EE 381V Advanced Probability in Learning, Inference and Networks **Spring 2018**
Instructor: Sanjay Shakkottai (Course Unique ID: 16030) **shakkott@austin.utexas.edu**

Overview: This course will focus on advanced probability inequalities and convergence, with applications to statistical learning, complex networks, and inference. This is primarily a "tools" class focusing on mathematical methods and proofs for the analysis of stochastic processes on discrete structures. The tools developed in this class are useful in a variety of network applications, including communication networks, social networks, machine learning, online platforms and epidemics/influence propagation.

Pre-requisites: Probability and Stochastic Processes (EE 381J or equivalent).

References: This course will be based on papers and books. Some references are:

1. *Concentration of Measure for the Analysis of Randomized Algorithms*, D. Dubhashi and A. Panconesi, Cambridge University Press, 2009.
2. *Concentration Inequalities - A Nonasymptotic Theory of Independence*, S. Boucheron, G. Lugosi and P. Massart, Oxford University Press, 2013. See also *Concentration of measure inequalities*, G. Lugosi, Lecture notes, 2009: http://www.econ.upf.es/∼lugosi/anu.pdf.
3. *A Probabilistic Theory of Pattern Recognition*, L. Devroye, L. Gyorfi, and G. Lugosi. Springer 1996.
3. *Large Deviations Techniques and Applications*, A. Dembo and O. Zeitouni, Springer, 2nd ed., 1998.
5. *Concentration Inequalities and Model Selection*, P. Massart, Lecture Notes in Mathematics 1896, Springer, 2007.
6. *Weighted Approximations in Probability and Statistics*, M. Csorgo and L. Horwath, Wiley, 1993.
7. *Epidemics and Rumors in Complex Networks*, M. Draief and L. Massoulie, Cambridge Univ. Press, 2010.
8. *Markov Chains: Gibbs Fields, Monte Carlo Simulation and Queues*, P. Bremaud, Springer, 1998.

Class Hours: Class will be held on **Monday and Wednesday, 1:30 - 3:00 pm** in **BUR 216**. Office hours will be held after class in EER 6.802.

Teaching Assistant: The TA for this class is Abishek Sankararaman: `abishek@utexas.edu`

Grading: Attendance is expected, and plus/minus grades will be assigned in this course. The breakdown is as follows:

(i) Homeworks and paper summaries: 30%

(ii) Midterm Exam: 30%

(iii) Final Project: 40%

Course Policy: Course material will be available on Canvas: `http://canvas.utexas.edu`. You may discuss homeworks and papers with other students, but you are not allowed to copy from others. University disciplinary procedures will be invoked if any form of cheating is detected. Course and instructor evaluations will occur in the last week of class. Academic accomodations may be provided to students with disabilities. Please contact the Division of Diversity and Community Engagement, Services for Students with Disabilities (phone: 471-6259) for additional information.

Topics Covered

1. *Overview and Concentration Techniques* – Chernoff, Hoeffding, Efron-Stein inequalities, Johnson-Lindenstrauss lemma, Negative association, FKG inequality
2. *Martingale Methods* – Doob's martingale, bounded difference and bounded variance methods (Azuma-Hoeffding/McDiarmid's inequality), Median concentration, Blowing up lemma, Eigenvalue based large deviations for DTMCs
3. *Talagrand's Inequality and Applications* – Talagrand's inequality for Hamming distance, configuration functions, Applications to Euclidean Traveling Saleman Problem (ETSP), Spanning Trees
4. *(if time permits) Entropy Method:* Log-Sobolev inequalities, applications, Proof of Talagrand's inequality
5. *Transportation Inequalities:* Marton's method (Tensorization of Pinsker's inequality), Quadratic transportation inequality
6. *Beyond Union Bounds:* Glivenko-Cantelli Theorem, VC Theorem, Shattering coefficient
7. *Mean Field Limits:* Kurtz's theorem, Exchange of time and space limits for many-particle systems, Exchangeability and connections to propagation of chaos
8. *Stein's Method:* Stein's Lemma, Berry-Esseen theorem, CLT for dependent random variables, Size-bias and zero-bias coupling, Stein-Chen method for Poisson approximations, Law of small numbers, Applications to random graphs
9. *Strong Approximations and Functional Limits:* Komlos-Major-Tusnady Theorems, Functional Strong Law of Large Numbers, Functional Central Limit Theorem, Functional Law of Iterated Logarithms

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