E6880: Random Matrix Theory with Engineering and Data Science Applications

Instructor: Ori Shental
Office hours: TBD

Prerequisites:
The main prerequisite is eagerness to learn about random matrix theory. True technical prerequisites are somewhat informal, and include comfort in math, especially linear algebra and probability.

Course purpose:
As surprising it may be sound, random matrix theory (RMT) is one of the most important tools for the algorithm engineer and practical researcher in the fields of engineering, being only second to linear algebra. The course will provide a comprehensive introduction to RMT and its applications to problems in wireless communications and signal processing.

Tentative schedule

Week #	Date	Course Topic	Class Topic	Assignment given	Assignment due	Project
1	9/7/2018	Introduction	Introduction and overview	HW0 ("Matlab")		
2	9/14/2018	Finite analysis	Wishart random matrices			
3	9/21/2018	Finite analysis	Joint eigenvalue distribution of Wishart random matrices	HW1 (finite)	HW0	
4	9/28/2018	Finite analysis	Marginal eigenvalue distribution of Wishart random matrices			
5	10/5/2018	Classical infinite analysis	Moments, Stieltjes transform and weak convergence			
6	10/12/2018	Classical infinite analysis	Marcenko-Pastur Law (via Stieltjes)	HW2 (infinite)	HW1	
7	10/19/2018	Infinite analysis from statistical physics	Cavity method			Project topic list and details
8	10/26/2018	Infinite analysis from statistical physics	Marcenko-pastur via Replica method			
9	11/2/2018	Infinite analysis from statistical physics	Marcenko-pastur via Replica method (cont')	HW3 (physics)	HW2	Project assignment deadline
10	11/9/2018	Application	Sparse data			
11	11/16/2018	Application	Capacity of MIMO channels		HW3	
Thanksgiving						
12	11/30/2018	Application	Capacity of MIMO channels (cont')			
13	12/7/2018	Final project	Presentation			Class presentation and final report submission

Homework:
There will be 4 homework assignments. Three of deriving some math and one working out some Matlab (or alike) solutions.

Project:
A topic that individual student chooses to work on. This could be reading a paper (out of a recommended list to be published around mid-term) and summarizing it for the entire class, or perhaps elaborating on results or algorithms that were not covered in depth in class. The project will involve submitting a report and an oral presentation of the project to the entire class. Overall, the objective of the individual project is to give the student a personalized learning experience while providing an opportunity to present the findings to the entire class and receive ample feedback.

Grading:

Homework: 40%
Project: 60%

References:

1. Any RMT textbook…
2. “Random matrix theory and wireless communications”, Antonia M. Tulino and Sergio Verdú, Foundations and Trends in Communications and Information Theory, June 2004.
3. “Random Matrix Methods for Wireless Communications”, Romain Couillet and Mérouane Debbah.