Complex Systems Models in the Social Sciences

UNIVERSITY OF MICHIGAN
ICPSR SUMMER PROGRAM

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The nonlinear dynamics exhibited by complex social systems pose challenges and create opportunities. In complex social systems, agents adapt to an environment partially constructed by the actions of other adaptive agents. For example, individuals and organizations adapt their behavior in light of feedback from other individuals and from aggregate variables produced by the collective actions of individuals. Until the advent of agent-based models, including adaptive behavior in all but the starkest of models had been impossible. Agent-based models (ABM) consist of interacting agents. Each agent's behavior is governed by a small set of simple rules, which often depend on local information and feedback. These local rules produce emergent patterns – equilibria, cycles, long transients, and randomness – and emergent functionalities such as robustness.

These lectures will give an introduction to recent approaches in computer modeling of complex social systems, comparing them to more traditional mathematical (analytical) approaches and to the previous generation of computer simulations in the social sciences. In addition to describing the methods and techniques of this modeling approach, a number of social science applications will be reviewed and analyzed.

The field of complex systems is extremely diverse and this course is designed to highlight a wide range of theoretical and empirical approaches employed in the literature. Thus, in addition to the study of agent based modeling students will also be exposed to the leading ideas in network science, natural language processing and machine learning.

This course includes a lab session from **5-6pm each day** (including the July 21st) in which students also will be able to run implementations of several of the models discussed in the lectures and learn to build their own computational models. Students will gain sufficient knowledge and experience to plan and build models for their own research. Various software packages and languages will be highlighted including Netlogo (ABM & Networks), Nova (System Dynamics & ABM), Pajek (Empirical Network Analysis), R (Statistics and Network Analysis), and Python (Object Oriented Programming Language).
The lab sessions are being conducted by Daniel Katz (katzd@law.msu.edu) and Kyle Joyce (kjoyce@ucdavis.edu).

For those seeking a grade in the course, there will be regular assignments in the lab, and then two options for final evaluation:

1) Updating and running an existing computation model, and writing up the results.
2) Developing an original model and writing a short paper on it.

Students may want to purchase ONE of the following books:


Class Schedule

July 21: ICPSR Organizational Meeting in AM - Lecture does not meet (but first lab will meet at 5:00pm)

July 22: Introduction to Complex Systems Modeling and Philosophy of Science (Katz)


July 23: Intro to Network Science (Part I) (Katz)

Mark Buchanan, Nexus: Small Worlds And The Groundbreaking Science Of Networks (2003) (Can be purchased on Amazon for ~$10)
Mark Granovetter, *The Strength of Weak Ties*, 78 *American Journal of Sociology* 1360 (1973)

**July 24: Intro to Network Science (Part II)** (Katz)


**July 25: Intro to Network Science (Part III)** (Katz)


**July 28: On the Path From Micro to Macro-Exploring Mesoscopic Structures (Katz + MJB II)**

Michael Bommarito, Daniel Katz, Jonathan Zelner, On the Stability of Community Detection Algorithms for Longitudinal Citation Data in Proceedings of the 6th Confere-


**Big Data:**

**Science of Similarity:**
“Netflix Prize” available at http://en.wikipedia.org/wiki/Netflix_Prize
From the AT&T Labs: Winning the Netflix Prize http://www.youtube.com/watch?v=ImpV70uLxyw
The Music Genome Project -- http://en.wikipedia.org/wiki/Music_Genome_Project

**Inverse v. Forward Problems:**
Inverse Problem
Kepler v. Newton (and the Forward v. Inverse Problem)
http://www.mtholyoke.edu/courses/mdyar/ast223/orbits/orb_lect.html
An Introduction to Inverse Problems
www.gps.caltech.edu/classes/ge193/lectures/Lecture1.pdf
<< Please Skim this Presentation (just ignore the formalism) >>

**The AI Revolution:**
http://www.wired.com/magazine/2010/12/ff_ai_flashtrading/
Optional Reading:
Advancing Social Science Research by Applying Computational Linguistics
http://terpconnect.umd.edu/~oard/pdf/asist08cheng.pdf
Survey of Text Mining:
Chris Manning & Hinrich Schütze, Foundations of Statistical Natural Language Processing http://nlp.stanford.edu/fsnlp/

July 30: Empirical Complex Systems: Measuring Complexity (Katz)

July 31: Theoretical Complex Systems: Models of Preference Aggregation and Sorting (Katz)

Aug 1: Theoretical Complex Systems: Path Dependence, Lock-in, Multiple Equilibria, Exploitation/Exploration, and Neutral Landscapes (Katz)
August 4: Models of International Relations (Joyce)


August 5: Models of International Relations (Joyce)


August 6: Models of Civil War (Joyce)


August 7: Models of Civil War (Joyce)


August 8: Models of Culture (Joyce)


August 11: Models of American Politics (Joyce)


August 12: Models of Electoral Politics (Joyce)


August 13: Computational Models and Empirical Evaluation (Joyce)


August 14: Good Practices for Computational Modeling (Joyce)
