Title: New Directions in Algorithms (CSE 208A)

Instructor: Russell Impagliazzo

Time: 2:20-3:40 pm, Tuesday and Thursday

Location: HSS 2154

Textbooks: Motwani and Raghavan, Randomized Algorithms (photocopy), Vazirani, Approximation Algorithms, CLRS (back-up) Note: abbreviated MR, V, CLRS.

Scope: The course will cover algorithmic concepts and techniques from the last twenty years, with the goal of reaching the research frontier in algorithms. It will try to be self-contained, beyond a basic understanding of algorithms (i.e., CSE 202), and to be of interest to most researchers in computer science, not just theorists. Research frontier topics are asterisked in the following:

1. Background: Probability theory. Read 441-446, of Motwani-Raghavan, starting with "discrete random variable". OR V. App. B
2. Background: Classification of probabilistic algorithms: Section 1.2 (pp. 9-10) and 1.5 (pp. 18-23). OR V. A.4
3. Background: Algebra and number theory, MR pp. 395-402.
4. Examples of probabilistic algorithms: The probabilistic method. Number theory: Chapter 14 MR. Prime testing. Finding primes. Modular square roots. Algebraic circuit zero-testing. (1 lecture)
5. Algorithms using probabilistic sampling: Game-tree evaluation (MR pp. 28-31), Min-Cut (MR pp. 7-9, 289-296) (1 lecture)
6. Approximation algorithms: greedy approx. algs, Vertex and set cover approx (V, Chapter 1, 2) (l.5 lectures)
7. Approximation algorithms: DP approx algs., Knapsack (V, Ch. 8): go through fast. (.5 lectures)
8. Approximate reductions from other problems: Metric TSP (V, Chapter 3.2) (.5 lecture)
9. D&C approximation algorithms: * Arora's Euclidean TSP approximation scheme (V, Ch. 11) (1.5 lectures)
10. On-line algorithms and competitive analysis(PR Chapter 13) (2 lectures)
11. * "Priority" model for greedy algorithms (research paper) (1 lecture)
12. Linear and convex programming basics (CLRS Ch. 29, MR, Ch. 9.10, V Ch 12) (1 lecture)
13. The ellipsoid algorithm (not in texts) (1 lecture)
14. The simplex algorithm (CLRS, Ch. 29) (1 lecture)

15. Approximation algorithms based on linear or geometric relaxation: primal-dual, randomized rounding, and * semi-definite programming. (V, Ch. 13-15, 26) (3 lectures)
16. Probabilistic analysis of simplex algorithm (1 lecture)
17. *Perturbed analysis of the simplex algorithm (research paper) (1 lecture)
18. Monte Carlo Markov Chain algorithms (MR, Ch. 6, 11) (1 lecture)
19. Approximating the permament for dense graphs (MR Ch. 11) (2 lectures)

Exact topics may change due to student interest.

Prerequisites: CSE 202 or the equivalent will be assumed as a prerequisite.

Assignments: There will be three homework assignments, a take-home final, and a project.

The homework and project can be done in a group of up to 3. The final must be individual effort.

You must cite any person, book, paper, document or web-site that you consult in doing assignments, other than myself and the textbooks above. Work without relevant citations is plagiarism. Work with citations is not, but it may not receive full credit if you did not solve problems yourself.

The homework assignments will be theoretical in nature, designing, analyzing and proving algorithms correct.

The project is to read and, to some extent, extend, a recent (since 1990) research paper in algorithm design or applications of algorithms. Extending may be to provide additional analysis, to give a stronger analysis for a special case of input, or to implement an algorithm and obtain experimental performance results. This project may be related to your own research or to projects for other classes, e.g, Pavel Pevzner's computational bio class. However, you must cite the related work for other classes, and rewrite the project to emphasize the use of algorithms. Suggested length is 5-8 pages.