C&O 671/471 Semidefinite Optimization
Spring 2022

Instructor: Levent Tunçel

Optimization over convex sets described as the intersection of the set of symmetric, positive semidefinite matrices with affine spaces: Semidefinite optimization vastly generalizes linear programming where variable vectors may be replaced with matrix variables and, in addition to linear equations and inequalities, one may utilize constraints requiring some of the matrix variables to be symmetric and positive semidefinite.

Topics Include:

- Duality theory for semidefinite optimization.
- Algorithms for semidefinite optimization: ellipsoid method, first-order methods and primal-dual interior-point methods for semidefinite optimization, and approximation algorithms based on semidefinite optimization.
- Formulations of problems from combinatorial optimization, graph theory, number theory, probability and statistics, complexity analysis of algorithms, engineering design and control theory. Theoretical and practical consequences of these formulations.
- Semidefinite Programming (SDP) representability and SDP extension complexity.
- Connections to other research areas: in addition to the above, connections to quantum computing, operator theory, real algebraic geometry.

Pre-requisites (for undergraduate students): MATH 239/249, CO255, PMATH 351 or at least AMATH/PMATH 331, CAV at least 80%.

Pre-requisites (for graduate students): Some familiarity with linear programming theory, real analysis and graph theory. Those graduate students who are unsure about whether they have the necessary background, should read Chapter 1 of the textbook for the course:

Polyhedral and Semidefinite Programming Methods in Combinatorial Optimization [QA402.5.T86 2010] (freely and electronically available through uWaterloo Library);

also, such students should read Chapter 1 (Introduction) and Chapter 2 (Convex Sets) of one of the supplementary books:

Convex Optimization by Boyd and Vandenberghe (freely and electronically available on the web through the authors' websites).

If a student encounters difficulties during these readings, it might be useful to contact the Instructor and have a discussion before committing to take the course for credit.