Math 581.05: Computational Tools for Complex Systems
Fall 2020

Instructor Information

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Classroom:	Zoom (https://wsu.zoom.us/j/2175488966)
Class Time:	Wednesday 3:10–4:00pm
Office Hours:	Friday from 1:30–2:30pm

Course Description

This course will introduce tools and methodology for analyzing complex social systems with network models. The first half of the course will cover standard network constructions and associated centrality metrics, clustering algorithms, dynamical models, and null models through classic papers and examples. The second half of the course will focus on the discrete formulation of political redistricting problems and related applications of sampling connected graph partitions. Beyond the theoretical components, this course will provide resources and experiences for relevant software packages including networkx and gerrychain.

Remote Logistics

Due to the circumstances surrounding the coronavirus outbreak, our course meetings will be held entirely online, through Zoom. Python scripts and notebooks will be uploaded to the course github page and will also be available in a CoCalc project. This will allow you to follow along as we experiment with the computational tools during our meetings. Further details will be discussed during our first meeting.

Course Materials

The main material we cover will be presented in lecture notes prepared by me and posted on the course webpage. For each topic, I will also suggest several relevant 'classic'[1] research papers for additional context. Some textbooks that cover the material from a broader perspective include:

- Networks (Newman)
- Network Analysis and Modeling (Clauset)
- Networks, Crowds, and Markets (Easely and Kleinberg)
- Dynamical Processes on Complex Networks (Barrat, Barthelemy, and Vespignani)
- A First Course in Network Science (Menczer, Fortunato, Davis)

[1] this means something different in applied math than pure math ☺

Learning Outcomes

The main purpose of the course is to introduce basic tools and concepts from social network analysis and computational redistricting. Specific learning outcomes include:

- Writing python programs incorporating the networkx package
- Understanding how network models arise from empirical data
- Facility with the standard concepts in networks analysis including centrality, clustering, and dynamics
- Understanding application of MCMC ensembles to political redistricting
- Using the gerrychain software to run Markov chains for graph partitions

Assignments and Assessment

Throughout the course there will be several suggested computational exercises. Students who want to work on projects related to this material will have opportunities to explore their interests.

Grading Policy

The course is being graded S/F. Active participation in lecture and discussion is important.

Weekly Topics

1. Introduction to NetworkX and Overview
2. Measures and Metrics
3. Null Models
4. Dynamics 1 (Diffusion)
5. Dynamics 2 (Compartment Models)
6. Clustering Methods 1 (Spectral Methods)
7. Clustering Methods 2 (Kitchen Sink)
8. Multiplex Networks
9. Applied Examples (Social Networks)
10. Introduction to Computational Redistricting
11. Geospatial Data
12. MCMC and Ensembles
13. Graph Partitioning
14. Applied Examples (Gerrymandering)
15. Applied Examples (Reform)

University Policy Statements