Dynamic Network Analysis (Spring 2018)  
Course 08-801, 08-640, 19-640

**Instructor**  
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**Introduction**

Who knows who? Who knows what? Who communicates with whom? Who is influential? How do ideas, diseases, and technologies propagate through groups? How do social media, social, knowledge, and technology networks differ? How do these networks evolve? How do network constrain and enable behavior? How can a network be compromised or made resilient? What are network cascades? Such questions can be addressed using Network Science. Network Science, a.k.a. social network analysis, link analysis, geo-network analysis, and dynamic network analysis is a fast-growing interdisciplinary field aimed at understanding simple & high dimensional networks, from both a static and a dynamic perspective. Across an unlimited application space, graph theoretic, statistical, & simulation methodologies are used to reason about complex systems as networks.

An interdisciplinary perspective on network science is provided, with an emphasis on high-dimensional dynamic data. The fundamentals of network science, methods, theories, metrics & confidence estimation, constraints on data collection & bias, and key research findings & challenges are examined. Illustrative networks discussed include social media based (e.g., twitter), disaster response, organizational, semantic, political elite, crises, terror, & P2P networks. Critical procedures covered include: basic centralities and metrics, group and community detection, link inference, network change detection, comparative analytics, and big data techniques. Applications from business, science, art, medicine, forensics, social media & numerous other areas are explored. Key issues addressed: Conceptualization, measurement, comparison & evaluation of networks. Identification of influential nodes and hidden groups. Network emergence, evolution, change & destabilization.
In this course, the fundamentals of network science, the methods, the theories, the constraints on data collection are examined. This graduate seminar, offers an overview and evaluation of the theory and research on networks broadly defined. Student are encouraged to bring and use their own data, or to use one of the large number of datasets available publicly in this area for assignments. Questions addressed include, but are not limited to: How do we conceptualize, measure, compare and evaluate various types of networks? How do we evaluate the impact of policies and technology on using these networks especially given the fact that these networks are dynamic? What nodes, relations, groups, motifs stand out in or are influential in a network? How do networks emerge, evolve, change? What is the difference in analyzing networks as complete graphs versus networks as emerging from a set of links? How can data on networks be collected and what are the limits of these collection techniques?

Prerequisite: Undergraduate-level statistics course or instructor permission. Linear algebra is recommended but not required. Students are encouraged to bring & use their own data, or to use provided data.

**Course Content**

Lecture slides, assignments and supplemental readings are available for the course on Canvas. Weka data mining software is freely available and can be downloaded from [http://www.cs.waikato.ac.nz/ml/weka/downloading.html](http://www.cs.waikato.ac.nz/ml/weka/downloading.html).

**Software**

**Required Software**

- **ORA-PRO** --- to be provided by Dr. Carley
- **NetMapper** --- to be provided by Dr. Carley
- **Note** – on all problem sets you must use ORA.

**Important Background Reading**


Available Software

AutoMap, available from CASOS -
http://www.casos.cs.cmu.edu/projects/automap/

Construct, available from CASOS -
http://www.casos.cs.cmu.edu/projects/construct/

Books

Required Books

Get a copy of Wasserman and Faust (SNA). Many books are available on-line. Papers are on Canvas.


Recommended Books (to be aware of)


Ian McCulloh, Helen Armstrong & Anthony Johnson, 2013, Social Network Analysis with Applications, Wiley

Sean Everton, 2012, Disrupting Dark Networks, Cambridge University Press


**Take care of yourself.**

Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at [https://www.cmu.edu/counseling/](https://www.cmu.edu/counseling/). Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

*If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:
CaPS: 412-268-2922
Re:resolve Crisis Network: 888-796-8226*

*If the situation is life threatening, call the police:*
On campus: CMU Police: 412-268-2323
Off campus: 911

If you have questions about this or your coursework, please contact Prof. Kathleen M. Carley [kathleen.carley@cs.cmu.edu](mailto:kathleen.carley@cs.cmu.edu)
**Assignments, Grading, and Late Work Policy**

**Homework:** 1-6 are each worth 100 points
- **HW1:** Release Jan 18, Due Jan 30 midnight
- **HW2:** Release Jan 29, Due Feb 13 midnight
- **HW3:** Release Feb 12, Due Feb 27 midnight
- **HW4:** Release Feb 23, Due Mar 8 midnight
- **HW5:** Release Mar 7, Due Mar 22 midnight
- **HW6:** Release Mar 21, Due Apr 5 midnight

**Paper Presentation:** 50 points each
- Papers to be assigned by instructor.
- You present a published paper. Provide detailed description and critic – apx 15 minutes.
- To be scheduled in second half of term.
- You ask questions of other presenters.
- These will be during the application sections
- You will produce a powerpoint deck

**Course Project:** 750 for PhD 350 for MS
- **P1:** Due Jan 31 - Project Short Proposal: 20 Due February; A brief discussion of your proposed research problem, dataset, methods, and expected challenges. No more than 500 words.
- **P2:** Due Feb 28 - Project Revised Proposal: 30
- **P3:** Due April 2 - Project Draft 1: 200/70 March; Intro, Background, and Methodology Sections
- **P4:** Due between April 23 and April 30 - Project Presentation: 230/100 To be scheduled in late April, 10-15 minute conference talk discussing your project’s methods and key findings
- **P5:** Due May 2 - Project Write Up: 270/130 Due Last Day of Class; Publication style write up of your project. See examples on CANVAS

Late Work Policy: You are expected to turn in all work on time. Because we understand that exceptional circumstances may arise, each student will be permitted to turn in two of their assignments up to 48 hours late with no penalty. Otherwise late assignment may be docked 15%.

For assistance with the written or oral communication assignments in this class, visit the Global Communication Center (GCC). GCC tutors can provide instruction on a range of communication topics and can help you improve your papers and presentations. The GCC is a free service, open to all students, and located in Hunt library. You can make tutoring appointments directly on the GCC website: [http://www.cmu.edu/gcc](http://www.cmu.edu/gcc). You may also visit the GCC website to find out about communication workshops offered throughout the academic year.
To find out more about any of the ways the GCC can help you, please email them at gcc-cmu@andrew.cmu.edu.
University Policy on Cheating and Plagiarism

You are expected to read and attend to the information in - University Policy on Academic Integrity. The full policy is available by clicking the hyperlinked text above. Additional information about the university process for handling violations and links to resources is also available via this comprehensive website: http://www.cmu.edu/academic-integrity/index.html.

It is extremely important that the home-works, assignments, papers and tests that you turn in during the course reflect your own understanding. To copy answers from another person not only denies you the necessary feedback on whether or not you really understand the material, but it also compromises your integrity. In addition, those who do not succumb to cheating feel that they are “getting the short end of the stick” when they see others getting away with it. For these reasons we expect everyone to behave with integrity. It is also important that the work represents your work. Thus, any unauthorized assistance in doing the course project or homework is also considered cheating.

In this class, without explicit permission of the instructor, the following do not count as original work and would constitute cheating:

- Turning in the same or largely similar paper to another class or classes.
- Joint work with another student on a problem set or final project.
- Copying material from the web without citing it correctly.
- Plagiarism, including – copying images, graphs, and tables from published work.
- Failure to correctly cite material produced by others regardless of whether it appeared in a blog, news article, web-post, journal publication, book, etc.
- Failure to correctly cite previously published works by yourself.
- Utilizing source code developed by others or drawn from the web for your project without explicit prior permission of the instructor, and appropriate reference.

Note, papers may be assessed using automatic tools for plagiarism detection.
Course Outline

Lecture I: Introduction – What is Dynamic Network Analysis
Carley, K.M. Chapter 1, 6.1
Wasserman, S. & Faust, K. Chapters 1(1.1,1.2,1.3,1.4), 2 (2.1, 2.2, 2.3) and 3.1 and 3.2

Lecture II: Network Elite
Carley, K.M. Chapter 2
Wasserman & Faust. Chapter 5

Lecture III: Groups
Carley, K.M. Chapter 4
Wasserman & Faust. Chapter 7,8,9,10,(12 --- for reference only)

Lecture IV: Network Topology


**Lecture V: Compare and Contrast Networks**

Carley, K.M. Chapter 6.3

Wasserman & Faust, Chapter 15


**Lecture VI: Issues of Analysis and Inference, Missing Data, Sampling**


**Lecture VII: Ego Networks**


**Lecture VIII: Meta-Networks**

Carley, K.M. Chapter 3


Matthew Benigni, Kenneth Joseph and Kathleen M. Carley, 2017, “Online Extremism and the Communities that Sustain It: Detecting the ISIS Supporting Community on Twitter,” PLOS ONE

**Lecture IX: Link Inference & Socio-Cultural Cognitive Mapping**


**Lecture X: Triads**


**Lecture XI: Social Influence**


**Lecture XII: Network Dynamics I**

Carley, K.M. Chapter 7.1, 7.2


**Lecture XIII: Network Dynamics II**

Carley, K.M. Chapter 6.2,6.4,6.5

Wasserman & Faust, Chapter 17(17.2)

Illustrative Video: [https://www.youtube.com/watch?v=CxJkVrD2ZlM](https://www.youtube.com/watch?v=CxJkVrD2ZlM)


**Adobe Software used to create video can be found at,**


**Additional Materials/Software:**

- GitHub page of python package pathpy, https://github.com/IngoScholtes/pathpy
Lecture XIV: Geo-Spatial Networks

Lecture XV: Fourier Analysis & Change Detection

Lecture XVI: Network Text Analysis
Carley, K.M. Chapter 8


Lecture XVII: Social Media Analytics
TBD

Lecture XVIII: Big Data Analytics

Pfeffer, Jürgen & Carley, Kathleen M. 2012. k-Centralities: Local Approximations of Global Measures Based on Shortest Paths. Proceedings of the WWW Conference 2012, 1st International Workshop on Large Scale Network Analysis (LSNA 2012), Lyon, France


**Lecture XIX: Application: Social Media & BotNets**


**Lecture XX: Application: Science Networks**


**Lecture XXI: Application: Diffusion**

Granovetter, M.S., 1973. The Strength of Weak Ties. American Journal of Sociology 78, 1360–1380.


Kempe, David, Jon Kleinberg, and Éva Tardos. 2003. "Maximizing the spread of influence through a social network." In *Proceedings of the ninth ACM SIGKDD international conference on Knowledge discovery and data mining*, pp. 137-146. ACM.

Lecture XXII: Application: Health


Lecture XXIII: Application: Organizations


Lecture XXIV: Application: Counter-Terrorism


Lecture XXV: Fake News
TBD

Lecture XXVI-XVIII: Final Presentations

Lecture XXIX LAST: The Future of Network Science
Carley, K.M. Chapter 9
