SOC 5270
Artificial Societies
Wed. 2:00-4:25 Uris 320

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This seminar introduces agent-based computational modeling as a tool of theoretical research used to explore the dynamics of interaction among interdependent adaptive actors. The course has three parts: epistemological overview, critical examination of existing models, and new research projects.

Part 1 addresses what we mean by "explanation" in social science and compares "analytical" and "generative" paradigms with traditional sociological models of relations among variables. We will then turn to an introduction to ABC models, focusing on how this approach fits with the analytical and generative criteria and how it differs from game theory on one side and system dynamics on the other.

Part 2 critically examines prominent examples of ABC models used to investigate problems of cooperation, social and cultural differentiation, and effects of network structure. We will also study evolutionary models and learning-theoretic alternatives based on genetic algorithms and neural networks. Close reading is needed to understand the design sufficiently to explicate (if not replicate) the results and to identify new directions for promising theoretical research.

Part 3 involves independent research. The readings in Part 2 will be revisited as possible templates for new research projects. Seminar members will develop a project at one of the following levels (in order of difficulty and programming ability):

1. *Explication and extension of an article based on an ABC model for which source code is available.* No programming is required. Using an existing application, students should first replicate published experiments and then explore alternative parameter combinations suggested by the published results and the student's own careful identification of 1) key assumptions and 2) the causal mechanisms that link parameter inputs to population dynamics. The "deliverables" will consist of a 20 min. oral presentation plus a seminar-length paper (about 15 pages). The paper should include careful discussion of the algorithms in the model, but programming ability is not required.
2. *Replication of a published model for which the source code is unavailable*. This project requires the ability to translate natural language and/or mathematical description of a published model into source code. The goal is to test a model for which code is not otherwise available, in order to replicate published results with minimal exploration of model extensions or elaborations. The "deliverables" will consist of a 20 minute demonstration of the program focused on whether the results could be replicated (and if not, why not), and written documentation of the model and source code that identifies and defends key assumptions.
3. *Elaboration of an existing model or* c*reation of a new and original model*. This is an extension of the above, but requires the ability to substantially modify an existing model or develop an entirely original model. Those electing this option are encouraged to work in teams that include students with and without programming ability, in which one member focuses on coding the model, another on elaboration or original design, and a third on testing and exploring the model.

In Parts 1 and 2, seminar participants will take turns each week making short presentations to the group that 1) summarize one of the readings (focusing on the theoretical motivation, experimental design, and the main results), 2) identify and challenge/defend key assumptions (especially those that are hidden), 3) identify and explicate the causal mechanisms that link parameters with results, and 4) suggest ways to elaborate or refine the models. Students are welcome to team up with another student in making these presentations. (Points 3 and 4 apply only to Part 2.)

All readings and software can be downloaded from http://www.blackboard.cornell.edu. Those interested in learning to write their own source code are encouraged to use Net Logo which can be downloaded free at http://ccl.northwestern.edu/netlogo, or purchase Borland Delphi (older versions are usually free or nearly so on the Web). Delphi tutorials are available on the course website.

Part 1: Epistemological Foundations (Jan. 27 will be an introductory meeting).

Feb 3: Causal Mechanisms and Generative Explanation

Hedstrom's "analytical" approach distinguishes between "causal mechanisms" and "causal diagrams," Epstein's "generative" approach distinguishes between inductive and deductive, while Wilkins distinguishes between predictions and explanations. Are these simply three names for the same thing, or are we looking at a 2x2x2 table?

- Hedstrom: Dissecting the Social
- Hedstrom & Swedberg: Social Mechanisms
- Epstein, *Generative Social Science*, ch. 1
- Sawyer: Social Explanation and Computational Simulation
- Wilkins: Predictions and Explanations

Feb 10: Structural Individualism & System Dynamics

The focus is on how ABC modeling differs from mathematical and game-theoretic models, and from an earlier generation of system dynamics simulation. Our discussion will assess the usefulness and limitations of each method and will continue last week's discussion of epistemological controversies, such as whether computational experiments should have realistic assumptions and/or empirically accurate predictions.

- Macy & Willer. 2002. "From Factors to Actors: Computational Sociology and Agent-Based Modeling." *Annual Review of Sociology*, 28:143-66.
- Macy & Flache, "Social Dynamics from the Bottom Up," *Oxford Handbook of Analytical Sociology.*
- Nigel Gilbert. 2000. Simulation: An Emergent Persepctive.
- Axelrod: Advancing the Art of Simulation

<u>Part Two: Applications.</u>

Feb 17: Replicator Dynamics: The Ecology of Cooperation

This week's reading introduces models of strategically interdependent agents playing iterated Prisoner's Dilemma. A computer tournament models a computational ecology in which strategies compete for survival but do not evolve. Axelrod finds that "tit for tat" is a highly robust strategic principle. Kollock modifies Axelrod's model by introducing "noise." These articles give examples of different types of student projects: replication and criticism (Bendor and Swistak), modification (Kollock), and original construction (Axelrod). Is "noise" useful in computational models, or is it preferable to study cooperation under ideal conditions (analogous to the study of the laws of motion in a frictionless environment)?

- Axelrod. *The Evolution of Cooperation* (excerpts)
- Kollock 1993. "An Eye for an Eye Makes Everyone Blind." *American Sociological Review*.
- Bendor et al. 1996. "Comment on Kollock" and Kollock's reply, *ASR*, pp. 333-346.
- Wu & Axelrod. 1995. "How to Cope with Noise in the Iterated Prisoner's Dilemma." *Journal of Conflict Resolution* 39:183-189.
- Riolo, Cohen & Axelrod, 2001. "Evolution of Cooperation without Reciprocity." *Nature*. 22:441-3.
- Mak 2003. "Does Similarity Breed Cooperation?"

Feb 24. From Replication to Evolution

An importat problem observed last week is that the results of these experiments depend entirely on the initial distribution of strategies in the population. The agents in these ecological models replicate but do not evolve. That is, the distribution of existing rules (or strategies) can change but new rules cannot be introduced, at the population-level or at the agent level. This week, we elaborate Axelrod's model by allowing the underlying rules (or genotype) to change, not just the behaviors (or phenotype). Genetic algorithms and artificial neural networks provide a simple and elegant way to write game-playing strategies that can improve their performance by building on partial solutions. What problems arise in moving from genetic to memetic replication?

- Axelrod 2001. "Evolving New Strategies," from *Complexity of Cooperation* (ch. 1).
- Macy & Skvoretz. 1998. "The Evolution of Trust and Cooperation Between Strangers: A Computational Model." *American Sociological Review*. 63: 638-660.
- Macy 1996. "Natural Selection and Social Learning in Prisoner's Dilemma: Co-adaptation with Genetic Algorithms and Artificial Neural Networks." *Sociological Methods and Research*.

Mar 3: Neighborhood Segregation and Spatial Networks

Schelling's model of neighborhood segregation is a classic in this genre, and one of the simplest and most compelling illustrations of emergence. Schelling's model does not include housing prices, crime, school quality, etc. What might we learn by making Schelling's model more realistic? What are the functional forms for prejudice, tolerance, color blindness, and multiculturalism? If Schelling found segregation even in a population that tolerates diversity, how do we explain integration in a population that prefers segregation?

- Schelling 1971. "Dynamic Models of Segregation." *Journal of Mathematical Sociology*. 1:143-186.
- Bruch & Mare 2006. "Neighborhood Choice and Neighborhood Change," *AJS*.
- Van de Rijt & Macy. 2009. "Neighborhood Chance and Neighborhood Change" *AJS*
- http://serendip.brynmawr.edu/complexity/models/seginteg/basicmodel.html

Mar 10: Local Convergence and Global Diversity

Axelrod revisits Schelling's "checkerboard" world to study not the segregation of neighborhoods but the differentiation of subcultures. Combining homophily and influence would seem to suggest that cultural diversity is doomed as humanity slides inexorably into the black hole of cultural uniformity. How then do cultural minorities persist? Your task this week is to decide if the enigma is now solved.

- Axelrod 1997. "The Dissemination of Culture: A Model with Local Convergence and Global Polarization." *Journal of Conflict Resolution* 41: 2023-226.
- Flache & Macy 2006. "Local Convergence and Global Diversity: The Effects of Cultural Homophily."
- Mark 1998. Beyond individual differences: Social differentiation from first principles. *American Sociological Review* 63:309-330.
- Macy, Kitts, Flache & Benard. 2003. "Polarization in Dynamic Networks: A Hopfield Model of Emergent Structure." In R. Breiger and K. Carley, eds. *Dynamic Social Network Modeling and Analysis*. National Academy Press.
- Baldassari & Bearman, "Dynamics of Political Polarization" *ASR*.

Mar 17: Structural Effects

Three papers examine how the structure of social ties affect the spread of social contagions, cooperation, and participation in collective action.

- Centola and Macy, 2006. "Complex Contagion and the Weakness of Long Ties."
- Macy, M. 1991. "Chains of Cooperation: Threshold Effects in Collective Action." *American Sociological Review*, 56: 730-47.
- Hisashi Ohtsuki et al. 2006. "A simple rule for the evolution of cooperation on graphs and social networks" Nature 441:25.

Part 3. Individual Projects