

Submittee: Yuriy Zinchenko

Date Submitted: 2013-09-11 11:31

Title: CRG 2013 Summer school on Optimization

Event Type: Summer-School

Location:

University of Calgary, Calgary AB, Canada

Dates:

June 14-28, 2013

Topic:

Selected Topics in Optimization

Methodology:

Lectures, labs, and seminars. The school is equivalent to a full term graduate level course, with attending registered students eligible for an academic credit via WDA or similar agreement.

Organizers:

Yuriy Zinchenko, Math & Stat, U Calgary

Speakers:

June 14 to June 18 /// Antoine Deza, Professor and Canada Research Chair in Combinatorial Optimization /// Department of Computing & Software, McMaster University /// Combinatorial, Geometric, and Computational Aspects of Linear Optimization /// Optimization has long been a source of inspiration and applications for geometers, and similarly, discrete and convex geometry has provided foundations for many efficient optimization techniques. Combinatorics forms an intrinsic part of optimization, and there is a rich interplay between geometry and combinatorics. // This module will illustrate these connections via the in-depth presentation and study of a generalization of linear optimization called colourful linear programming and the associated colourful simplicial depth question. // In statistics, there are several measures of the depth of a point p relative to a fixed set S of sample points in dimension d . One of the most intuitive is the simplicial depth of p introduced by Liu (1990), which is the number of simplices generated by points in S that contain p . // Obtaining a lower bound for the simplicial depth is a challenging problem. Caratheodory Theorem can be restated as: The simplicial depth is at least 1 if p belongs to the convex hull of S . Barany (1982) showed that the simplicial depth is at least a fraction of all possible simplices generated from S . Gromov // (2010) improved the fraction via a topological approach. Barany's result uses a colourful version of Caratheodory Theorem leading to the associated colourful simplicial depth question. // The module presents recent generalizations of the Colourful Caratheodory Theorem due to Arocha et al. and Holmsen et al. and a strengthening of these. Using a combinatorial generalization, a new lower bound for the colourful simplicial depth is explained, improving the earlier bounds of Barany and Matousek and of Stephen and Thomas. Computational

approaches for small dimensions and the colourful linear programming feasibility problem introduced by Barany and Onn are discussed. // Post-module evaluation: the students will be given a set of problems from which they can choose 1 and will be marked based on a written report they have to submit within 4 weeks. The problems will cover combinatorial, geometric, and computational challenges of colourful linear programming and colourful simplicial depth so students can pick the approach they are more comfortable with. Team work is encouraged. /// June 19 to June 23 /// UBCO group led by Heinz Bauschke, Professor and Canada Research Chair in Convex Analysis and Optimization /// Department of Mathematics and Statistics, UBC Okanagan /// This course block is dedicated to general area of convex analysis and specifically deals with four separate aspects of modern optimization: monotone operators, variational analysis, derivative-free optimization, and computer-aided convex analysis. /// Dr. Heinz Bauschke: An Invitation to Monotone Operator Theory /// Monotonicity (for set-valued operators) is an elegant and powerful mathematical notion capturing both gradients of convex functions and matrices with a positive semidefinite symmetric part. Monotone operators are ubiquitous in the analysis and understanding of modern convex optimization problems. In these lectures, I aim to highlight (1) definitions and basic results for monotone operators, connections to convex analysis and duality theory; (2) applications of monotone operator theory to the Chebyshev and the Klee problem from analysis; (3) splitting methods for finding zeros of the sum. References: H.H. Bauschke and P.L. Combettes, Convex Analysis and Monotone Operator Theory in Hilbert Spaces, Springer, 1st edition, 2011. R.T. Rockafellar and R.J-B Wets, Variational Analysis, Springer, corrected 3rd printing, 2009. (Evaluation is written by homework, no group work). /// Dr. Shawn Wang: Variational Analysis for Beginners /// In differential calculus, Fermat's theorem states that if a differentiable function has a local minimum or a local maximum at a point, then the function derivative at that point is zero. /// In many practical optimization problems, the objective functions are not differentiable. What should we do if the function is not differentiable? Modern variational analysis provides basic constructs and techniques which are well-suited to this purpose. Three lectures as follows will be delivered. // (1) Subdifferentials and subderivatives for convex and nonconvex functions. // (2) Proximal averages of functions and resolvent averages of matrices. // (3) Chebyshev and Klee functions. // A standard reference is: R.T. Rockafellar and R.J-B Wets, Variational Analysis, Springer, corrected 3rd printing, 2009. Evaluation is written, no group work. /// Dr. Warren Hare: Introduction to Derivative Free Optimization /// Optimization, the study of minimizing or maximizing a function, arises naturally in almost every scientific research field. Applications can be found in everything from business (e.g., minimizing cost and maximizing profit), to government (e.g., minimizing hospital wait times), to engineering (e.g., maximizing structural integrity). In many modern applications, evaluating of the objective function of a problem is acquired through the output of complicated simulation software. In such situations, analytic structure to the objective function is unavailable, so gradients cannot be computed and one must resort to methods that rely on nothing more than function evaluations. The study and design of such methods is growing field of "Derivative Free Optimization" (DFO). In this lecture series we will explore some of the past, present, and future of DFO. We shall discuss the famous "Nelder-Mead" method, and explore its theory, strengths, and weaknesses. We shall examine modern "Simplex Gradient" algorithms and their convergence theory. Final, we shall see how the modern tools of nonsmooth analysis are currently being employed to generate new powerful methods in DFO. Evaluation is written by homework, no group work. /// Dr. Yves Lucet: Computer-Aided Convex Analysis /// Convexity is what makes an optimization problem easy or hard: nonconvex problems are difficult to solve and one has usually to settle for a local minimum while convex optimization problems, even if there are nonsmooth, can be solved with polynomial time algorithms. Convex analysis has built numerous tools to build such efficient algorithms. Using the Computational Convex Analysis numerical library, we will compute convex operators and build an intuition on the insight they give. The lab will introduce the main operators found in convex analysis and will draw from the other 3 lectures to visualize operators in 2 and 3D. Then the lab will introduce advanced operators and several applications (computer vision, robot navigation, etc.) The focus will be on conjectures and open problems in computational convex analysis even for functions of one variable. No programming experience is required since the library contains numerous high

level operators. // Evaluation: 5 questions to be answered individually with the help of a computer. First 2 hours will be tutorial like, the last 2 hours will be more free-form and will provide time to answer the questions. /// June 24 to June 28 /// Miguel F. Anjos, Canada Research Chair in Discrete Nonlinear Optimization in Engineering Mathematics & Industrial Engineering, Ecole Polytechnique de Montreal /// Conic Relaxations for Discrete Optimization /// Conic optimization involves optimizing a linear function over the intersection of an affine space and a closed convex cone. One special case of great interest is the cone of positive semidefinite matrices, for which the resulting problem is called a semidefinite optimization problem. Semidefinite and conic relaxations are known to be highly effective for approximating many hard discrete optimization problems. This course will give an introduction to conic relaxations for discrete optimization. // Assessment: students will be assessed by a combination of (i) individual short quizzes, and (ii) a small group project. A suitable textbook, research papers and reading material will be chosen by the respective mentors.

Links:

Comments / Miscellaneous:

Number of attendees exceeded the number of registered participants (some chose not to register and simply attended the event). In the demographics section only registered participants are listed.

File Uploads:

Additional Upload 1: http://www.pims.math.ca/files/final_report/SummerSchool_Outline.pdf
