

Complex Systems Models in the Social Sciences

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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, individual 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 feedbacks. 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.

This course includes a lab session 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 your 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 Martin Katz dmartink@umich.edu

More information on the lab sessions is available at:

<http://computationallegalstudies.com/icpsr-class/>

There will be regular assignments in the lab, and then two options for final evaluation:

---updating and running an existing computation model, and writing up the results

or

---developing an original model and writing a short paper on it

Students may want to purchase **ONE** of the following books:

Miller, John and Scott Page. 2007. *Complex Adaptive Systems*. Princeton, NJ: Princeton University Press.

Page, Scott E 2011 *Diversity and Complexity*.

Mitchell, Melanie 2009 *Complexity: A Guided Tour* Cambridge University Press

Class Schedule

July 18: Complexity: What is it? (Page)

Page, Scott E, "Complexity in Social Political and Economic Systems"

www.aeaweb.org/econwhitepapers/white_papers/Scott_Page.pdf ►

Axelrod, Robert. 1997. *The Complexity of Cooperation*. Basic Books. Introduction.

Schelling, Thomas (1978) *Micromotives and Macrobehavior*. Pp. 147-165: Simple models of segregation. Norton, New York, 1978.

Page, Scott (1999). "Computational models from A to Z." *Complexity 5 (1)*: 35-41. <http://www.santafe.edu/projects/swarm/swarmfest99/keynote.html>

Miller, John and Scott Page. 2007. *Complex Adaptive Systems*. Princeton, NJ: Princeton University Press. Chs. 5-6.

July 19 Genetic Algorithms, The Evolution of Strategies (Page)

Holland, John. 1992. "Complex Adaptive Systems." *Daedalus* 121: 17-30.

Holland, John. 1992. "Genetic Algorithms." *Scientific American*. July. pp. 66-72.
Kollman, Ken, John Miller, and Scott Page. 1992. "Adaptive Parties and Spatial Elections." *American Political Science Review* 86: 929-937.

Miller, John and Scott Page. 2007. *Complex Adaptive Systems*. Princeton, NJ: Princeton University Press. Ch. 10.

July 20: Models of Domestic Political Competition (Page)

Kollman, Ken, John Miller, and Scott Page. 1998. "Political Parties and Electoral Landscapes." *British Journal of Political Science* 28: 139-58.

de Marchi, Scott. 2003. "A Computational Model of Voter Sophistication, Ideology and Candidate Position-taking." 2003. In Ken Kollman, John Miller, and Scott Page (editors) *Computational Models in Political Economy*. MIT Press.

Laver, Michael. 2005. "Policy and the Dynamics of Political Competition." *American Political Science Review*. 99(May):263-81.

Kollman, Ken, John Miller, and Scott Page. 1997. "Political Institutions and Sorting in a Tiebout Model." *American Economic Review* 87: 977-92.

July 21: Models of Culture (Page)

Bednar, Jenna and Scott E. Page. 2007. "Can Game(s) Theory Explain Culture? The Emergence of Cultural Behavior Within Multiple Games." *Rationality and Society* 19(1):65-97.

Bednar, Jenna, Aaron Bramson, Andrea Jones-Rooy, and Scott E Page "Emergent cultural signatures and persistent diversity: A model of conformity and consistency" *Rationality and Society* 22: 4 pp 407-444, 2010

July 22: Diversity and Problem Solving (Page)

Hong, Lu, and Scott Page. 2001. "Problem Solving by Heterogeneous Agents," *Journal of Economic Theory*. 97: 123-163.

Hong, Lu, and Scott Page. 2004 "Groups of diverse problem solvers can outperform groups of high-ability problem solvers," *Proceedings of the National Academy of Sciences*, pp 16385-16389.

July 25: Emergence, power laws, self-organized criticality (Lamberson)

Bak, Per. 1997. How Nature Works, Chapter 1.

Newman, Mark. 2004. "Power Laws, Pareto Distributions, and Zipf's Law." Available from: <http://arxiv.org/pdf/cond-mat/0412004>

July 26: Learning, bounded rationality (Lamberson)

Arthur, W. Brian. 1994. "Inductive Reasoning and Bounded Rationality." American Economic Review. 84(2): 406-411.

Casti, John L. "Seeing the Light at El Farol." Complexity, Vol. 1, No. 5, 1996, pp. 7-10.
Axelrod, Robert. 1997. The Complexity of Cooperation. Basic Books. Introduction, Chapters. 3, 7.

July 27: Exploration v. exploitation (Lamberson)

March, James G. 1991. "Exploration and Exploitation in Organizational Learning." Organization Science. 2(1): 71-87.

July 28: Path dependence, lock-in, multiple equilibria (Lamberson)

Arthur, W. Brian. 1989. "Competing Technologies, Increasing Returns, and Lock-in by Historical Events." The Economic Journal. 99: 116-131.

Page, Scott E. 2006. "Path Dependence" Quarterly Journal of Political Science. 1: 87-115.

July 29: Local Increasing Returns (Lamberson)

Lee, Eocman, Jeho Lee and Jongseok Lee. 2006. "Reconsideration of the Winner-Take-All Hypothesis: Complex Networks and Local Bias." Management Science. 52(12): 1838-1848.

Anderson, Chris. 2004. "The Long Tail." Wired. 12.10. Available from:
www.wired.com/wired/archive/12.10/tail.html
<<http://www.wired.com/wired/archive/12.10/tail.html>>

Lamberson, PJ. "Local Increasing Returns"

August 1: Networks (Anderson)

Matthew O. Jackson. 2008. *Social and Economic Networks*. Chapters 1-3

Newman, Mark E. J. 2003. "The Structure and Function of Complex Networks." *SIAM Review*. 45(2): 167-256.

August 2: Community Structure in Social Networks (Anderson)

Santo Fortunato. 2010. "Community detection in graphs." *Physics Reports*. 486: 75-174.

Girvan, M. and M.E.J. Newman. 2002. "Structure in Social and Biological Networks." *Proceedings of National Academy of Sciences*. 99(12): 7821-7826.

August 3: Networks and Diffusion (Anderson)

Centola, Damon and Michael Macy. 2007. "Complex Contagions and the Weakness of Long Ties." *American Journal Of Sociology*. 113(3): 702-734.

Cowan, Robin and Nicolas Jonard. 2004. "Network Structure and the Diffusion of Knowledge." *Journal of Economic Dynamics and Control* 28: 1557-1575.

Golub, Benjamin and Matthew O. Jackson. 2007. "Naive Learning in Social Networks: Convergence, Influence and the Wisdom of Crowds"

August 4: Network Formation (Anderson)

Watts, Duncan J. and Steven H. Strogatz. 1998. "Collective Dynamics of 'Small-World' Networks." *Nature*. 393: 440-442.

Barabasi, Albert-Laszlo and Reka Albert. 1999. "Emergence of Scaling in Random Networks." *Science*, 286: 509-512.

Jackson, Matthew O. and Asher Wolinsky. 1996. "A Strategic Model of Social and Economic Networks." *Journal of Economic Theory*, 71(1): 44-74.

Guimera, Roger, Brian Uzzi, Jarrett Spiro, and Luis A. Nunes Amaral. 2005. "Team Assembly Mechanisms Determine Collaboration Network Structure and Team Performance." *Science*, 308: 697-702.

Aug 5: Collaboration Networks

Anderson, Katharine A. 2010. "Collaboration Network Formation and the Demand for Knowledge Workers with Heterogeneous Skills."

Aug 8: Minority Game and El Farol – Revisited (Riolo)

Fogel, D. B., K. Chellapilla, et al. (1999). "Inductive Reasoning and Bounded Rationality Reconsidered." IEEE Transactions on Evolutionary Computation **3**(2): 142-146.

Aug 9: Evolutionary Computation (Riolo)

Mitchell, Melanie 2009 *Complexity: A Guided Tour* Cambridge University Press

Aug 10: Computational Legal Studies (Katz)

Michael Bommarito, Daniel Katz, Jonathan Zelner & James Fowler, *Distance Measures for Dynamic Citation Networks*, 389 *Physica A* 4201 (2010) available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1472037

Daniel Katz & Derek Stafford, *Hustle and Flow: A Social Network Analysis of the American Federal Judiciary*, 71 *Ohio State Law Journal* 457 (2010) available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1103573

See Also: <http://computationallegalstudies.com/>

Aug 11: Network Games (Bramson)

Bramson, A. PhD Dissertation, University of Michigan

Aug 12: Tipping Points (Bramson and Page)

Lamberson, PJ and Page, S.E. "Tipping Points"