00-9:00 Breakfast
9:00-9:15 Introduction and welcoming remarks
9:15-12:00 Lectures

9:15-10:05	Dimitris Bertsimas, MIT
10:05-10:20	Coffee Break (TCPL)
10:20-11:05	Dan Iancu, Stanford
11:15-12:00	Raphael Hauser, Oxford

12:00-13:30 Lunch
13:45-16:45 Lectures

13:45-14:30	Constantine Caramanis, University of Texas Austin
14:30-15:00	Coffee Break (TCPL)
15:00-15:45	Erick Delage, HEC Montreal
16:00-16:45	Levent Tuncel, Waterloo

17:30-19:30 Dinner

Sunday

7:00-9:00 Breakfast

9:15-10:00 Lectures and discussions

9:15-10:00	Pablo Parrilo, MIT
10:00-10:30	Coffee Break (TCPL)
10:30-11:30	Informal panel discussion on "What steps are needed to reach broad use of robust optimization in practice?"

12:00-13:30 Lunch (if desired)

Checkout by 12 noon.

** 2-day workshops are welcome to use BIRS facilities (2nd Floor Lounge, TCPL, Reading Room) until 15:00 on Sunday, although participants are still required to checkout of the guest rooms by 12 noon. There is no coffee break service on Sunday afternoon, but self-serve coffee and tea are always available in the 2nd floor lounge, Corbett Hall. **

Name of 2012 2-day Workshop
Date of 2012 2-day Workshop

ABSTRACTS

(in chronological order)

1. A computationally tractable theory of performance analysis in stochastic systems
   Dimitris Bertsimas, MIT

Modern probability theory, whose foundation is based on the axioms set forth by Kolmogorov, is currently the major tool for performance analysis in stochastic systems. While it offers insights in understanding such systems, probability theory is really not a computationally tractable theory. Correspondingly, some of its major areas of application remain unsolved when the underlying systems become multidimensional: Queuing networks, network information theory, pricing multi-dimensional financial contracts, auction design in multi-item, multi-bidder auctions among others.

We propose a new approach to analyze stochastic systems based on robust optimization. The key idea is to replace the Kolmogorov axioms as primitives of probability theory, with some of the asymptotic implications of probability theory: the central limit theorem and law of large numbers and to define appropriate robust optimization problems to perform performance analysis. In this way, the performance analysis questions become highly structured optimization problems (linear, conic, mixed integer) for which there exist efficient, practical algorithms that are capable of solving truly large scale systems.

We demonstrate that the proposed approach achieves computationally tractable methods for (a) analyzing multiclass queuing networks, (b) characterizing the capacity region of network information theory and associated coding and decoding methods generalizing the work of Shannon, (c) pricing multi-dimensional financial contracts generalizing the work of Black, Scholes and Merton, (d) designing multi-item, multi-bidder auctions generalizing the work of Myerson.

This is joint work with my doctoral student at MIT Chaithanya Bandi.

2. Supermodularity and affine policies in dynamic robust optimization
   Dan Iancu, Stanford

We consider robust dynamic optimization problems, where the unknown parameters are modeled as uncertainty sets. We seek to bridge two classical paradigms for solving such problems, namely (1) Dynamic Programming (DP), and (2) policies parameterized in model uncertainties (also known as decision rules), obtained by solving tractable convex optimization 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. We also derive conditions under which such affine rules can be obtained by optimizing simple (e.g., affine) objective functions over the uncertainty sets.

Our results suggest new modeling paradigms for dynamic robust optimization, and our proofs, which bring together ideas from three areas of optimization typically studied separately (robust optimization, combinatorial optimization - the theory of lattice programming and supermodularity, and global optimization - the theory of concave envelopes), may be of independent interest.

We exemplify our findings in an application concerning the design of flexible contracts in a two-echelon supply chain, where the optimal contractual pre-commitments and the optimal ordering quantities can be found by solving a single linear program of small size.

3. Robust portfolio optimization under heavy tailed returns
   Raphael Hauser, Oxford

We consider the problem of optimizing a portfolio of trend-following quant strategies under heavy tailed distributions. Approaching this problem by modelling returns through mixture distributions, we derive robust and relative robust methodologies and discuss conic optimization approaches to solving these models.

4. Some problems in robust high dimensional statistics
   Constantine Caramanis, University of Texas Austin

Dealing with missing, noisy or corrupted data is of fundamental importance in many applications. This is all the more true in the high dimensional setting, where the dimensionality of the parameter space is potentially much greater than the number of samples available. A basic challenge lies in the fact that in this regime, outliers, or corrupted points, typically cannot be removed using outlier detection techniques. Meanwhile, even a few outliers can completely skew the results of existing algorithms.

In this talk, we revisit some basic problems in statistics, and develop practical and efficient algorithms with provable guarantees for dealing with outliers in the high dimensional regime.

5. On a class of uncertainty sets for distributionally robust optimization
   Erick Delage, HEC Montreal

Decisions often need to be made in situations where one has incomplete knowledge about some of the parameters of the problem that he is addressing. While stochastic programming (SP) can provide essential guidance in managing the risks associated to such decision problems, it is often impossible (or too expensive) to identify the stochastic model that accurately embodies all available knowledge of these parameters. Recently, there has been a renewed interest toward employing the robust optimization principles to handle the resulting distributional ambiguity. In this talk, I will present a class of distributional uncertainty sets that enables, for a wide range of distributionally robust optimization (DRO) models, a reduction to a simpler (parametric-)robust optimization model. An overview of applications of the DRO approach to portfolio selection, multi-vehicle routing, and airline fleet composition problems will provide insights on: 1) the dangers of blindly committing to a stochastic model; 2) how little might be the additional computational investment needed to account for distributional ambiguity; 3) the need for tools that can estimate the value of additional distribution information.

6. An improvised approach to robustness in linear and semidefinite optimization
   Levent Tuncel, Waterloo

I will present an approach to robust optimization which utilizes techniques based on computing weigthed centers of convex sets and introducing cuts based on interactions with the decision maker throughout the optimization process (rather than having the decision maker supply regions of uncertainty ahead of time).

This talk is based on joint work with Mehdi Karimi and Somayeh Moazeni.

7. Diagonal and low-rank matrix decompositions, correlation matrices, and ellipsoid fitting
   Pablo Parrilo, MIT

We establish links between, and new results for, three problems that are not usually considered together. The first is a matrix decomposition problem: given a matrix X formed as the sum of an unknown diagonal matrix and an unknown low rank positive semidefinite matrix, decompose X into these constituents. The second problem is the facial structure of the elliptope, i.e., the set of valid correlation matrices. The third problem is a basic geometric question: given n points in R^k (where n>k) determine whether there is a centered ellipsoid passing exactly through all of the points.

We show that in a precise sense these three problems are equivalent. Furthermore we establish a simple sufficient condition for all three problems that guarantee their solvability using a convex optimization-based heuristic.

Joint work with James Saunderson (MIT), Venkat Chandrasekaran (Berkeley/Caltech), and Alan Willsky (MIT).