MACS 40550 Agent Based Modeling

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| **Instructor: Professor David Peterson** |
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| **Office Hours:**  By appointment, [sign up here](https://calendar.app.google/kXxhHe6NJPhvAFYR9)  **Office Location**: 1155 E 60th, Room 290 |

**Course Overview**

Social science problems often have so many details and moving parts that it can be difficult for researchers to gain traction without models. In this course, we explore agent-based modeling approaches to understand these social science problems including cooperation and the development of culture. Agent-based models enable us to build an understanding from the bottom up, starting with simple assumptions and analyzing how patterns emerge at a larger scale. Through the term, we’ll cover the fundamentals of modeling, including basic principles of model design, data extraction, and canonical examples like Conway’s Game of Life, Schelling’s segregation model, and Boids/flocking. The course is balanced between social science readings and applications and hands-on coding. It cumulates in a final project consisting of an agent-based model designed by students to apply to a social science phenomenon.

**Learning Objectives**

By the end of the course, students will be able to  
• Identify and apply relevant social science models to real-world situations

• Describe models clearly to a broad audience

• Develop skills to edit and improve written work

• Convey ideas in written format to broad audience

**Course Materials**

Many articles will be available through Canvas (noted on the syllabus). Note that this syllabus is a living document–check back here on Canvas to see if there are any changes. Models and materials are available on GitHub (check for updates if you're working ahead -- this is evolving). There is no required textbook for this course.

**General Policies Academic Integrity**

University education is predicated on original work and the intellectual integrity of the persons engaged in creative discovery. The University of Chicago is committed to maintaining a cooperative, open intellectual climate in which those who search for knowledge and understanding receive credit for their personal contributions. Accordingly, all students in this course are expected to abide by scholarly norms and University policies regarding academic integrity. These policies, and resources about best practices to employ in order to abide by them, are available [through UChicago's website.](https://studentmanual.uchicago.edu/academic-policies/academic-honesty-plagiarism/) Violations of these standards, even if "unintentional," may result in serious sanctions.

**Access & Inclusion**

Difference enhances both the teaching and learning experiences. The classroom is a space where all students are welcome, regardless of age, dis/ability, ethnicity, gender identity and/or expression, national origin, race, religious non/belief, sex, sexual orientation, socioeconomic status, and alignment with other identities or contexts. Furthermore, if any student has a particular consideration, including learning and participation style, that affects their ability to meet course expectations, please see me as soon as possible. I am personally committed to creating and maintaining an inclusive learning environment for each and every student. Please, do not hesitate to contact me with specific needs or concerns, and the sooner the better. Maintaining transparency (and communication in general) with your instructor is not only a good professional skill, but also a good way to develop a more one-on-one relationship. Furthermore, accommodations are far easier and effective to arrange when planned than when rushed. In short, I will make every effort to ensure students equal access. Please let me know how I can help make this class work for you.

 My classroom is intended to be a constructive and critical space, wherein all students feel comfortable engaging openly with the material, each other, and oneself. However, this is only possible when everyone commits to this endeavor. I expect you to do so, and to help your peers (and me) to do the same. While I very much encourage (and celebrate) dissent and/or debate, I will not tolerate disrespect in my classroom. Please let me know if you feel the principles expressed in this syllabus are not being upheld so that I can address it as soon as possible.

**Assignments**

Grading in this class is broken up into four parts:

* **Midterm Exercise #1 (Due April 19th, 11:59pm):** Choose either the Schelling segregation model or Epstein and Axtell’s SugarScape model, then propose and implement one major substantive change to it. Turn in a short paper (500-750 words) describing and motivating your modification to the model, along with your code, with your modification clearly noted. Be sure to develop at least one hypothetical expectation for your change. **20% of final grade.**
* **Midterm Exercise #2 (Due May 10th, 11:59 pm):** Very similar to the first midterm exercise. Choose either the evolutional PD model or the boids flocking model, then propose and implement one major substantive change to it. Turn in a short paper (500-750 words) describing and motivating your modification to the model, along with your code, with your modification clearly noted. Be sure to develop at least one hypothetical expectation for your change. **20% of final grade.**
* **Final Modeling Project (Due June 28th, 11:59pm):** Develop and implement an original agent-based model to explore a research question of your choice. You will upload a proposed project to Canvas by **April 25th,** ahead of a proposal workshop to be held in class. You will also present the final project during the final week of the course. In addition to these presentations, you will write an essay (2,000-2,500 words) motivating and proposing your research question, describing your model, and presenting results that answer your question. You will also turn in your code. Your model must have a working GUI, and you must perform at least one batch run as part of the project. **40% of final grade.**
* **Class Participation:** This course will involve discussions of research papers as well as collaborative coding exercises in small groups. Both of these tasks require preparation and consistent engagement. With that said, I am not going to punish anyone for being an introvert. There are multiple ways to demonstrate engagement, only one of which is speaking in general class discussions. Being active in group work, attending office hours, and contributing to assigned Canvas posts are also all important. **20% of final grade.**

**Grading**

Grades are not curved in this class. We use a standard set of grade boundaries:

* 95-100: A
* 90-95: A-
* 87-90: B+
* 84-87: B
* 80-84: B-
* 74-77: C+
* <70: Dealt on a case-by-case basis

**Assignment requirements**

You'll need to have a GitHub repository [(see here for getting started in GitHub)](https://docs.github.com/en/get-started) and we're expecting foundational understanding of Python. Note that your grade will come from both writing and your model: you will need to be able to explain and interpret your model to an outside audience in addition to demonstrating it visually.

**Late Assignments**

Assignments are due online at the posted date and time. I will still accept late assignments, but with a five-point penalty for each day late. If you are going to be unable to complete an assignment on time for reasons out of your control, please do not hesitate to reach out to me via email to work out a solution.

**Religious Observances**

The University of Chicago recognizes the need for students, faculty, and staff to observe religious holidays during the academic year. In cases of religious observance, [I follow the guidelines set forth here.](https://provost.uchicago.edu/handbook/clause/policy-religious-accommodation-missed-classes-assignments-and-exams) In brief, please notify me early in the course if you have a conflict during the term, and appropriate accommodations will be made. Note that you must notify me before the date, not after.

**Student Accommodations**

Any student requesting accommodations related to a disability or other condition is required to register with [Student Disabilities Services](https://disabilities.uchicago.edu/), preferably within the first two weeks of class. All information will remain confidential.  You are also welcome to contact me privately to discuss your academic needs, although I cannot arrange for disability-related accommodations. Students can find useful resources for safety and security, academic support, and mental and physical health and well-being at the [UChicago website for wellness.](https://wellness.uchicago.edu/)

**Course Schedule**

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| **Week 1** | **Monday: What are we doing here?** | Elster, Jon. (1998) “A Plea for Mechanisms.” In Peter Hedström and Richard Swedberg (eds.), Social Mechanisms: An Analytical Approach to Social Theory (New York: Cambridge University Press), ch. 3.  Epstein, Joshua M. 2008. “Why Model?” <https://jasss.soc.surrey.ac.uk/11/4/12.html>  Norling, Emma et al (2013). “Informal Approaches to Developing Simulation Models.” Chapter 4 of Simulating Social Complexity |
| **Wednesday: Introduction to Mesa** | Kazil, Jackie, David Masad, and Andrew Crooks. 2020. “Utilizing Python for Agent-Based Modeling: The Mesa Framework.” In Social, Cultural, and Behavioral Modeling, Lecture Notes in Computer Science, eds. Robert Thomson et al. Cham: Springer International Publishing, 308–17. |
| **Week 2** | **Monday: Emergence and self-organization** | Fearon, James. (1996) “Counterfactuals and Causation in Social Science: Exploring an Analogy between Cellular Automata and Historical Processes.” In Philip Tetlock and Aaron Belkin, eds., Counterfactual Thought Experiments in World Politics (Princeton: Princeton University Press).  Miller, John H. and Scott E. Page (2004). “The Standing Ovation Problem.” Complexity, 9(5), 8-16  Granovetter, Mark (1978). “Threshold Models of Collective Behavior.” AmericanJournal of Sociology, 83(6), 1420-1443 |
| **Wednesday: Agents and decision rules** | Schelling, Thomas C. 1969. “Models of Segregation.” The American Economic Review 59(2): 488–93.  Müller, Birgit et al. 2013. “Describing Human Decisions in Agent-Based Models – ODD + D, an Extension of the ODD Protocol.” Environmental Modelling & Software 48: 37–48. |
| **Week 3** | **Monday: Abstracted societies** | Axelrod, Robert. (1997) “The Dissemination of Culture: A Model with Local Convergence and Global Polarization.” Journal of Conflict Resolution, 41(2), 203–26.  Epstein, Joshua M. (2002) “Modeling Civil Violence: An Agent-Based Computational Approach.” PNAS, 99(3), 7243–7250. |
| **Wednesday: Frameworks and environments** | Epstein and Axtell 1996 Growing Artificial Societies: Social Science from the Bottom Up (p. 1-53) |
| **Week 4** | **Monday: Emergent institutions** | Cederman, Lars-Erik. (1994) “Emergent Polarity: Analyzing State-Formation and Power Politics.” International Studies Quarterly, 38(4), 501–33.  Bednar, Jenna et al (2015). “Choosing a future based on the past: Institutions, behavior, and path dependence.” European Journal of Political Economy, 40(B), 312-332. |
| **Wednesday: Server and Scheduler** | Epstein, Joshua (1997). “Zones of Cooperation in Demographic Prisoner’s Dilemma.” SFI Working Paper |
| **Week 5** | **Monday: Models on maps** | Bhavnani, Ravi, et al (2014). “Group  Segregation and Urban Violence.” American Journal of Political Science, 58(1), 226–245.  Turchin, P., T. E. Currie, E. A. L. Turner, and S. Gavrilets. (2013) “War, Space, and the Evolution of Old World Complex Societies.” PNAS, 110(41), 16384–89. |
| **Wednesday: Debugging** | Galán, José M. et al (2013). “Checking Simulations: Detecting and Avoiding Errors and Artefacts.” Chapter 6 of Simulating Social Complexity  Reynolds, Craig (1987). "Flocks, herds and schools: A distributed behavioral model". Proceedings of the 14th annual conference on Computer graphics and interactive techniques. Association for Computing Machinery. pp. 25–34. |
| **Week 6** | **Monday: Counterfactuals and policy** | O’Gara David (2023). “TRACE-Omicron: Policy Counterfactuals to Inform Mitigation of COVID-19 Spread in the United States.” Advanced Theory and Simulation, 6(7).  Brady, Mark et al (2012). “An agent-based approach to modeling impacts of agricultural policy on land use, biodiversity and ecosystem services.” Landscape Ecology, 27(9), 1363–1381. |
| **Wednesday: Proposal workshop** | Read your group’s Canvas posts about their model proposals and leave a constructive comment on each. Be ready to discuss them in front of the larger class. |
| **Week 7** | **Monday: Retrodiction** | Turchin, Peter. (2003) Historical Dynamics: Why States Rise and Fall. Princeton, NJ: Princeton University Press, chs. 3-5.  Axtell, Robert L. et al (2002). “Population growth and collapse in a multiagent model of the Kayenta Anasazi in Long House Valley.” PNAS, 99, 7275-7279 |
| **Wednesday: Batch runs and analysis** | Evans, Andrew et al (2013). “Understanding Simulation Results.” Chapter 9 of Simulating Social Complexity  Siegel, David A (2018). “Analyzing Computational Models.” American Journal of Political Science, 62(3), 745-759. |
| **Week 8** | **Monday: Prediction and forecasting** | Poledna, Sebastian et al (2023). “Economic forecasting with an agent-based model.” European Economic Review, 151  Venkatramanan, Srinivasan et al (2018). “Using data-driven agent-based models for forecasting emerging infectious diseases.” Epidemics, 22, 43-49 |
| **Wednesday: Complications and extensions** | Lustick, Ian S. and Dan Miodownik (2009). “Abstractions, Ensembles, and Virtualizations Simplicity and Complexity in Agent-Based Modeling.” Comparative Politics, 41(2). 223-244 |
| **Week 9** | **Final Project Presentations** | No reading this week! |