ECE 498LV — Network Science: Dynamics and Flow
Spring 2017

Lecturer: Prof. Lav R. Varshney, varshney@illinois.edu
Office Hours: T 12:30-2:00pm, 314 CSL and by appointment

Lecture: TR 11:00-12:20am, 4070 Electrical & Computer Engineering Building

Course Webpage: http://courses.ece.uiuc.edu/ece498lv3/

Course Goals

- Can we predict the behavior of the nematode *C. elegans* by looking at the connectivity pattern of its neurons?
- Can we characterize the pulse of life in New York City by looking at flows of taxi cabs?
- Can we design flavorful culinary recipes by understanding knowledge on shared flavor compounds in ingredients?

By taking an engineering perspective on network science, we can address these problems; more traditional problems in communications, computing, and power; and more!

Brief Technical Description

Network science studies connections and flows among interacting objects, and the dynamic evolution of these structures. This course will cover the mathematics of networks, drawing on an emerging set of principles and techniques that originate in engineering theory, physics, biology, and the social sciences. The goal is to equip students with conceptual tools for understanding complex network systems. Examples taken primarily from neuronal, knowledge, and infrastructure networks.

Suggested Prerequisites

ECE 210, ECE 313, MATH 286, MATH 415, or their equivalents. Programming in matlab and/or python.

Requirements

- Homework [including data/programming assignments] (35%)
- Midterm exam [in class] (20%)
- Final exam [as designated by university] (20%)
- Group project [open-ended topics, written report, in-class conference-style presentations] (25%)
- Graduate students enrolled for 4 credits will complete an additional individual research project

Note that all homework will be due in class.
Textbook

- Further readings and lecture notes will be provided through the course website.

Detailed Course Topics

- Introduction to networks and their mathematical abstraction
- Empirical study of networks and important design questions in application domains
  - infrastructure networks—electricity, water, communications
  - neuronal networks—human connectome and connectome of small organisms
  - knowledge networks—citation, semantic, etc.
- Fundamentals of network theory
  - mathematical representations, components, paths, degrees, walks
  - software for network analysis
- Dynamics of networks
  - review of differential equations, difference equations, linear systems theory
  - review of (scalar) nonlinear dynamics
  - network dynamics
  - epidemics
  - synchronization
- Flow on networks
  - shortest paths
  - maximum flow
  - bottleneck flow
  - multicommodity flow
- Measures and metrics
  - centrality, from principles of dynamics and flow
- Network visualization
  - Laplacian graph drawing
- Random networks
  - Erdos-Renyi graphs, exponential random graphs, and scale-free networks

Academic Integrity

Academic integrity and discipline will be based on the standards set forth by the College of Engineering and the University of Illinois. The University has the responsibility for maintaining academic integrity so as to protect the quality of education and research on our campus and to protect those who depend upon our integrity. It is the responsibility of the student to refrain from infractions of academic integrity, from conduct that may lead to suspicion of such infractions, and from conduct that aids others in such infractions.

Examples of Infractions of Academic Integrity

A. Cheating -- Using or attempting to use in any academic exercise materials, information, study aids, or electronic data that the student knows or should know is unauthorized. During examinations, students should assume that external assistance (e.g., books, notes, calculators, conversation with others) is prohibited unless specifically authorized by the instructor. Substantial portions of the same academic work may not be submitted for credit more than once or by more than one student without authorization.
B. Fabrication -- Unauthorized falsification or invention of any information or citation in an academic endeavor. Fabrication also includes altering the answers given for an exam after the examination has been graded. Fabrication also includes submitting false documents for the purpose of being excused from a scheduled examination or other academic assignment.

C. Facilitating Infractions of Academic Integrity -- Helping or attempting to help another to commit an infraction of academic integrity, where one knows or should know that through one's acts or omissions such an infraction may be facilitated. Examples include: 1) allowing another to copy from one's work during an examination, 2) taking an exam by proxy for someone else, and 3) unauthorized removal of an examination or quiz from a classroom, faculty office, or other facility (such as the proctor's office) would be committing a breach of academic integrity.

A complete listing of Infractions of Academy Integrity and University Policy can be found at this web site: http://admin.illinois.edu/policy/code/article1_part4_1-401.html