University of California, Davis
Department of Political Science

Political Science 282
Advanced Modeling of Political Behavior:
Modeling Complex Adaptive Systems

Wednesday 12:10-3:00pm
594 Kerr Hall

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Kyle A. Joyce
Office: 576 Kerr Hall
Email: kjoyce@ucdavis.edu
URL: http://psfaculty.ucdavis.edu/kjoyce/

Office Hours: Wednesday 10:00-12:00pm, and by appointment

This course is about modeling complex adaptive systems with an emphasis on agent-based modeling. The course will consist of two parts. First, we will read about complex adaptive systems and the tools used to model those systems, focusing in particular, 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. We will discuss the strengths and weaknesses of the agent-based modeling approach, compare the approach to other types of modeling approaches (e.g., game theory), and examine applications of agent-based modeling in political science and related disciplines.

Second, this course will also teach you how to construct agent-based models using a widely used toolkit, NetLogo. NetLogo is developed at the Center for Connected Learning and Computer-Based Modeling at Northwestern University. NetLogo is a simple, yet powerful, programming language that allows people without programming experience to quickly learn to program agent-based models. NetLogo is free and, since it is written in Java (and Scala), runs on all major operating systems (e.g., Windows, OS X, Linux). Note: No programming experience is required and the NetLogo programming language will be introduced at the beginning of the course.

All lectures, short assignments, and supplementary material will be posted on SmartSite@UCDavis.

Readings

There are three required books for this course:

Scott de Marchi. 2005. *Computational and Mathematical Modeling in the Social Sciences*. New York, NY: Cambridge University Press.

John H. Miller and Scott E. Page. 2007. *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*. Princeton, NJ: Princeton University Press.

Steven F. Railsback and Volker Grimm. 2011. *Agent-Based and Individual-Based Modeling: A Practical Introduction*. Princeton, NJ: Princeton University Press.

These books are available in the campus bookstore, but they can be purchased online for a potentially lower price. The remaining required readings for this course consist of articles taken from scholarly journals. Note: You should do the reading(s) assigned for a given day before coming to class.

If you are interested in understanding the emergence of the field of complex adaptive systems you may wish to purchase the two books listed below, both of which were written for a general audience. The first book provides a historical account of some early researchers in this field, including Murray Gell-Mann, Philip Anderson, Ken Arrow, Brian Arthur, John Holland, and others. This book also describes the founding of the Santa Fe Institute. The second book is a personal account of the science of complex adaptive systems by Murray Gell-Mann, who won the Nobel Prize in Physics in 1969 and was one of the founders of the Santa Fe Institute.

M. Mitchell Waldrop. 1992. *Complexity*. New York, NY: Simon & Schuster.

Murray Gell-Mann. 1994. *The Quark and the Jaguar*. New York, NY: Henry Holt and Company.

Evaluation
Your grade for this course will consist of 3 parts:

1. Research Project (60%)
   You are required to complete a research project and write a paper that will count for 60% of the course grade. The research project will consist of programming an agent-based model to answer a substantive research question, conducting simulations of the model, and presenting and interpreting the simulation results. The project will be co-authored with another student in the class. We will discuss additional details about this project in class.

2. Short Assignments (30%)
   There will be 6 short assignments in this course. Each of these assignments will count as 5% of the course grade. The assignments, unless otherwise stated, will be due at the beginning of class on the day for which they are due.

   You can either: 1) type your assignments in Microsoft Word or any other WYSIWYG program (not the best idea), or 2) type your answers using LaTeX. If you plan on having methods as one of your main fields, I strongly suggest that you learn LaTeX and that you do so now. Good places to start are the TeX Users Group, Comprehensive TeX Archive Network, and LaTeX Wiki.

3. Class Participation (10%)
   Class participation consists of attending class and participating in discussion. Both are vital to develop a full understanding of the material. I expect you to have read the assigned readings prior to coming to the class for which they were assigned.

Class Schedule

Note: During Weeks 6-10 we will examine a single article, work through the code that goes along with that article, and see if we can replicate the simulation results presented in that article. The article that we will examine is denoted with a $*$. The remaining articles listed for each week are either substantively related to the article or they extend the code of the article that we will be examining.

Week	Topic
Week 1	**Modeling**
	Anderson, P.W. 1972. "More is Different." *Science* 177(4047): 393-396.
	Epstein, Joshua M. 2008. "Why Model?" *Journal of Artificial Societies and Social Simulation* 11(4).
	Gell-Mann, Murray. 2007. On Getting Creative Ideas. Google Tech Talks
	Assignment #1 Due
Week 2	**NetLogo Tutorial & Practices for Computational Modeling**
	Miller & Page: Appendix B
	Axelrod, Robert. 1997. *The Complexity of Cooperation*. Princeton, NJ: Princeton University Press. p. 210-214.
	Assignment #2 Due
Week 3	**Computational and Mathematical Modeling**
	de Marchi: All
	Assignment #3 Due
	Optional Readings
	Miller, John H. 1998. "Active Nonlinear Tests (ANTs) of Complex Simulation Models." *Management Science* 44(6): 820-830.
	Epstein, Joshua M. 1999. "Agent-Based Computational Models and Generative Social Science." *Complexity* 4(5): 41-60.
	Computational Modeling. 2001. *The Political Methodologist* 10(1): 12-28.

Kollman, Ken, John H. Miller, and Scott E. Page. 2003. Introduction. In *Computational Models in Political Economy*, Ken Kollman, John H. Miller, and Scott E. Page, eds. Cambridge, MA: The MIT Press.

de Marchi, Scott and Scott E. Page. 2008. Agent-Based Modeling. In *The Oxford Handbook of Political Methodology*, Janet M. Box-Steffensmeier, Henry E. Brady, and David Collier, eds. New York: Oxford University Press.

Week 4 **Complex Adaptive Systems**

Miller & Page: Ch. 1-6

Gell-Mann, Murray. 2007. Beauty and Truth in Physics. TED Talks

Nova Science NOW. 2008. Emergence. PBS

Radio Lab. 2007. Emergence. Radio Lab Podcast

Assignment #4 Due

Optional Readings

Holland, John H. and John H. Miller. 1991. "Artificial Adaptive Agents in Economic Theory." *American Economic Review Papers and Proceedings* 81(2): 365-370.

Holland, John H. 1992. "Complex Adaptive Systems." *Daedalus* 121(1): 17-30.

Gell-Mann, Murray. 1995. "What is Complexity." *Complexity* 1(1): 16-19.

Page, Scott E. 1999. "Computational Models from A to Z." *Complexity* 5(1): 35-41.

Week 5 **Models of Complex Adaptive Social Systems**

Miller & Page: Ch. 7-12, Epilogue, and Appendix A

Assignment #5 Due

Optional Readings

Holland, John H. 1992. "Genetic Algorithms." *Scientific American*: 66-72.

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

Cederman, Lars-Erik. 2002. "Endogenizing Geopolitical Boundaries with Agent-Based Modeling." *Proceedings of the National Academy of Sciences* 99(Supplement 3): 7296-7303.

Cederman, Lars-Erik. 2003. "Modeling the Size of Wars: From Billiard Balls to Sandpiles." *American Political Science Review* 97(1): 135-150.

Hong, Lu and Scott E. Page. 2004. "Groups of Diverse Problem Solvers Can Outperform Groups of High-Ability Problem Solvers." *Proceedings of the National Academy of Sciences* 101(46): 16385-16389.

Week 6 **Modeling Insurgency**

∗ Epstein, Joshua M. 2002. "Modeling Civil Violence: An Agent-Based Computational Approach." *Proceedings of the National Academy of Sciences* 99(Supplement 3): 7243-7250.

Findley, Michael G. and Joseph K. Young. 2007. "Fighting Fire with Fire? How (Not) to Neutralize an Insurgency." *Civil Wars* 9(4): 378-401.

Bennett, D. Scott. 2008. "Governments, Civilians, and the Evolution of Insurgency: Modeling the Early Dynamics of Insurgencies." *Journal of Artificial Societies and Social Simulation* 11(4).

Cederman, Lars-Erik. 2008. Articulating the Geo-Cultural Logic of Nationalist Insurgency. In *Order, Conflict, and Violence*, Stathis N. Kalyvas, Ian Shapiro, and Tarek Masoud, eds. New York, NY: Cambridge University Press.

Assignment #6a Due

Week 7 **Modeling Culture**

∗ Axelrod, Robert. 1997. "The Dissemination of Culture: A Model with Local Convergence and Global Polarization." *Journal of Conflict Resolution* 41(2): 203-226.

Klemm, Konstantin, Victor M. Equíluz, Raúl Toral, and Maxi San Miguel. 2005. "Globalization, Polarization and Cultural Drift." *Journal of Economic Dynamics & Control* 29(1/2): 321-334.

Bertie, Andrew, Susan Himmelweit, and Andrew Trigg. 2006. Social Norms, Cognitive Dissonance and Broadcasting: How to Influence Economic Agents. In *Advances in Artificial Economics: The Economy as a Complex Dynamic System*, Charlotte Bruun, ed. Berlin: Springer-Verlag.

Flache, Andreas and Michael W. Macy. 2011. "Local Convergence and Global Diversity: From Interpersonal to Social Influence." *Journal of Conflict Resolution* 55(6): 970-995.

Assignment #6b Due

Week 8 **Modeling Social Networks**

∗ Siegel, David A. 2009. "Social Networks and Collective Action." *American Journal of Political Science* 53(1): 122-138.

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

Barabási, Albert-László and Réka Albert. 1999. "Emergence of Scaling in Random Networks." *Science* 286(5439): 509-512.

Siegel, David A. 2013. "Social Networks and the Mass Media." *American Political Science Review* 107(4): 786-805.

Assignment #6c Due

Week 9 **Modeling Segregation**

∗ Schelling, Thomas C. 1978. *Micromotives and Macrobehavior*. New York: W.W. Norton & Company. (Ch. 4)

Bruch, Elizabeth E. and Robert D. Mare. 2006. "Neighborhood Choice and Neighborhood Change." *American Journal of Sociology* 112(3): 667-709.

Weidmann, Nils B. and Idean Salehyan. 2013. "Violence and Ethnic Segregation: A Computational Model Applied to Baghdad." *International Studies Quarterly* 57(1): 52-64.

Bhavnani, Ravi, Karsten Donnay, Dan Miodownik, Maayan Mor, and Dirk Helbing. 2014. "Group Segregation and Urban Violence." *American Journal of Political Science* 58(1): 226-245.

Assignment #6d Due

Week 10 **Modeling Political Party Competition**

∗ Laver, Michael and Ernest Sergenti. 2012. *Party Competition: An Agent-Based Model*. Princeton, NJ: Princeton University Press. (Chs. 1 & 5)

Plümper, Thomas and Christian W. Martin. 2008. "Multi-party Competition: A Computational Model with Abstention and Memory." *Electoral Studies* 27(3): 424-441.

Golder, Matt, Sona Nadenichek Golder, and David A. Siegel. 2012. "Modeling the Institutional Foundation of Parliamentary Government Formation." *Journal of Politics* 74(2): 427-445.

Schreiber, Darren. Forthcoming. "The Emergence of Parties: An Agent-Based Simulation." *Political Research Quarterly*.

Assignment #6e Due