CptS 591: Elements of Network Science

Syllabus

Last updated: January 18, 2021

Course Information

Credit Hours: 3
Semester: Spring 2021
Meeting times and location: TuTh 9:10–10:25am, via Zoom. Class meetings will happen synchronously.
Course website: Canvas will be used for the management of this course. This includes posting of lecture material, Zoom recordings of lectures, assignments, announcements, and messages; and handling of student submissions and instructor feedbacks.

Instructor Information

Instructor: Assefaw Gebremedhin
Email: assefaw DOT gebremedhin AT wsu DOT edu
Homepage: http://www.eecs.wsu.edu/~assefaw

Office Hours (via Zoom): Tuesdays 12–1pm, or by appointment.

Course Description

This 3 credit, graduate-level course introduces fundamental elements of the emerging science of complex networks, with emphasis on social and information networks. Students will learn about mathematical and computational methods used to analyze networks, models used to understand and predict behavior of networked systems, and theories used to reason about network dynamics. Students will also be exposed to current research in the field, and they will be given an opportunity to explore a chosen topic through a semester project.

Topics to be covered include:

- *Network structure, modeling and algorithms*:
  Graph theory essentials; Basic network properties; Random graphs; Spectral graph theory; Centrality; PageRank; Hubs and Authorities; Graph similarity; Community detection
- *Network dynamics*:
  Cascading behaviors; Information diffusion; Epidemic models; Influence maximization.
- *Graph embeddings*:
  Graph embeddings; representation learning
- *Temporal networks*:
  Models and algorithms for analysis of time-varying networks.

Learning Outcomes

At the conclusion of the course students should be able to:

- Explain basic metrics and measures used to characterize networks
- Analyze a network using the various measures and a suitable network analysis software tool
- Discuss the strengths and weaknesses of random graph models
- Understand and apply key algorithms for node ranking, network comparison, and community detection
- Understand and apply models and theories used to reason about cascading behaviors, information diffusion, contagion, and decentralized navigation in networks
- Understand and explain the interdisciplinary nature of the area of network science
- Critique research papers in the area
- Apply knowledge gained in the course to carry out a project and write a scientific report

Audience

The course is suitable for graduate students in computer science, engineering disciplines, epidemiology, sociology, economics, mathematics, physics, and related fields.

Prerequisites

Students are expected to have basic knowledge of algorithms (equivalent to completing an undergraduate algorithms course such as CptS 350), some programming experience (e.g. in Python, R, C, or Java), and familiarity with basic linear algebra (e.g. solution of linear systems and eigenvalue/vector computation) and basic probability and statistics.

Coursework

The course consists of lectures (twice a week, 75 min each) and involves a set of assignments and exercises, one exam, and a semester project.

- **Assignments (30%).** There will be three assignments mostly spread through the first half of the semester and a few, periodic exercises. Assignments and exercises are to be completed and submitted individually.
- **Semester Project (50%)**. Working in teams of two or three, students will complete a semester project. A semester project could take one of several forms: analysis of an interesting dataset using existing methods and software; comparison of existing methods and software tools in the context of a specific application; implementation of a new method; exploration of a chosen research topic.

  Each project will have required submissions at three different stages—the submissions are called *Reaction Paper*, *Project Proposal* and *Final Report*—and will culminate with a presentation in class.

  For the Reaction Paper part students will get to pick and read two closely related papers out of a list of papers the instructor provides and write a short reaction paper summarizing and critiquing the two papers and identifying opportunities for further work. Project Proposal is a short document (2 or 3 pages long) that describes the proposed project and the tentative plan to carry it out. Ideally it is an outgrowth of the Reaction Paper component, but can also deviate from it. The outcome of the project will be a final report of about 8 to 12 pages long.

  Guidelines for writing the proposal and the final report will be provided at an appropriate time during the semester. A more complete project description detailing the various components will also be provided.

  The 50% weight of the semester project towards final grade is further broken down into its components as follows: Reaction Paper 7%, Project Proposal 7%, Presentation 8%, Final Report 28%.
- **Exam (18%)**. There will be one mid-term exam.
- **Class Participation (2%)**. Students are expected to actively participate in class discussions, in-class exercises and thought experiments.

Expectations for Student Effort

For each hour of lecture equivalent, students should expect to have a minimum of two hours of work outside class.

Grading

Letter grades will be given according to the following ranges:

A (93–100%), A- (90–92.99%), B+ (87–89.99%), B (83–86.99%), B- (80–82.99%), C+ (77–79.99%), C (70–76.99%), C- (67–69.99%), D (60–66.99%), F (less than 60%).

Books and Course Material

There is no required textbook for the course. Lecture notes, Zoom recordings of lectures, readings, and related resources will be posted at the course website as the course proceeds.

The following book will be used as a frequent reference:

- D. Easley and J. Kleinberg, *Networks, Crowds and Markets*, Cambridge Univ. Press, 2010. Available online at http://www.cs.cornell.edu/home/kleinber/networks-book

Other related references include:

- M.E. J. Newman, *Networks: An Introduction*, Oxford University Press, 2010.
- U. Brandes and T. Erlebach (Eds.), *Network Analysis: Methodological Foundations*, Springer, 2005. This book is available via the doi: http://dx.doi.org/10.1007/b106453
- A.L Barabasi, *Network Science*, http://barabasi.com/book/network-science

Software

The graph analysis package igraph will be used as the primary software resource. The package igraph is open-source and free.

Tentative Schedule

Week	Topics	Assignments
01 (Jan 19/21)	Introduction, Graph theory refresher	Survey out
02 (Jan 26/28)	Network properties	Survey due, Assignment 1 out
03 (Feb 02/04)	Intro to igraph	
04 (Feb 09/11)	Random graphs	Assignment 1 due
05 (Feb 16/18)	Spectral graph theory	Assignment 2 out
06 (Feb 23/25)	Centrality	NO CLASS 2/25
07 (Mar 02/04)	PageRank, Hubs & Authorities	Assignment 2 due
08 (Mar 09/11)	Community detection, project discussion	
09 (Mar 16/18)	Graph similarity, signed networks	Mid-Term
10 (Mar 23/25)	Graph embeddings	Reaction paper due
11 (Mar 30/Apr 01)	Cascading behaviors	Project proposal due
12 (Apr 06/08)	Influence maximization, Epidemic models	Assignment 3 out
13 (Apr 13/15)	Temporal networks	Assignment 3 due; NO CLASS 4/13
14 (Apr 20/22)	Wrap-up, project presentations	
15 (Apr 27/29)	Project presentations	
16 (May 04/06)	Finals week	Final project report due

Policies

Conduct

Students are expected to maintain a professional and respectful classroom environment. This includes turning off audio when one is not speaking, joining meetings in time and staying to the end, for example.

Correspondence

All class related correspondence with the instructor will be made via Canvas.

Attendance

Regular attendance is required. While students may miss class for urgent reasons, repeated absences that are not cleared with the instructor will factor into the Class Participation portion of the semester grade.

Missing or Late Work

Submissions will be handled via Canvas. Students are expected to submit assignments and reports by the specified due date and time. Submissions turned in up to 24 hours late will be accepted with a 10% grade penalty per 12 hours late. Except by prior arrangement, missing or work late by more than 24 hours will be counted as zero.

Academic Integrity

Academic integrity is the cornerstone of higher education. As such, all members of the university community share responsibility for maintaining and promoting the principles of integrity in all activities, including academic integrity and honest scholarship. Academic integrity will be strongly enforced in this course. Any student who violates the University's standard of conduct relating to academic integrity will receive an F as a final grade in this course, will not have the option to withdraw from the course and will be reported to the Office of Student Standards and Accountability.

Cheating includes, but is not limited to, plagiarism and unauthorized collaboration as defined in the Standards for Student Conduct WAC 504-26-010 (3). You can learn more about Academic Integrity on the WSU campus at http://conduct.wsu.edu. If you have any questions about what is and is not allowed in this course, you should ask the course instructor before proceeding.

Students with Disabilities

Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Washington Building 217; 509-335-3417) to schedule an appointment with an Access Advisor. All accommodations must be approved through the Access Center. For more information, consult the webpage http://accesscenter.wsu.edu or email at Access.Center@wsu.edu.

COVID-19 Policy

Students are expected to abide by all current COVID-19 related university policies and public health directives, which could include wearing a cloth face covering, physically distancing, self-attestations, and sanitizing common use spaces. All current COVID-19 related university policies and public health directives are located at https://wsu.edu/covid-19/.

Accommodation for Religious Observances or Activities

Washington State University reasonably accommodates absences allowing for students to take holidays for reasons of faith or conscience or organized activities conducted under the auspices of a religious denomination, church, or religious organization. Reasonable accommodation requires the student to coordinate with the instructor on scheduling examinations or other activities necessary for course completion. Students requesting accommodation must provide written notification within the first two weeks of the beginning of the course and include specific dates for absences. Approved accommodations for absences will not adversely impact student grades. Absence from classes or examinations for religious reasons does not relieve students from responsibility for any part of the course work required during the period of absence. Students who feel they have been treated unfairly in terms of this accommodation may refer to Academic Regulation 104 – Academic Complaint Procedures.

Important Dates and Deadlines

Students are encouraged to refer to the academic calendar often to be aware of critical deadlines throughout the semester. The academic calendar can be found at
http://registrar.wsu.edu/academic-calendar.

Changes

This syllabus is subject to change. Updates will be posted on the course website.