Course number and title: CSTS-UH 1078 Networks

Credits: 4.0

Prereqs: None

Faculty: Moses Boudourides

Office: C1-137

Office Hours: Mo, We 4:00-5:00 pm or by appointment

Course description:

How do the various social, technological, and other networks in which humans live shape our behavior, agency, knowledge, beliefs, and preferences? Is it possible to map or otherwise quantify the ways in which these networks – of friends, media and information, biological and chemical processes, transportation – both facilitate and are shaped by various converging or diverging patterns of human sociality? Such general questions have been taken up within a range of disciplines in the sciences, social sciences, and humanities. Although there are multiple approaches and answers put forward within these different domains, they all share a basic vocabulary. This course aims to convey and allow students to explore this common vocabulary of formal concepts and processes related to understanding networks. They will do so by taking up tools for making elementary computations as they experiment with their own scenarios for analyzing the complex patterns of relationships that shape our lives.

The course has no prerequisites, nor does it require any mathematical or physical or technical skills, though one of the objectives of the course is a practical and experimental engagement with key aspects of Computational Network Science. For this purpose, the programming language Python will be used as a tool for implementing network computations. Students do not need to know Python or to possess major skills with computing. They will only have to install the Jupyter Notebook application on their computers so that they might be able to use computations that will be already coded and provided by the professor. In the first two weeks of the course, students will be guided through the required installation and use of Jupyter Notebooks.

Learning outcomes:

By the end of this course, students will be able to:

- Demonstrate familiarity with a number of important issues about the ubiquitous network entanglements in our everyday lives and with a large range of network applications in STEM (mostly from Mathematics, Biology, Medicine, Computer Science, Engineering, Technology, etc.) but also in Social Sciences (Economics, Sociology, Anthropology, Management, Policy Studies, etc.) and in Humanities (Literature, History, the Arts, etc.).
- Elaborate a fundamental vocabulary used to study or describe the various typologies and structural characteristics of networks.
- Explain how networks expand or shrink, foster or suppress, become resilient or immune or vulnerable to attacks or to the spread of viral effects.
- Use various computational tools to measure, analyze, interpret, and even predict possible trends in the evolution of networks.

Teaching and learning methods:

. Each week will be divided in two parts:

  . The lecture.

  . The computational exploration and experimentation.

. During the first part, the instructor will deliver lectures and engage in discussions with students, answering questions or suggesting additional literature to those interested in going further in those directions. Moreover, in the first part, there will be an introduction to the weekly assignment and guidance to its implementation. The second part will include a demonstration of various exploratory computations, visualizations, simulations and experiments illustrating from a practical point of view the week's discussion topics and also covering further assistance to the implementation of that week's assignment. During both parts, students will be prompted to develop topics for critical discussion and debate and will practice related computational methodologies by running examples of these computations on their own laptops (or possibly at a computer lab).

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. Over the course of the semester, students will also be required to work on a team project and present it in front of the class on the last day of the course. They will also be asked to submit individual written reports of their project in order to achieve a deeper understanding of and ability to explain the course's main concepts.

Course materials:

Required textbook:

- Jackson, M.O., *The Human Network: How Your Social Position Determines Your Power, Beliefs, and Behaviors*, Pantheon, 2019.

Suggested reading:

- Scott, J., *Social Network Analysis*, SAGE, 4^{th} Edition, 2017.
- Newman, M., *Networks*, Oxford University Press, 2^{nd} Edition, 2018.
- Russell, M. A. and M. Klassen (2019). *Mining the Social Web: Data Mining Facebook, Twitter, LinkedIn, Instagram, GitHub, and More* (3rd ed.). Sebastopol, CA.: O'Reilly.
- Menczer, F., Fortunato, S., & Davis, C.A., *A First Course in Network Science*, Cambridge University Press (this is a forthcoming book expected to come out in late 2019; reading material from this book will be added only provided that the publisher will give us permission to use the pdf of the book draft).

Assignments:

The course entails two types of assignments:

- Reading assignment.
- Computational assignment.

The reading assignment will correspond to selected chapters or sections from the course textbooks and the suggested reading. Moreover, there will be some other auxiliary material (in the form of slides, publications or excerpts from various published volumes) that will be given the week before the one it will be discussed in class. *The due date for students finishing the reading assignment will be on every Monday during the semester (or the day before the first session of the course)*, as this is the material that will be presented, discussed and used in computational explorations during that week.

The computational assignment will be given as a Jupyter Notebook, which will include the Python code for the implementation of various network computations and visualizations. Students are not expected to be able to program in Python. During the first two weeks of the course, instructions will be given to install and use Jupyter Notebooks in their own laptops or personal computers. In every week's Jupyter Notebook of the computational assignment, students will be asked to work (meaning to re-run) the existing (already coded) computations in the Notebook possibly changing a few parameters in the exhibited code (mostly about the type of networks and some display features of graphics or visualizations). In this way, though their work on the Jupyter Notebooks of the assignments, students are expected to experiment with a number of computational scenarios discussed during the lecture part and, eventually, to reach the goal of "learning by doing" in order to be able to master the learning objectives of the course. Although the computational assignment would be expected to be worked out by the majority of the class, an alternative assignment for those students who are not technically inclined would be to write a short paper on a topic given to them on individual basis by the instructor during the first class of the week. In this paper, students are required to expand on the readings of the week (including other literature too) in such a way that they would demonstrate their understanding on the course material of that week and still show off their skills in writing. *All the assignments will be due on every Friday during the semester*. Notice that the computational assignments should be in the form of Jupyter Notebooks and the papers as Word documents, while students need only to submit them electronically (either through NYU Classes or by email to the instructor).

Team Final Project:

There will be no final written exam. Instead students are expected to complete a final project. This will be a team project in groups of three students. The topics of the project will be introduced during the course overview in the first week and further discussed in the second week. The teams of students should be formed before the third week. Depending on the topic of the project, most of the course computational assignments will scaffold up toward the final project. The deliverables of the final project (*due the last week of the course*) are the following:

(i) A paper (report), double-spaced with a ten-page maximum, including (1) a summary and problem definition, (2) discussion of the research design, measurement and network methods employed, (3) overview of programming work on the basis of the already given computational assignments, (4) review of results, and (5) the scientific literature used in the project or covering similar investigations. The paper must be provided as an Adobe Acrobat pdf.

(ii) The dataset (possibly) used in the project.

(iii) Complete program code in Python in a Jupyter Notebook (extracted from the already given computational experiments).

Selected papers of the students' final projects (possibly all of them) will be presented at an open event after the last week of the course (probably during the scheduled exam time) and they will be posted on the web.

Grading:

The final grade will consist of the following:

- Class participation: 10%
- Computational assignments: 60%
- Team final project: 30%

Tentative course schedule:

Week 1: Basic Concepts of Networks (including the course overview, discussion on the topics of final projects, and instructions how to use the Jupyter Notebook)

Reading assignment: Jackson, Chapter 1; Scott, Chapter 1

Computational assignment: Basic network typologies, construction and visualization

Week 2: Examples of Empirical Networks (including discussion on the topics of final projects, and instructions how to use the Jupyter Notebook)

Reading assignment: Menczer et al., Chapter 0, Newman, Chapters 2 and 3

Computational assignment: Graph adjacency

Week 3: Network Motifs (including discussion on the topics of final projects and deadline for the formation of teams)

Reading assignment: Menczer et al., Chapter 1, Scott, Chapter 6; Newman, Chapter 6

Computational assignment: Various types of subgraphs

Week 4: Network Centralities

Reading assignment: Menczer et al., Chapters 3 and 4, Scott, Chapter 5; Newman, Chapter 7

Computational assignment: Graph centralities

Week 5: Network Communities

Reading assignment: Menczer et al., Chapter 6, Newman, Chapter 11

Computational assignment: Graph communities (Louvain algorithm)

Week 6: Random Networks, Small Worlds and Preferential Attachment

Reading assignment: Menczer et al., Chapters 2 and 5, Newman, Chapters 12 and 14

Computational assignment: Random network typologies, construction and visualization

Week 7: Network Homophily (Assortativity-Mixing)

Reading assignment: Newman, Chapter 8

Computational assignment: Measures of assortativity-homophily

Week 8: Network Diffusion, Contagion and Influence

Reading assignment: Jackson, Chapter 3

Computational assignment: Experiments on network influence

Week 9: Network Dynamics and Temporal Networks

Reading assignment: Menczer et al., Chapter 7, Jackson, Chapter 9

Computational assignment: Trajectories in temporal graphs

Week 10: Networks from Scientometric Data

Reading assignment: Newman, Chapter 4

Computational assignment: Co-authorship networks

Week 11: Networks from the Internet and Social Media Data

Reading assignment: Russell, Chapter 1

Computational assignment: Twitter data and network analysis

Week 12: Networks from Literature and Literary Texts

Reading assignment: Russell, Chapter 4

Computational assignment: Text data and co-occurrence networks

Week 13: Financial Networks

Reading assignment: Jackson, Chapter 4

Computational assignment: A case study of financial networks

Week 14: Critical and Controversial Issues on Networks (course wrap-up and presentation of the team final projects)