The DIMACS/Simons Collaboration on Bridging Continuous and Discrete Optimization

[December, 2017] DIMACS is pleased to announce an upcoming Special Focus on Bridging Continuous and Discrete Optimization as part of a broader partnership with the Simons Institute for the Theory of Computing. The new DIMACS/Simons Collaboration on Bridging Continuous and Discrete Optimization features activities at both DIMACS and the Simons Institute that are devoted to advancing capabilities in optimization by promoting collaborations and methods that bridge continuous and discrete optimization. The planned activities will bring together computer scientists, mathematicians, operations researchers, engineers, statisticians, and algorithm developers to advance both the foundations and applications of optimization.

Optimization capabilities touch our everyday lives through more efficient supply chains, better traffic management, more secure power grids, and a host of other important applications. In the short history of the field of mathematical optimization, advances in underlying theory, practical implementation, and raw computing power have brought us from solving linear programs with a few hundred variables to those with more than a million. Widely available general-purpose solvers make sophisticated tools for linear, integer, and nonlinear programming broadly accessible to practitioners. New applications, particularly those stemming from machine learning and data science, are now challenging the field with issues related to uncertainty, scale, speed, and complexity. The field is responding with innovative approaches leading to advances such as faster algorithms for maximum flow and near-real-time approximations, more efficient interior-point methods, and faster cutting-plane methods. Many of these innovations bring together ideas from both continuous and discrete optimization.

Historically, continuous and discrete optimization have followed largely distinct trajectories and drawn inspiration from different branches of mathematics. The study of discrete optimization is most closely associated with discrete mathematics and theoretical computer science, while continuous optimization is rooted in the well-developed mathematical theory of convex analysis and geometry. Despite their different perspectives, the interplay between discrete and continuous optimization has been and continues to be mutually beneficial. In the last decade, partly stimulated by the growth of machine learning and by the proliferation of massive datasets, new areas of research have emerged at the interface of continuous and discrete optimization and the flow between them is increasing. This expanded interface has already led to a number of breakthroughs in both areas, and the increasing pace of activity suggests that the time is right to accelerate progress by stimulating collaboration across the many communities of optimization. This is the goal of the DIMACS/Simons Collaboration, which kicked off with an intensive Program on Bridging Continuous and Discrete Optimization now underway at the Simons Institute that will continue through the end of the fall semester. Beginning with a Boot Camp to introduce key themes, the Simons program brings together roughly 120 faculty, postdocs, students, and researchers from industry as long-term participants in the Simons program. The

Simons program also includes four workshops on: 1) Discrete Optimization via Continuous Relaxation; 2) Fast Iterative Methods in Optimization; 3) Hierarchies, Extended Formulations and Matrix-Analytic Techniques; and 4) Optimization, Statistics and Uncertainty.

In January 2018, the Collaboration continues with the launch of the DIMACS Special Focus on Bridging Continuous and Discrete Optimization, which is scheduled to run through 2020. The DIMACS Special Focus builds on the Simons program to involve a broader range of people and institutions. It aims to advance the foundations and practical applications of optimization via research visits, collaboration with additional activities and institutes, and seven additional workshops on the topics of:

- ADMM and Proximal Splitting Methods in Optimization
- Optimization and Machine Learning
- Randomized Numerical Linear Algebra, Statistics, and Optimization
- Continuous Approaches to Computing Discrete Partition Functions
- Polynomial Optimization
- Optimization in Distance Geometry
- Mixed-Integer Nonlinear Optimization

Both DIMACS and the Simons Institute coordinate many of their activities around designated scientific themes. Themed programs at the Simons Institute typically span a single semester, while DIMACS special foci typically span several years. The Collaboration on Bridging Continuous and Discrete Optimization aims to leverage these different timescales. The intense focus and energy of the Simons program will launch the collaboration and build momentum around the theme, while the longer time afforded by the DIMACS special focus will allow ideas to broaden and develop more fully.

The Collaboration on Bridging Continuous and Discrete Optimization is modeled on the existing DIMACS/Simons Collaboration in Cryptography that began in 2015 and was the first such partnership between the two centers. In addition to DIMACS and the Simons Institute, the Collaboration is coordinating workshops with the TRIPODS Institute for Optimization and Learning at Lehigh University and with a month-long program on Mixed Integer Nonlinear Programming sponsored by the Centre de Recherches Mathématiques (CRM). Other workshops will coordinate with and relate to future programs at the Simons Institute on Foundations of Data Science and Geometry of Polynomials.

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Related Link:
Special Focus on Bridging Continuous and Discrete Optimization:
http://dimacs.rutgers.edu/SpecialYears/2018_Optimization/