Syllabus

1 Introduction

This class is about approximation algorithms for NP-hard optimization problems and their limitations. It assumes undergraduate knowledge of algorithms and complexity. **The class meets on Mondays and Wednesdays at 2-3:30pm at RLP 0.104.**

Instructor: Dana Moshkovitz
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Office hours: Friday 11am-noon
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Office hours: Thursday 2-3pm
TA Desk 1

The website for the class is:
www.cs.utexas.edu/~danama/courses/approximability18/index.html

We will use Canvas for grading:
https://canvas.utexas.edu/

We will use Piazza for questions and answers:
piazza.com/utexas/fall2018/cs395tmoshkovitz/home

2 Textbooks

There are several textbooks that cover some of the material:

1. *David Williamson and David Shmoys, The Design of Approximation Algorithms, Cambridge University Press, 2011.* Covers combinatorial approximation algorithms, applications of linear programming and semidefinite programming to approximation algorithms, as well as hardness of approximation based on the PCP Theorem.

2. *Vijay Vazirani, Approximation Algorithms, Springer-Verlag, 2001.* Covers similar material to the previous book.

3. *Sanjeev Arora and Boaz Barak, Computational Complexity – A Modern Approach, Cambridge University Press, 2009.* Covers the Hadamard based construction of PCP, the combinatorial proof of the PCP Theorem, Fourier analysis. A draft of the book is available online free of charge, http://www.cs.princeton.edu/theory/index.php/Compbook/Draft, but the latest edition contains corrections and improvements.

4. *Ryan O'Donnell, Analysis of Boolean Functions, Cambridge University Press, 2014.* Covers Fourier analysis.

There are many lecture notes online that cover topics from the class. For approximation algorithms check out the webpages of: Anupam Gupta and Ryan O'Donnell, Chandra Chekuri, Shuchi Chawla and others. For hardness of approximation check out the webpages of: Dana Moshkovitz, Ryan O'Donnell and Venkat Guruswami, Subhash Khot.

3 Syllabus

Basic combinatorial approximation algorithms; Linear programming (LP) and approximation algorithms; Semidefinite programming (SDP); Hierarchies of linear and semidefinite programming and their limitations; Hardness of Approximation, Multi-prover games and probabilistic checking of proofs (PCP); Linearity testing, Hadamard-based PCP, coding theory, Fourier analysis; Sum-Check and PCP with polylog queries; Composition, PCP of proximity, robust PCP, decoding PCP; Gap amplification (powering); expanders, small set expanders and PCP; Parallel repetition; The long code and optimal inapproximability results; The Unique Games Conjecture, Dictator tests and integrality gaps.

4 Workshops

Some of the meetings will be regular lectures, and some will be "workshops" in which the students give mini-lectures. Workshops will give students ample opportunity to give lectures and receive feedback. The workshops will be held on Mondays as detailed on the course's website. Before a workshop we will publish a schedule with the topics of the mini-lectures. Usually there will be problems to solve and a mini-lecture will present a solution, but sometimes mini-lectures will be expositions of advanced topics.

5 Final Grade

Every student should solve one problem every week from the set of workshop problems. Over the semester, at least three of those problems should be ones designated *harder* or *longer*. Each solution will be graded on a scale of A=3/B=2/C=1/F=0. Each student will give a talk on their solution every few weeks. There will be a rotation among the students in the class to determine who speaks in which workshop.

The final grade will be determined as follows:

- 70% Correctness of solutions
- 15% Delivery of workshop talks
- 15% Participation