CO759: Approximation and Randomized Algorithms (Topics in Discrete Optimization)

Spring 2013 TTh 10:00-11:20am, QNC 1507

http://www.math.uwaterloo.ca/~cswamy/courses/co759/

Instructor: Chaitanya Swamy

Course Outline

This is a graduate-level, introductory course into approximation and randomized algorithms. Many discrete optimization problems (arising in theory and practice) turn out to be *NP*-hard, and thus optimal solutions cannot be computed unless *P*=*NP*. One approach to deal with this situation is to design an *approximation algorithm* for the problem, that is, an efficient algorithm that is guaranteed to return a provably near-optimal solution. Over the past three decades, the theory of approximation algorithms has blossomed into a beautiful and powerful theory with deep and interesting connections to mathematical programming and analysis. The course will study some of the successful paradigms for designing approximation algorithms such as greedy methods, linear-programming (LP) based methods—the primal-dual method, deterministic and randomized rounding of LP solutions, semidefinite-programming relaxations, approximation of metrics. Randomization turns out to be an extremely useful idea in the design of approximation algorithms, and algorithms in general. We will also study some key tools in probability and their applications in the design of algorithms. A significant subset of the following topics will be covered.

- Set cover. The greedy algorithm, randomized rounding, primal-dual methods.
- Facility location. Local-search, LP-rounding, primal-dual methods.
- Network Design. Cut-covering problems and the primal-dual schema. Iterative rounding methods and applications to survivable network design and degree-bounded network design.
- Two gems in randomized algorithms. Karger's min-cut algorithm, and the Karger-Klein-Tarjan linear-time minimum-spanning-tree algorithm.
- Cut problems. LP-rounding algorithms for multiway cut, multicut, sparsest cut, and their applications.
- Metric embeddings: L1-embeddings, FRT trees and their applications.
- Cut-tree packings: Räcke trees and their connection with FRT trees.
- Semidefinite-programming relaxations: max-cut and sparsest cut.
- The Lovász local lemma and its applications.
- Counting problems: random walks and their applications.
- The unique games conjecture. Raghavendra's result.