CS59300 COMPUTATION AND LEARNING ON GRAPHS

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*Course syllabus

- Course title: Computation and Learning on Graphs
- Prerequisites:
  (a) Knowledge of basic computer science principles, sufficient to write a reasonably non-trivial computer program (CS 15900, CS 18200, CS 25100); Confidence in learning and using the packages in tensorflow, pytorch, networkx.
  (b) Familiarity with the undergrad-level probability theory (MA 41600).
  (c) Familiarity with the undergrad-level linear algebra (MA 26200, MA 26500).
  (d) Suggested but not requested: Basic knowledge about machine learning (e.g. Understanding the phrases of training, testing, generalization) (CS 37300, CS 47100).
- Learning outcomes: Networks/Graphs are a nature tool for modeling structured data that represents complex social, technological and scientific systems. Coupled with the emergence of large-scale structured data, this course focuses on the computational and algorithmic approaches to analyze graphs and networks. Students are introduced to cutting-edge machine learning techniques apt to reveal insights on the social, technological, and scientific worlds, by means of studying their underlying network structure and interconnections.
- Materials: No required course materials. Relevant suggested materials include:
  (a) Stanford CS224W, `http://web.stanford.edu/class/cs224w/`;
  (b) Yale CS561, spectral graph theory, `https://www.cs.yale.edu/homes/spielman/561/`;
  (c) Statistical Mechanics of Complex Networks (Albert and Barabasi; 2001);
  (d) Mathematical results on scale-free random graphs (B. Bollobas; 2003);
  (e) Random Graphs and Complex Networks by van der Hofstad. Monograph-style lecture notes.
  (f) Geometric Deep Learning: Grids, Groups, Graphs, Geodesics, and Gauges by Michael M. Bronstein, Joan Bruna, Taco Cohen, Petar Veličković.
  (g) A Book on Graph Neural Networks `https://graph-neural-networks.github.io/`.
- Grading criteria:
  (a) Homework: 10% * 2 = 20%;
  (b) One Midterm: 20%;
  (c) Course project: 60% including proposal 10% + project milestone 5% + final report 30% + presentation 15%

- Syllabus (tentative):
  1. Introduction & Basic Concepts of Graphs
  2. Random Graphs I & Probabilistic Analysis
  3. Random Graphs II & Real Network Properties
  4. Community Detection I & Spectral Clustering
  5. Community Detection II & Spectral Graph Theory
  6. Random Walks & PageRank
  7. Semi-supervised Learning & Graph Regularization
  8. Graph signal Processing & Convolution
  9. Graphical Modeling & Message Passing
  10. Large-scale Graph Training
  11. Network Embedding
  12. Link Prediction & Recommendation
  13. Group Equivariance & Invariance
  14. Graph Isomorphism & GNN Representation power
  15. Motifs & Graphlets, Node Structural Role
  16. Learning Graph Generative Models