High Performance Optimization: Theory, Algorithm Design and Engineering Applications

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Research Samples and Project Highlights

Optimization of the Utilization of Ontario's Power Grid

> A. Hajimiragha, M. Fowler, and C. A. Canizares, Hydrogen Economy Transition in Ontario-Canada Considering the Electricity Grid Constraints, International Journal of Hydrogen Energy, accepted April 2009, 23-page manuscript.

This paper uses a mixed-integer linear optimization model to analyze in detail the optimal utilization of Ontario's power grid during off-peak hours for hydrogen production for transportation applications. This work earned the Ph.D. student Amirhossein Hajimiragha the **2009 MITACS Best Novel Use of Mathematics in Technology Transfer Award**.

Optimal Procurement of Reactive Power in Competitive Electricity Markets

> I. El-Samahy, K. Bhattacharya, C. A. Canizares, M.F. Anjos, and J. Pan, A Procurement Market Model for Reactive Power Services Considering System Security, IEEE Transactions on Power Systems, Vol. 23, No. 1, February 2008, pp. 137-149.

This paper proposes a novel reactive power market structure and a mixed-integer nonlinear optimization model for the optimal procurement of reactive power in competitive electricity markets. The paper was invited for presentation at the panel "Reactive Power Management and Payment Mechanisms in Competitive Electricity Markets" held during the IEEE-PES General Meeting 2008. This work earned the Ph.D. student Ismael El-Samahy the **2008 MITACS Best Novel Use of Mathematics in Technology Transfer Award**.

Guelph-McMaster Collaboration at the Interplay of Theory and Application

> N. Krislock and H. Wolkowicz, Explicit Sensor Network Localization using Semidefinite Representations and Clique Reductions, CORR 2009-04, submitted to SIAM Journal of Optimization, May 2009.

This paper proposes a facial reduction algorithm that exploits the degeneracy inherent in sensor network localization problems to reduce very large problems to much smaller semidefinite optimization problems. In particular, problems with up to $100,000$ sensors are solved in minutes on an ordinary laptop.

Major Contribution to the Theory of Interior-Point Methods

A. Deza, E. Nematollahi and T. Terlaky, How good are interior point methods? Klee-Minty cubes tighten iteration-complexity bounds, Mathematical Programming 113 (2008) 1-14.

This result highlights that, although the central path for an interior-point method is a smooth analytical curve in the interior of the set of feasible solutions, it might be severely distorted by redundant constraints without changing the feasible set. The construction gives a nearly worst-case example for path-following interior point methods and provides a counterexample for the conjectured maximal curvature.

Hybrid Interior-Point Cutting-Plane Method for Semidefinite Optimization

A. Engau, M.F. Anjos, and A. Vannelli. A Hybrid Interior-Point Cutting-Plane Method for Semidefinite Programming Relaxations in Discrete Optimization, Submitted to *Mathematical Programming*, May 2009.

This paper introduced a hybrid interior-point cutting-plane method for semidefinite optimization that uses feasibility indicators to dynamically add and remove valid constraints that improve the bounds provided by the relaxation. Computational results indicate that this hybrid method finds optimal solutions in **less time than solving the final relaxation with all relevant constraints known in advance**.
This is an exemplary documentation of our successful collaboration between the Universities of Waterloo (Alexander Engau and Miguel F. Anjos) and Guelph (Anthony Vannelli).