CS2429 PCP and the Hardness of Approximation
Fall 2007
Location: GB244
Time: Wednesday, 12-2 pm

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Course Web Site: http://www.cs.toronto.edu/ toni/Courses/PCP/PCP.html
Refer to this site periodically for important announcements and other information. All handouts will be available on the site in postscript form.

Text: For the beginning of the course, we will be using a draft of a new textbook, entitled "Computational Complexity: A Modern Approach," to be published Spring 2007. (Available online for free.) We will also make extensive use of papers, and handouts that will be available from the course webpage.

Course Description

This is a graduate topics level course on probabilistically checkable proofs (PCP's) and the theory of approximation. It is appropriate for graduate students in theory, or for any graduate student with sufficient background and interest in theory. The first part of the course will be an introduction to the revoluationary concept of probabilistically checkable proofs, and a proof of the PCP theorem. The second part of the course will cover many hardness results on the approximation of NP-hard problems, that can be obtained from the PCP theorem, or strenghtenings. In the last part of the course we will focus on open problems in the area. We will discuss the unique games conjecture (UGC) as well as Feige's hypothesis, and show how these stronger assumptions imply resolutions for most of the open problems in the theory of approximation.

Throughout the course, we will try to focus on the fundamental methods used to obtain these results. The primary methods include: an understanding of graph expansion and its ramifications, Fourier analysis, coding theory and specifically the Hadamard and long codes, and the theory of testing.

Below is a more detailed list of the topics that I hope to cover. I will lecture for the first part of the course. Students will be expected to give a presentation (possibly in groups) on an advanced topic (from a list of choices) in the second half of the course.

- P, NP, introduction to the PCP theorem
- Equivalent definitions of the PCP theorem
- Simple Inapproximability results that follow from PCP theorem.
- Irit Dinur's proof of the PCP theorem.
- Fourier Analysis and Long Codes
- Hastad's 3-bit PCP theorem
- Set Cover Inapproximability
- The Unique Games Conjecture
- UGC-hardness of MaxCut
- UGC-hardness of Vertex Cover
- Feige's hypothesis and inapproximability results using this hypothesis
- Integrality gaps and connections to PCP-based inapproximability results
- The Parallel Repetition Theorem

Marking Scheme:

There will be 3 assignments, each worth 1/5 th of your grade. There will be a course presentation which is worth 2/5 of your grade.

The work you submit must be your own. You may discuss problems with each other; however you should prepare written solutions alone. You are not permitted to consult people outside of the class, texts or web sites for solutions.