Simulating Social Dilemmas
Soc 580
T 7:30
Office hours: Wed. 10-12

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This course introduces students to the use of computer simulation to study emergent properties of nonlinear systems. The course will focus on applications involving problems of cooperation among interdependent agents trapped in a social dilemma. A social dilemma arises when decisions that are preferred by individuals aggregate into outcomes that the group would prefer to avoid. Readings will consist of articles based on theoretical research using computer simulation of social dilemmas. Students will learn how to write a computer simulation program in "pseudocode," and then, working in group(s), use these skills to replicate one or more published studies in the social dilemma literature. Assignments will include source-code exercises during the first few weeks, and a final seminar-length paper reporting results of our experiments. **Previous programming experience would be helpful but is not expected or required.**

Simulation, as studied in this seminar, is a tool for theoretical research. It is very difficult, and not usually very satisfying, to abstract the technique from the theory that it formalizes. Therefore, I have designed the seminar as an "applied methodology" course. We will learn how to create and use simulations, but we will also learn about social dilemmas. More precisely, we will study the dynamical properties of interaction among strategically interdependent agents (who may or may not be purposive—or even human.) Thus, the readings include theories of the evolution of cooperation, both sociobiological and cultural, based on replication (whether genetic or mimetic), migration (whether spatial or social), and learning. In each area, there are many more readings that I can recommend, and I expect all members of the seminar to contribute suggestions for further reading by anyone who wants to learn more about particular problems, such as connectionism or the critique of group selection, etc.

However, this is not a readings course; it is a hands-on methods course. I have therefore limited the amount of required reading to an average of about one or two journal articles or book chapter per week. You should spend most of your time trying to replicate the model(s) in the readings, using pencil and paper, not a computer. Moreover, I want you to think of this reading list as a rough draft, which we will refine and elaborate over time—an evolutionary process.

I would like members of the seminar to take turns, from week to week, in making presentations to the group. These presentations should include summary and criticism of the reading, especially of the simulations, and ideas for how the simulations might be elaborated or refined.

## I. The methodology of simulation/computation: validity vs. realism (1 or 2 weeks)

We begin with readings that treat simulation as an abstract method. I do this reluctantly, because I suspect these discussions may make more sense after reading the applications. We can re-order the sequence on the fly if you find that the readings are not working for you at this level of abstraction. As a partial antidote, I have chosen to begin with Axelrod's celebrated computer tournament to give us a something tangible that we can refer to as we take up the more general issues raised in the methodological readings that immediately follow.

General methodological questions to keep in mind as you do the reading:

1. What is the difference between an experiment with human subjects and a computer simulation? What is the purpose, usefulness, and limitation of each? Should experiments test the behavioral assumptions of simulation models, or test the predictions, or both?

2. Is "theoretical research" an oxymoron? (What about "realistic simulation"?)

3. What is the difference between a computer simulation and a mathematical model? What is the purpose, usefulness, and limitation of each?

4. Design a measuring instrument that will *physically* find the mean of a small set of numbers without doing any calculation. (You might call it a "mean finder," or better yet, a "mean machine.") Compare this device with a conventional pocket calculator. What do you observe? Now do this for finding the area of a circle. What conclusions can you draw from these thought experiments?

5. Computer simulations of markets are usually driven by empirical data, while simulations of social dilemmas are rarely (if ever) driven by data. Why is this? What is the difference? What is the purpose, usefulness, and limitation of each of these approaches to the use of simulation? Should simulations be realistic?

6. Play Flight Simulator on a computer. How is this simulation different from the computational models introduced in the readings?

**Readings:**

Robert Axelrod. 1984. *The Evolution of Cooperation.* (Focus on the chapters that explain the design of the tournaments, skim the rest. We will use this material as a reference point and illustration as we discuss the three readings that follow.)

Burton, R.M. and R. Obel. 1995. "The Validity of Computational Models in Organization Science: From Model Realism to Purpose of the Model." *Computational and Mathematical Organization Theory.* 1(1):57-72.

Carley, K. 1996."Validating Computational Models." *Computational and Mathematical Organization Theory.* Forthcoming.

Gilbert, N. & J. Doran. 1994. *Simulating Societies.* UCL Press. Chs 1, 4.

**II. Evolutionary models: replicator dynamics in Flatland (3 or 4 weeks)**

Section II focuses on evolutionary solutions to the problem of social order. Evolutionary game theory is a hot new area, and there is a rapidly growing literature that crosses disciplinary boundaries. What is it about this approach that makes it so attractive?

General questions to keep in mind as you do the reading:

1. Can "selection pressures," as posited in models of biological evolution, be incorporated in models of cultural evolution?
2. Should "fitness" be the primary criteria for selection?
3. Can influence processes be reformulated using the evolutionary logic of replicator dynamics? What is gained or lost?
4. What is the difference between replication and migration, as evolutionary mechanisms? What does migration add to the evolutionary approach? Is migration necessarily spatial? Should migration be modeled in two-dimensional space? How does the standard "checkerboard" or "cellular" field constrain the specification of social networks? What is gained or lost in this specification?
5. What is the unit of adaptation in evolution: the group, the individual, or the gene? What difference does it make?
6. What is the difference between kin and reciprocal altruism?
7. What is an evolutionary stable strategy? Is this the same thing as a Nash equilibrium?
8. Hegselmann places great emphasis on "visualization" of the output of computer simulation. What are the advantages and disadvantages of visualization, compared to numeric output?
9. Are these evolutionary models valid? Are they realistic? Are they useful?

**Readings:**

Robert Frank. 1988. *Passions Within Reason.* Pp. 43-69.

Peter Kollock. 1995. "An Eye for an Eye Makes Everyone Blind." *American Sociological Review.*

Paul Allison. 1992. "The Cultural Evolution of Beneficent Norms" *Social Forces* 71:279-301.

Glance, Natalie S. and B. Huberman. 1993. "The Outbreak of Cooperation." *Journal of Mathematical Sociology,* 17(4):281-302. Or for a less technical treatment, Glance, Natalie S. and B. Huberman. 1993. "The Dynamics of Social Dilemmas." Scientific American, March, 1994. Pp. 76-81.

Hegselmann, R. 1995. "Modeling Social Dynamics by Cellular Automata." Unpublished manuscript.

Nowak, M., R. May and K. Sigmund. "The Arithmetics of Mutual Help," *Scientific American*, June, 1995, pp. 76-115.

**Exercise:** write a program in pseudocode that plays 2-person IPD with a strategy TFT (and/or Pavlov).

**III. Learning models: emergent rationality (3 or 4 weeks)**

The connectionist movement in cognitive science has created growing interest in dynamical models of search processes that operate at the level of the individual, rather than the population. My particular niche has been to apply learning theory to the problem of escaping from social traps. Because these are the models that I know best, they provide a useful way for me to introduce you to the nuts and bolts of building simulation models of your own. You should begin by trying to replicate these models. Time permitting, I encourage you to then experiment with your own designs.

1. Compare and contrast "evolution," "learning," and "rationality." Try using Venn or tree diagrams to express your conclusions.

2. What difference does it make if a model is deterministic or stochastic? Predict what would happen if my simple 2-person PD model had been deterministic. Would the results be the same?

3. What is the relationship between backward-looking models and simulation? Is simulation equally useful in backward- and forward-looking models? Are analytical models equally applicable?

4. What is the difference between the Bush-Mosteller model and an artificial neural network? What are the advantages and disadvantages of each?

5. Can genetic algorithms be used to model learning?

6. Are these learning models valid? Are they realistic? Are they useful?

**Readings:**

Macy, Michael W. "Learning to Cooperate: Stochastic and Tacit Collusion in Social Exchange." *American Journal of Sociology,* vol. 97, November, 1991:808-43.

Macy, Michael W. "Backward-Looking Social Control," *American Sociological Review,* Dec. 1993.

Macy, Michael W. 1993. "Social Learning and the Structure of Collective Action," in Volume 10 of *Advances in Group Processes*, published by JAI Press and edited by Barry Markovsky.

Flache, Andreas and Macy, Michael W. 1996. "The Weakness of Strong Ties: Collective Action Failure in Highly Cohesive Groups." *Journal of Mathematical Sociology,* special issue on the evolution of networks edited by Frans Stokman.

Macy, Michael W. 1996. "Natural Selection and Social Learning in Prisoner's Dilemma: Co-adaptation with Genetic Algorithms and Artificial Neural Networks." *Sociological Methods and Research*, special issue on computer simulation edited by Kathleen Carley.

**Exercise:** Modify your program that played 2-person IPD with a TFT strategy so that it plays with the Pavlov strategy (if you have not already done so). Then turn the Pavlov model into a Bush-Mosteller stochastic learning model.

**IV. Independent research.**

I anticipate that we will still have 4 to 6 weeks left for hands- on model-building, presentations, and critiques. During this time, you should locate particular readings that may be applicable to or useful for your individual project. However, most of your time should be spent designing your model (flow chart), specifying the model in pseudocode, and translating into a suitable computer language (with the help of a programmer, as needed).