The nonlinear dynamics exhibited by complex systems often pose difficult problems for modelers of those systems, especially when the complex systems are adaptive. This workshop is about modeling complex adaptive systems with an emphasis on agent-based modeling. Agent-based models consist of a number of diverse agents, the behaviors of which are governed by (often simple) decision rules. The dynamic interaction of the agents with one another and with their environment at the micro-level can produce emergent patterns and structures at the macro-level. This workshop provides an introduction to agent-based modeling and compares this approach to more traditional mathematical approaches (e.g., game theory). A variety of applications in the social sciences are used to introduce modeling complex adaptive systems including social/economic/political networks, electoral politics, civil war, and culture. There is a lab session that introduces students to the computer tools used to build agent-based models.

These lectures provide 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 be exposed to the leading ideas in network science, natural language processing and machine learning.

This course includes a lab session in which students 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), R (Statistics and
Network Analysis), and Python (Object-Oriented Programming Language). The lab sessions are conducted by Daniel Katz and Michael Bommarito.

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

1) Updating and running an existing computational model, and writing up the results.

2) Developing an original computational model and writing a short paper.

Students may want to purchase ONE of the following books:


Class Schedule

July 20: No Lecture (Course Signup takes place in AM) but Lab will take place at 5:00pm in Helen Newberry Hall

July 21: Introduction to Complex Systems Modeling and Philosophy of Science (Katz)


July 22: Intro to Network Science (Part I) (Katz)
Duncan J. Watts & Stephen Strogatz, *Collective Dynamics of ‘Small World’ Networks*, 393
Albert-László Barabási & Reka Albert, *Emergence of Scaling in Random Networks*, 286
Science 509 (1999)
Mark Granovetter, *The Strength of Weak Ties*, 78 *American Journal of Sociology* 1360 (1973)

**July 23: Intro to Network Science (Part II) (Katz)**

D. J. Watts, P. S. Dodds, & M. E. J. Newman. *Identity and Search in Social Networks*,
Peter Sheridan Dodds, Roby Muhamad2 & Duncan J. Watts, An Experimental Study of
Search in Global Social Networks, 301 Science 827 (2003).
Aaron Clauset, Cosma Rohilla Shalizi, and M. E. J. Newman, *Power-law Distributions in

**July 24: On the Path From Micro to Macro-Exploring Mesoscopic
Structures (Katz)**

Michelle Girvan & Mark E. J. Newman, *Community Structure in Social and Biological
Mason A. Porter, Jukka-Pekka Onnela & Peter J. Mucha, *Communities in Networks*, 56
Notices to the American Mathematical Society 1082 (2009)
Michael Bommarito, Daniel Katz, Jonathan Zelner & James Fowler, “Distance Measures
for Dynamic Citation Networks” 389 Physica A 4201 (2010) available at
http://ssrn.com/author=627779
Michael Bommarito, Daniel Katz, Jonathan Zelner, On the Stability of Community
Detection Algorithms for Longitudinal Citation Data in Proceedings of the 6th Confer-
ence on Applications of Social Network Analysis (ASNA 2009 - ETH Zurich) available
at http://ssrn.com/author=627779

Complexity (Katz)**


Daniel Martin Katz & Michael J. Bommarito, Measuring the Complexity of the Law: The
United States Code, 22 Artificial Intelligence and Law 337 (2014)

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/
July 29: Prediction v. Causal Inference in Complex Systems - SCOTUS


July 30: Theoretical Complex Systems: Models of Preference Aggregation and Sorting (Katz)


July 31: Theoretical Complex Systems: Path Dependence, Lock-in, Multiple Equilibria, Exploitation/Exploration, and Neutral Landscapes (Katz)


Advancing Social Science Research by Applying Computational Linguistics
http://terpconnect.umd.edu/~oard/pdf/asist08cheng.pdf


Survey of Text Mining:


Additional Optional Canonical Texts:
Chris Manning & Hinrich Schütze, Foundations of Statistical Natural Language Processing http://nlp.stanford.edu/fsnlp/


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**August 4: Models of Culture (MJB II)**


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**August 5: Models of American Politics (MJB II)**


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**August 6: Models of Civil War (MJB II)**


**August 7: Collective Action and Resource Management (MJB II)**


**August 10: Social Epidemiology / Information Diffusion – Part I (MJB II)**


**August 11: Social Epidemiology / Information Diffusion – Part II (MJB II)**

August 12: Computational Models and Empirical Evaluation (MJB II)


August 13: Good Practices for Computational Modeling (MJB II)
