Syllabus - Fall2022

Course CSCI-6250/4250 4cr: Frontiers of Network Science
Monday - Thursday 12:00-13:40, Sage 4510

Class Website

http://www.cs.rpi.edu/~szymansk/fns.22/index.php

Instructor

Prof. Boleslaw K. Szymanski, e-mail: szymansk@cs.rpi.edu
Office Hours: Monday 14:00 – 14:45, Wednesday 11:00 – 11:45 webex by appointment

Teaching Assistant

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Office Hours: TBA, webex by appointment

Textbooks

Albert Laszlo Barabasi ***Network Science,***
Cambridge University Press, 2016
On-line version is available at http://barabasi.com/networksciencebook/
In addition, class notes will be used.

Course Description

This course offers an introduction to Network Science and a review of current research in this field. Classes will interchangeably present chapters from the textbook and the related current research. The emphasis will be on the mathematical background of network science: graphs and networks; random networks and various types of scale-free networks; and on network properties such as assortativity, mobility, and robustness; social networks and communities; and dynamics of processes on networks.

Prerequisites

CSCI-2300; a 4000 level algorithms-based CSCI (e.g. 4020, 4050, 4260, 4800), or MATH (4100, 4150, 4200, 4210, 4800) course; junior or senior level standing; some familiarity with probability theory, linear algebra, and calculus; or permission of the instructor.

Course Content

- Mathematical background of network science: graphs and networks.
- Random networks and their properties.
- Scale-free networks, small world networks and Barabasi-Albert model.
- Mobility and networks
- Network robustness
- Social networks and communities
- Assortativity of networks
- Dynamic processes

Grading Criteria

Undergraduates: One individual programming homework (40% of the total grade), followed by **one individual presentation** of the selected research paper (50% of the total grade), with questions and participation in discussions for at least two student presentations will provide the remaining (10%) of the total grade.

The programming homework will be handed out approximately after the end of the 4th week, together with choice of networks for experiments, and due in three weeks after that. The homework will require using network analytics tools, Gephi (or programming) and analysis of the results obtained for the real and synthetic networks. The graded homework will be returned to undergraduates approximately two weeks after they are handed in. Students will have these grades as their means to determine progress in the course by mid-semester.

Students will choose a topic for research and presentation either from the list of topics associated with the textbook or seminal papers that need to be approved by the instructor in the 7th week. The 20 min in class presentation of the assigned topic will be scheduled starting at the end of October.

Graduates: Students will choose a topic for research and presentation either from the list of topics associated with the seminal papers, or from their own current work, if approved by the instructor during the first two weeks of the class. Around 6th week of the course, the research plan will be due of 3-5 pages defining the project part of the presentation on which research will be based (25%). The 40 min presentation will be due starting at the end of October (40%), and a written report of 8-12 pages due at the last class (25%). The remaining 10% of the grade will be assigned based on participation in discussions of the presentations.

Grade ranges: A 96. A- 91, B 85, B- 80, C 70, C- 60, F <60.

Student Learning Outcomes

Upon completion of this course, all students will be able to:

1. Apply fundamental network science ideas to create models and understand dynamics of networked systems;
2. Compare, contrast, and describe the similarities and differences of different kinds of networks and processes modeled on networks;
3. Critique the strengths and weaknesses of each of the models and types of networks based on them and these network types performance in diverse network science applications;
4. Understand the principles of applying network science to disciplinary science and design and set up basic models for some specific applications.

Additionally, graduate students will also be able to:

5. Read, analyze, and critique published literature in the field of network science and social networks;
6. Assess novelty of network science research and its relation to the state of the art in the field.

Course Assessment Measures

Undergraduates: The students' performance will be measured using four different methods listed below.

(i) Programming homework

(ii) After selection of a current research paper or textbook problem for presentation, students will presentation the selected papers, including their content, and evaluate their scientific results.

(iii) Contributions to in-class discussions

The programming homework and presentation plans will measure the student's ability to apply concepts of network science to network analysis.

The presentation slides and evaluation of the paper results will measure student's ability to prepare summary material based on fundamental scientific concepts and basic research.

Graduates: Graduates: Again, students' performance will be measured using three different methods:

(i) After selection of a current research paper or own research for presentation, students will presentation the selected topics, including content, and evaluate their scientific results.

(ii) Contributions to in-class discussions

(iii) Independent and novel mini-project on the topic of the presentation using different data, or methods.

The first two methods are the same as the undergraduate methods (i) and (ii), while the third method assesses students' ability to apply network science to novel problems

Academic Integrity

Student-teacher relationships are built on trust. For example, students must trust that teachers have made appropriate decisions about the structure and content of the courses they teach, and teachers must trust that the assignments that students turn in are their own. Acts, which violate this trust, undermine the educational process. The Rensselaer Handbook of Student Rights and Responsibilities defines various forms of Academic Dishonesty and all students should make themselves familiar with these forms to avoid them.

In this class, all assignments that are turned in for a grade must represent the student's own work. Submission of any assignment that is in violation of this policy will result in a penalty of 0 points for assignment and failing of the course in case of repetition.

If you have any question concerning this policy, please ask for clarification before preparing or submitting an assignment or making a presentation.

The penalty for not adhering to these academic integrity rules is a failing grade for the assignment on the first offense, then failing the course and potential disciplinary actions by the Institute on any subsequent offenses.

Attendance Policy:

Attendance in classes is in general not required but it is recommended because the material presented in classes includes topics beyond the textbook. However, the attendance and active participation is required in at least two research presentations with active participation is needed to receive a score for *active participation*.

Missed deadline for homework, unless justified by medical or personal reasons and approved by instructor, will lower the achieved score by 10% for each week of delay.

Presentations can be rescheduled but only in emergencies.

Initial calendar:

The list shows the topics covered in classes, brown are lectures based on textbook, **green** are research presentations, and **blue** are presentations by students.

Aug. 29: L01 Overview and Introduction to Network Science/Graph Theory (chapter 1)
Sept. 01: L02 Introduction II (chapter 1)
Sept. 06: L03 Graph Theory (chapter 2) topics for student presentations;
Sept. 08: L04 Graph Theory II (chapter 2)
Sept. 12: L05 Random Networks (chapter 3)
Sept 15: Research topic selections by graduates are due before noon
Sept. 15:L06 **Research: U.S. Senate Clustering; U.S. Congress Polarization;**
Sept. 19: L07 Small World Networks (chapters 4);
Sept. 22: L08 Introduction to Gephi + Examples;
Sept. 26: Homework out
Sept. 26: L09 Q&A session for H1; Scale Free Networks (chapters 4-5);
Sept. 29: L10 Barabasi-Albert Model (chapter 5);
Oct. 03: Deadline for undergraduates to register their networks before noon
Oct. 03: L11 Evolving Networks (chapter 6);
Oct. 06: L12 Degree Correlation (chapter 7, narrated, no class meeting)
Oct. 13: L13 Degree Correlation II (chapter 7)
Oct. 17: Grads' research plan write ups are due before noon
Oct. 17: Homework 1 due by email before noon

Oct. 17: L14 **Research: James Flamino, NEST;** Robustness (chapter 8)
Oct. 20: Research paper selections by undergraduates are due before noon
Oct. 20: L15 **Research: Cheng Ma, Physics; Brendan Cross CS**
Oct. 24: L16 **Research: Mon Ma, CS; Global Risk Networks;** Robustness II (chapter 8)
Oct. 27: L17 **Discussion of Homework 1**
Oct. 31: L18 **Presentations:** *Universal resilience patterns,* Roman Nett (L),
Dynamics of ranking, Seth Laurenceau (L).
Nov. 03: L19 **Presentations:** *Net: Cell Graph Convolutional Network*, Vasundhara Acharya (L),
Decay of collective memory and attention I, Olivia Lundelius (S), *Decay II,* Mara Schwartz (S),
Polarization and tipping points, William Allen (S);
Nov. 07: L20 **Presentations:** *The increasing dominance of teams,* Linh Tran (L),
Scientific prize network, Connor Wooding (L), **Research: Aamir Mandviwalla, CS;**
Nov. 10: L21 **Presentations:** *Controllability of complex networks*, Yanna Ding (L),
Balancing Speed and Coverage I, Yuxiao Li (S), *Balancing II*, Harry Sui (S),
Fast Algorithm for Community Detection, Megan Goulet (S).
Nov. 14: L22 **Presentations:** *Social network structure and composition,* Shawn George (L),
Understanding individual human mobility patterns, Neha Deshpande (L),
Quantifying the future lethality of terror organizations, Richard Pawelkiewicz (S).
Nov. 17: L23 **Presentations:** *Graph Convolutional Networks for Text I,* Narayan Hiremagalur (L)
Graph II, Dhruva Narayan (L), Clique and link percolation, Andrew Celi (S).
Nov. 21: L24 **Presentations:** *Super GAT I,* Fnu Mohbat (L), *Super GAT II,* Aitazaz Khan (L),
Epidemic modeling, Devyn Smith (S).
Nov. 28: L25 **Presentations:** *Quantifying the evolution of individual scientific impact,*
Brandon Rozek (L), *Quantifying reputation and success in art*, Matt Zbikowski (L).
Contact Networks, Sean Patch (S).
Dec. 01: L26 **Presentations:** *Immunization,* Min Tan (S), *Brain network,* James Oswald (L),
Epidemics on networks, John Jacob (S).
Dec. 05: L27 **Presentations:** Beyond the degree distribution, Michael Leddy (S);
The product space conditions the development of nations, Astra Ford (L),
Entropy Measures of Human Communication Dynamics, Theodore Wu (S), *From Data to Complex Network Contro*l, Long Guo (S), *Temporal Network Epistemology*, Zhengtong Chen (S).
Dec. 08: L28 **Presentations:** *Dynamics of Political Bias in Parler & Twitter,* Mav Modi (L),
A network framework of cultural history, Jack Bartley (S),
Social Networks through the Prism of Cognition, Luke Hamel (S),
*Creation, Evolution, and Dissolution of Social Groups, C*hristos Kreatsoulas (S).