Conference Report
Atlantic Optimization Days 2006

David Bremner

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October 5th and 6th 2006, the first of what will hopefully be series of Atlantic meetings on optimization was held in Fredericton. The organizers were myself and Hugh Thomas (UNBF Mathematics and Statistics). The primary funding committments for the meeting came from AARMS. The organizers are also grateful for the support of the Canadian Operations Research Society, the IVS/NVision Lecture endowment, the MITACS Student Advisory Committee, and the UNB office of Vice-President Research and Faculty of Computer Science. Thanks to the generous support by these organizations, we were able to offer travel funding for students, postdocs, and speakers, and we did not have to charge a registration fee. The lack of registration fee made it possible for local students and professors to drop in to the meeting as their schedule permitted.

The meeting featured lectures on a variety of topics within discrete and continuous optimization. There were two one hour lectures, one by Jon Borwein (Dalhousie) on *Maximum Entropy-type Methods and (Non-)Convex Programming* and one by Tamas Terlaky (McMaster) on *Klee-Minty Cubes and the Central Path*. A second lecture by Terlaky on *Linear Optimization — Twenty years of Interior Point Methods — What is next?* was given in the evening under the aegis of the IVS/NVision endowed lecture in Computer Science. Four sessions of shorter talks by researchers from the region and around the world; titles and abstracts are given in the appendix. The breadth and overall quality of the talks was very good, especially for a regional meeting.

It is a common complaint among researchers in the Atlantic Region that geography isolates us and our students from our national and international peers. It is my hope that events such as Atlantic Optimization Days can both stimulate regional collaboration and provide some of the opportunities for exposure to the wider research world that are provided by the other mathematics instututes for students and researchers in larger centers to the west of us. Along these lines, hopefully the next event will include some participants from Memorial; unfortunately the people we invited had scheduling conflicts for this one.

A Abstracts

S1: Combinatorial optimization

S1.1 Online Network Synthesis

Donglei Du
Faculty of Business Administration
UNB Fredericton

We consider an on-line network synthesis problem. Let $N = \{1, \ldots, n\}$ be a set of n sites. Traffic flow requirements between pairs of sites are revealed/updated one by one. Whenever a new request between some pair (i, j) of distinct sites is revealed, an on-line algorithm must install the additional necessary network edge-capacities without decreasing the existing capacities such that all the flow requirements are met, one at a time. The objective is to minimize the sum of edge-capacities installed by the algorithm. The performance of an on-line algorithm is measured by the competitive ratio, defined to be the worst-case ratio between the total capacity by the on-line algorithm and the total optimal (off-line) capacity assuming we have prior information on all the requirements initially. We present a best possible algorithm, one that achieves the optimal competitive ratio, for this problem along with a matching lower bound.

S1.2 Exploiting equalities in polynomial programming

Luis Zuluaga
Faculty of Business Administration
UNB Fredericton

We propose a novel solution approach for polynomial programming problems with equality constraints. By means of a generic transformation, we show that solution schemes for the (typically simpler) problem without equalities can be used to address the problem with equalities. In particular, we propose new solution schemes for mixed binary programs, pure 0-1 quadratic programs, and the stable set problem.

S1.3 Improved bounds for the symmetric rendezvous value on the line

Qiaoming Han
Faculty of Business Administration
UNB Fredericton

A notorious open problem in the field of rendezvous search is to decide the rendezvous value of the symmetric rendezvous search problem on the line, when the initial distance apart between the two players is 2. We show that the symmetric rendezvous value is within the interval $(4.1820, 4.2574)$, which considerably improves the previous best known

result $(3.9546, 4.3931)$. To achieve the improved bounds, we call upon results from absorbing markov chain theory and mathematical programming theory—particularly fractional quadratic programming and semidefinite programming. Moreover, we also establish some important properties of this problem, which may be of independent interest and useful for resolving this problem completely. Finally, we conjecture that the symmetric rendezvous value is asymptotically equal to 4.25 based on our numerical calculations.

I1: Invited Talk

Maximum Entropy-type Methods and (Non-)Convex Programming

Jonathan M. Borwein
Canada Research Chair,
Faculty of Computer Science
Dalhousie University

I shall discuss in "tutorial mode" the formalization of inverse problems such as occur in *signal recovery* and *option pricing* as (convex and non-convex) optimization problems over an infinite dimensional space of signals. I shall touch on the following topics:

1. The impact of the choice of "entropy" (e.g., Boltzmann-Shannon, Burg entropy, Fisher information) on the *well-posedness* of the problem and the form of the solution.
2. Convex programming duality: what it is and what it buys you.
3. Consequences for algorithm design.
4. Non-convex extensions: life is often hard but not always.

Reference.

J.M. Borwein and A.S. Lewis, *Convex Analysis and Nonlinear Optimization. Theory and Examples*, Canadian Mathematical Society Books in Math, Volume 3, Springer-Verlag, New York, 2000. Revised edition 2005.
Related papers are available at the D-DRIVE document server
`http://locutus.cs.dal.ca:8088/`

S2: Operations Research and Applications

S2.1 Dealing with adjacency in forest management using integer programming and the new stand-centred constraints.

Eldon Gunn
Department of Industrial Engineering
Dalhousie University

Forest managers have struggled with the issue of planning the spatial impact of their forest prescriptions. Harvesting adjacent stands either in the same period or within a defined green-up period can produce unacceptable openings in the forest. In the past few years we have been working with a new IP formulation that has extended fairly dramatically the scale of problems that can be effectively dealt with using integer programming. In this talk we describe the problem, the new formulation, strengthening and lifting methods that improve this formulation and give some computational results.

S2.2 Multi Objective Design for Block Layouts

Uday Venkatadri
Department of Industrial Engineering
Dalhousie University

The block layout problem (BLP) deals with finding an optimal arrangement of departments in a facility. The problem is difficult to solve to optimality when the number of departments exceeds 12. As a result, the block layout problem is often solved using meta-heuristics. A promising recent development in meta-heuristic representation is the sequence pair.

Flow-distance is the most commonly used measure for the block layout problem since it is a surrogate for the cost of loaded material transfer. Other measures such as work-in-process and the cost of equipment are also important in layout design.

In this talk, we present a meta-heuristic based approach which utilizes the sequence pair representation to generate layouts based on three objectives: flow-distance, average work-in-process, and minimum number of required discrete material handling devices. We have conducted numerical experiments on a number of standard problems to study the tradeoffs between different objectives. These results will be discussed.

E: IVS/NVision Lecture

Linear Optimization — Twenty years of Interior Point Methods — What is next?

Tamás Terlaky
Canada Research Chair in Optimization
Department of Computing and Software
Director, School of Computational Engineering and Science.
McMaster University

In spite of their efficiency in practice, Simplex Methods are known to suffer from degeneracy of the linear optimization problems, and they have exponential worst case complexity proved by the Klee-Minty examples.

The two decades of research in Interior Point Methods (IPMs) triggered a tremendous theoretical and computational performance improvement in solving linear and also nonlinear optimization problems. In this talk we reflect those achievements.

It is known that Interior Point Methods are not affected by degeneracy and they enjoy polynomial worst case complexity, depending on the number of inequalities and a condition number of the problem. In the light of the Klee-Minty example we illustrate the theoretical limitations of IPMS too.

The question "What next?" naturally arises. The understanding of the strength and limitations of simplex and interior point methods may lead to new classes of algorithms.

S3: Continuous optimization and non-linear analysis

S3.1 Global Optimization with Maple

Janos D Pinter

PCS and Dalhousie University
Halifax, NS, Canada

This talk and software demonstration is based on a recent electronic book that presents Maple as an advanced model development and optimization environment. A special emphasis is placed on solving multiextremal models using the Global Optimization Toolbox for Maple. Following a brief topical introduction, an extensive collection of detailed numerical examples and illustrative case studies is reviewed.

The following topics are covered by the e-book:

- A brief introduction to Operations Research / Management Science (ORMS)
- Maple as an integrated platform for developing ORMS studies and applications
- A review of the key global optimization concepts

- The Global Optimization Toolbox (GOT) for Maple, including a concise discussion of the core LGO solver technology
- Model development tips
- Detailed "hands-on" numerical examples of using the GOT, from a simple illustration of the key tools and options to more advanced challenges
- Illustrative case studies from the sciences and engineering.

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S3.2 Updating search directions in direct search methods

Mason Macklem
Faculty of Computer Science
Dalhousie University

Classical line-search optimization algorithms typically involve three stages: at the current iterate, evaluate higher-order information, use this information to locate a descent direction, and determine an amount to move in that direction. Another approach, which does not require the use of higher-order information, is to use only objective function values on a grid of points around each iterate, and to expand or contract the grid based on the success or failure in improving the best objective function value found. This approach has most famously been formulated in the GPS algorithms of Torczon, which proved convergence results for a general class of direct search algorithms, designed to contain a variety of classical algorithm including Hooke-Jeeves and the standard coordinate search algorithm; however, this formulation left open the approach for selecting the grid directions, and restricted the ability to update the grid directions as the algorithm learns the local behaviour of the objective function. This talk will discuss generally some approaches to updating the grid directions in a class of direct-search methods.

S3.3 Duality and Exact Penalization via a Generalized Augmented Lagrangian Function

Xiaoqi Yang
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Hong Kong Polytechnic University

In this talk, we will discuss the existence of an optimal path and its convergence to the optimal set of a primal problem of minimizing an extended real-valued function via a generalized augmented Lagrangian and corresponding generalized augmented Lagrangian problems, in which no convexity is imposed on the augmenting function. We will show that these results further imply a zero duality gap property between the primal problem and the generalized augmented Lagrangian dual problem. A necessary and sufficient condition for the exact penalty representation in the framework of a generalized augmented Lagrangian is obtained. In the context of constrained programs, we will show that generalized augmented Lagrangians present a unified approach to several classes of exact penalization results.

I2: Invited Talk

Klee-Minty Cubes and the Central Path

Tamás Terlaky
Canada Research Chair in Optimization
Department of Computing and Software
Director, School of Computational Engineering and Science.
McMaster University

We consider a family of linear optimization problems over the n-dimensional Klee-Minty cube and show that the central path may visit all of its vertices in the same order as simplex methods do. This is achieved by carefully adding an exponential number of redundant constraints that forces the central path to take at least 2^{n-1} sharp turns. This fact suggests that any feasible path-following IPM will take at least 2^n iterations to solve this problem. This construction exhibits the worst-case iteration-complexity of IPMs. In addition, we discuss some implications for the curvature of the central path.

Joint work with Antoine Deza, Eissa Nematollahi, Yuriy Zinchenko

S4: Geometric Aspects

S4.1 Polytopes and arrangements: diameter and curvature

Antoine Deza
CRC in Combinatorial Optimization
McMaster University

By analogy with the conjecture of Hirsch, we conjecture that the order of the largest total curvature of the central path associated to a polytope is the number of inequalities defining the polytope. By analogy with a result of Dedieu, Malajovich and Shub, we conjecture that the average diameter of a bounded cell of an arrangement is less than the dimension. We substantiate these conjectures in low dimensions, highlight additional links, and prove a continuous analogue of the d-step conjecture

Joint work with Tamás Terlaky and Yuriy Zinchenko.

S4.2 Optimization of coverings

Achill Schürmann
Institute of Algebra and Geometry
Technical University of Magdeburg

We describe optimization tools which we recently used to obtain new best known sphere coverings of $\mathbf{R}^d$, for several dimensions $d \geq 6$. Used techniques include determinant maximization (MAXDET) and semidefinite programming (SDP). In order to obtain mathematically rigorous proofs, we provide certificates using integers only. The used C/C++ routines can be obtained from our webpage

`http://fma2.math.uni-magdeburg.de/~latgeo/RMD-1.0/HTML/rmd.html`