Network Analysis: Advanced Topics
ICPSR Summer Program, Ann Arbor
Summer 2024

Prerequisites: an introduction course in network analysis, familiarity with statistical modeling, and experience using the R programming language

Lecture: MH 1437, 1:30 – 4:30 pm

Instructors:

- Professor Olga Chyzh, olga dot chyzh at utoronto dot ca
  Office Hours: Monday/Wednesday 4:30–5:30 pm

- Professor Shahryar Minhas, minhassh at msu dot edu
  Office Hours: Monday/Wednesday 9–10 am
  Office Hours Zoom Link: https://msu.zoom.us/j/4458946005

Teaching Assistant: Samuel Morgan Martin, sammart at umich dot edu
TA Office Hours: By appointment

Overview and Objectives

Social science data are inherently network data. Individuals are embedded within networks of friendships and professional relations; administrative units influence and are influenced by the nearby units; countries are nested within complex alliance and trade networks. The course introduces the inferential tools for analyzing such data, including the Exponential Random Graph models (ERGMS), actor-oriented model of network dynamics (SIENA), Latent Space Models (LSMs), and Local Structure Graph Models (LSGMs). For each model, we work through the mathematical and theoretical foundations, discuss published social science applications of them, and utilize the models on example datasets.

Learning Outcomes

This course is designed as a series of weekly modules that build upon each other. Each module covers one or more state-of-the-art approaches to statistical analysis of network data. For each model covered, the objectives are that students will:

- Develop a firm grasp of the assumptions and formulation of the model.
- Understand how to interpret results.

- Understand how to evaluate the fit and assumptions of the model.
- Use software to apply the model.
- Read published substantive applications of the model.
- Evaluate the potential for application of the model to their own research.

Two overarching objectives are that students will (1) develop an ability to compare the relative merits of the various models covered for a given empirical application and (2) develop a comprehensive sense of the state of the literature on statistical models for social networks.

Class Communications

I will try to be very responsive to any questions that you have over email. In addition, I've set up a Slack channel for the course. Here is an invite link: `https://join.slack.com/t/slack-czs8916/shared_invite/zt-1za5wu8ua-TVKdWRG4FZ4l4fk3M9HcFg`.

Homework

Students will have a weekly homework typically assigned on Monday and due on Friday. For each homework, students will apply the methods covered that week to a dataset made available by the instructor. Each student will submit their homework as an R-script and a pdf file. Each homework will take 1–3 hours to complete.

Coding Sessions

For each method covered we will run through applications in R during class. Students are strongly encouraged to follow along during class and review/run through these examples after class. Students will be provided with data, but may also use their own datasets.

Grading Scale

Grades will be assigned based on performance on the homework assignments. Each assignment will be graded (0–no submission, 1–does not demonstrate comprehension of the methodology, 2–adequate comprehension demonstrated, 3–excellent comprehension demonstrated). The final grade will be calculated using the following grading scheme to the sum of homework grades.

A+	≥ 9
A	≥ 8
A-	≥ 6
B+	≥ 4
B-	< 4

Course Schedule

The schedule below gives the required reading. The readings listed for a particular day should be read before class time that day.

Week 1

- Tuesday: Course Overview and Introduction to Network Analysis
  - Michael D. Ward, Katherine Stovel, and Audrey Sacks. Network analysis and political science. *Annual Review of Political Science*, 14:245–264, 2011.
  - Stanley Wasserman and Katherine Faust. *Social Network Analysis: Methods and Applications*. Cambridge University Press, 1994. Chapters 1 and 2.
- Wednesday: Centrality, Reciprocity, Transitivity
  - John F. Padgett and Christopher K. Ansell. Robust action and the rise of the Medici, 1400-1434. *American Journal of Sociology*, 98(6):1259–1319, 1993.
  - Scott L. Feld. Why your friends have more friends than you do. *American Journal of Sociology*, 96(6):1464–1477, 1991.
  - Kupferschmidt, Kai. Why do some COVID-19 patients infect many others, whereas most don't spread the virus at all? *Science*, May 19, 2020.
  - Mark S. Granovetter. The strength of weak ties. *American Journal of Sociology*, 78(6):l360–1980, 1973, **Trigger Warning:** This article uses racial and gendered language common at the time of its writing.
- Thursday: Communities, Homophily, **HW 1 due**.
  - Albert-László Barabási. *Network Science*. Cambridge university press, 2016. Chapter 9.
  - Wayne W Zachary. An information flow model for conflict and fission in small groups. *Journal of Anthropological Research*, 33(4):452–473, 1977.
  - Jonathan Renshon. Status deficits and war. *International Organization*, 70(3):513–550, 2016.
  - Roger V Gould. Multiple networks and mobilization in the Paris Commune, 1871. *American Sociological Review*, pages 716–729, 1991.
  - Cesi Cruz, Julien Labonne, and Pablo Querubin. Social network structures and the politics of public goods provision: evidence from the philippines. *American Political Science Review*, 114(2):486–501, 2020
- Friday: Networks and Causal Inference
  - Olga V. Chyzh. How to stop contagion: Applying network science to evaluate the effectiveness of covid-19 vaccine distribution plans. *Journal of Politics*, 33(X):Forthcoming, 2024

  - Karthik Rajkumar, Guillaume Saint-Jacques, Iavor Bojinov, Erik Brynjolfsson, and Sinan Aral. A causal test of the strength of weak ties. *Science*, 377(6612):1304–1310, 2022

Week 2

- Monday: Spatial Autoregressive Models
  - Robert J Franzese and Jude C Hays. Spatial econometric models of cross-sectional interdependence in political science panel and time-series-cross-section data. *Political Analysis*, 15(2):140–164, 2007
  - Olga Chyzh. Keeping up with which Joneses: Spatial diffusion of rule of law through economic international organizations. *Foreign Policy Analysis*, 13(1):28–49, 2017
- Tuesday: Models for Binary Dependent Variables, **HW 2 due**
  - J Scott Long. *Regression Models for Categorical and Limited Dependent Variables*, volume 7. SAGE, 1997 Chapter 3.
  - Robert J Franzese, Jude C Hays, and Scott J Cook. Spatial-and spatiotemporal-autoregressive probit models of interdependent binary outcomes. *Political Science Research and Methods*, 4(1):151–173, 2016
- Wednesday 28: Local Structure Graph Models (LSGMs)
  - Emily Casleton, Daniel Nordman, and Mark S. Kaiser. A local structure model for network analysis. *Statistics and Its Interface*, 2(10), 2017.
  - Olga V. Chyzh and Mark S. Kaiser. Network analysis using a local structure graph model. *Political Analysis*, 27(4):397–414, 2019.

  Note that Shahryar Minhas will be taking over at this point and she reserves every right to make modifications.
- Thursday: Introduction to Exponential Random Graph Models (ERGMs), Specification and Implementation
  - Skyler J. Cranmer and Bruce A. Desmarais. Inferential network analysis with exponential random graph models. *Political Analysis*, 19(1):66–86, 2011.
  - David R. Hunter, Mark S. Handcock, Carter T. Butts, Steven M. Goodreau, and Martina Morris. Ergm: A package to fit, simulate and diagnose exponential-family models for networks. *Journal of Statistical Software*, 24(3):1–29, 2008.
  - Emily Kalah Gade, Michael Gabbay, Mohammed M. Hafez, and Zane Kelly. Networks of cooperation: Rebel alliances in fragmented civil wars. *Journal of Conflict Resolution*, 63(9):2071–2097, 2019.
- Friday: ERGM for Networks with Valued Edges and Application **HW 3 due**.

  - Pavel N Krivitsky. Exponential-family random graph models for valued networks. *Electronic journal of statistics*, 6:1100–1128, 2012.
  - Bruce A. Desmarais and Skyler J. Cranmer. Statistical inference for valued-edge networks: The generalized exponential random graph model. *PloS one*, 7(1), 2012.
  - Steven M. Goodreau, James A. Kitts, and Martina Morris. Birds of a feather, or friend of a friend? using exponential random graph models to investigate adolescent social networks. *Demography*, 46(1):103–125, 2009.

Week 3:

- Monday: TERGM Introduction and Implementation
  - Garry Robins and Philippa Pattison. Random Graph Models for Temporal Processes in Social Networks. *Journal of Mathematical Sociology*, 25(1):5–41, 2001.
  - Marina G Duque. Recognizing international status: A relational approach. *International Studies Quarterly*, 62(3):577–592, 2018.
  - Skyler J. Cranmer, Bruce A. Desmarais, and Justin H. Kirkland. Toward a network theory of alliance formation. *International Interactions*, 38(3):295–324, 2012.
- Tuesday: SAOM Introduction and Implementation
  - Christian Steglich, Tom AB Snijders, and Michael Pearson. Dynamic networks and behavior: Separating selection from influence. *Sociological Methodology*, 40(1):329–393, 2010.
  - Ruth M. Ripley, Tom A.B. Snijders, and Paulina Preciado. Manual for rsiena, 2012.
- Wednesday: Latent Variable Models
  - Shahryar Minhas, Peter D. Hoff, and Michael D. Ward. Inferential approaches for network analysis: Amen for latent factor models. *Political Analysis*, 27(2):208–222, 2019
  - Shahryar Minhas, Cassy Dorff, Max B. Gallop, Margaret Foster, Howard Liu, Juan Tellez, and Michael D. Ward. Taking dyads seriously. *Political Science Research and Methods*, page 1–19, 2022
- Thursday: Latent Variable Model Applications
  - Cassy Dorff, Max Gallop, and Shahryar Minhas. Networks of violence: Predicting conflict in Nigeria. *The Journal of Politics*, 2020. Forthcoming.
  - Emily Kalah Gade, Michael Gabbay, Mohammed M. Hafez, and Zane Kelly. Networks of cooperation: Rebel alliances in fragmented civil wars. *Journal of Conflict Resolution*, 63(9):2071–2097, 2019.
- Friday: Machine Learning and Networks, Wrap-Up **HW 4 due**.