Randomized Algorithms, CME 309/CS365

Ashish Goel

Handout #1, Course Outline

The last twenty five years have witnessed a tremendous growth in the area of randomized algorithms. During this period, randomized algorithms have gone from being a tool in computational number theory to a mainstream set of tools and techniques with widespread application. Three benefits of randomization have spearheaded this growth: simplicity, speed, and robustness to input parameters. This course presents the basic concepts in the design and analysis of randomized algorithms at a level accessible to advanced undergraduates and to graduate students.

The course will be organized into two interleaved parts. The first thread will develop basic probabilistic tools that are recurrent in algorithmic applications. The second thread will focus on specific areas of application. Applications will be given along with each tool to illustrate it in concrete settings.

The following is a tentative outline of the course.

Tools and Techniques: Basic probability theory; randomized complexity theory; game-theoretic techniques; Markov, Chebyshev, and moment inequalities; limited independence; coupon collection and occupancy problems; tail inequalities and Chernoff bounds; conditional expectation and martingales; Markov chains and random walks; stable distributions; probability amplification and derandomization.

Applications: sorting and searching; data structures; combinatorial optimization and graph algorithms; metric embeddings; online and streaming algorithms; algorithms for massive data sets including similarity search, nearest neighbors, and clustering; number-theoretic algorithms.

Prerequisites: Basic undergraduate courses in Algorithms and Probability Theory.

Text-books: The first book below is a required text-book for this course. The others are good supplementary readings. The first book can be found for free on the Stanford library webpage (`http://library.stanford.edu/bks24_id=3503`).

1. Motwani and Raghavan. *Randomized Algorithms,* Cambridge University Press, 1995.
2. Mitzenmacher and Upfal. Randomized algorithms and probability analysis. Cambridge University Press, 2005.
3. William Feller. *An introduction to Probability Theory and Its Applications,* Volumes I and II, John Wiley, New York, 1968.
4. Patrick Billingsley. *Probability and Measure,* John Wiley and Sons, 1986.

The text-book material may be supplemented with assigned reading from recent publications.

For administrative details, see the class web-page at `http://www.stanford.edu/~ashishg/cme309`