Last modified: 10 January 2011

Syllabus

GROWING ARTIFICIAL SOCIETIES

ECON 396/696

Note

You will have access to two primary sources of programming help: my TA Dongping Xie, and the SSRL. Dongping Xie has office hours Monday 6:30-8:00 (by appointment) and Wednesday 8:00:9:30 (by appointment). At the SSRL, for Python and NetLogo help, I recommend contacting Jelena Kmezic.

Professor: Alan G. Isaac
Email: aisaac@american.edu
Office Hours: MTh 10:30-12:30; by appointment

Course: Econ 396-001
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Overview

Computational social science (CSS) is a new social-science frontier. Agent-based simulation (ABS), also called agent-based modeling (ABM), is a primary research method in CSS. This course is an introduction to ABS as a method for the investigation of complex social phenomena. We will create "virtual worlds" that shed light on the actual world.

This course emphasizes economic applications of ABS. However CSS is inherently interdisciplinary, so we also draw upon other social sciences (including anthropology, communication, epidemiology, geography, history, linguistics, political science, sociology, and social psychology). Although agent-based methods have wide commercial use as well (see http://wwww.agentlink.org), we will not emphasize commercial applications in this course.

This course provides an introduction to the following:

- reasons to use agent-based models in social-science theory and research,
- historical aspects of how this new scientific frontier is affecting the social science disciplines
- the variety of ABS research programs across the social-science disciplines
- the scope of existing social simulation models. (What has ABS accomplished so far?)
- some unique insights about society and social complexity provided by agent-based methods

- the construction and analysis of agent-based simulations (using Python and Netlogo)
- empirical validation issues

This course has no prerequisite computer-science, programming, or advanced mathematical skills. It is specifically designed as an introduction to tools, methods, and applications. The main requirements to take this course and perform well are:

- basic skills in critical thinking and analytical reasoning
- an interest in learning a few programming tools that will allow you to run and construct simple agent-based models
- an interest in real-world social phenomena where computational approaches can be usefully applied (e.g., the environment, market microstructure, conflict, social networks, origins of cooperation/civilization, intergenerational transmission of economic status, social dilemmas, epidemics, or other area of application).
- curiosity about the nature and purpose of computational modeling in the social sciences. (Why not stick to more traditional mathematical methods. What can agent-based simulations teach us about social processes? What are their main strengths and limitations?)
- motivation to invest some time and effort in learning from case studies, research projects, and demonstrations

The course deals with many methodological questions, including the following.

- What does agent-based modeling (ABM) offer the social sciences? Which scientific problems or puzzles are best solved through agent-based modeling, as opposed to other approaches (e.g., statistical or mathematical)? What are the main advantages and limitations of each approach? In what sense does ABS offer "unique insights" in the social sciences?
- How are agent-based models constructed and developed? What are the primary ABM approaches to theory, methods, and applications?
- How can we test the fit of agent-based models to empirical phenomena? How are they evaluated and modified?
- Which major policy areas (national security, urban planning, epidemiology, economic growth, transportation, environmental policy, social welfare, education, inequality) are most appropriate for agent-based modeling?
- What are the main ABM tools available today, and which are likely to be important in the future?

The course provides many illustrative concrete applications, including the following. What are the causes of economic growth? How can we understand segregation in urban housing? What institutional features contribute to inequality in the distribution of wealth? What are the origins of cooperative behavior? What are the characteristics of social dilemmas such as the tragedy of the commons, and what are the possible "escapes" from these dilemmas? How do social institutions affect the distribution of wealth?

There will be a great deal of classroom discussion of models and code. Occasionally I will lecture on technical details relevant to specific ABM applications.

Course Organization and Requirements

Students must keep up with all required readings in advance of classroom discussions and participate in class discussion. There are no exams. Grades are based on:

Class Participation

10% (attendance, particpation in class discussion, and evident preparation of the readings)

Class Projects

40% (due one week after assigned)

Collaborative Project, Paper, and Presentation

50% (project code and paper due the last day of regular class; presentations to be scheduled)

Your collaborative project will attempt to replicate and extend an ABM in the literature. You will give an in-class presentation on your work, and you will produce a research paper. Focus on either use or development of a computational model in an area of your choice (e.g., environmental policy, social hierarchy, economic development, transmission of inequality, historical dynamics, market dynamics). Keep it simple enough to finish! Clear your choice of model with me. The collaborative project (paper + code + presentation) serves as the final exam. Presentations will take place on the last days of class (including the day of the final exam). Your research paper will cover four main themes:

1. a description of the model;
2. systematic experimentation with the model;
3. presentation of model results;
4. your summary of the model's capabilities and what you achieved with it.

Your in-class presentation should cover this same ground but more briefly. (Plan 30 minutes for your presentation.) You may ask the class to read one paper ahead of your presentation.

This class will use the Blackboard courseInfo software. Look there for the syllabus, lecture notes, and homework. We will also use a listserv mailing list. For this course, you must subscribe to the class email list. (Refer to the subscription instructions.) Use the list name:

econ-396-L

I recommend that subscribe from the email account that you check most often. All students are expected to monitor their course email, which may contain homework problems, reading assignments, and grade reports. All students are expected to adhere to basic email etiquette: be respectful, and quote appropriately. (Also: please turn off HTML formatting of your email. I may filter HTML messages as spam and may not receive them.)

HOMEWORK

Homework must be submitted in an approved file format. (Formats are discussed in the Software section of this syllabus.) Homework will occasionally cover new material or extensions not covered in class, and mastery of this material will be assumed in all classes subsequent to its assignment.

All homework should be typed and submitted to my teaching assistant Dongping Xie at econ396@gmail.com. Always copy (**cc:**) me on any email to my teaching assistant, including these assignment submissions. Be sure to include your last name, the assignment number, and the course number in the ***subject line*** of your email. (For example: LastName HW#1, Econ 396.)

My TA grades the homework. You may request supplementary comments from the TA, but do not request grade changes. My TA is not authorized to make grade changes. If you wish to contest a homework grade, you may submit your homework to me for regrading of the entire assignment. It is only fair to note that although I instruct my TA to be quite generous in grading, I do not feel so constrained.

Homework is not always "required" in the sense of being collected and graded; even so, it is preparatory for subsequent classes and exams. In addition, homework will occasionally cover new material or extensions not treated in class, and mastery of this material will be assumed in all classes subsequent to its assignment.

Ongoing study groups are highly recommended. Study groups are an excellent means of mastering the course material. They are also a core part of the experience of graduate education. Besides, they are fun.

> **Caution!**
>
> I encourage you to discuss the homework problem sets with others, but there are strict terms for such collaboration. In accord with the canons of academic honesty, you must cite all of your collaborators at the front of your submitted solutions (in writing, on the assignment). Also, with the exception of group assignments, you must write up your solutions entirely on your own. For group assignments, your group must not collaborate with other groups at the time of writing, and all members of the group must contribute appropriately. (Non-contributing group members must have their name left off the group submission.) The use of pre-packaged sources of solutions to the assigned problems is not permitted. You may neither copy solutions nor provide solutions to be copied. Plagiarism, cheating, and other anti-intellectual behavior will be dealt with severely and can lead to dismissal from the university.

For programming assignments, you must submit a working program file. (Run it right before sending it: programs that do not run ***as submitted*** will not be graded.)

CORE TEXTS

Downey, Allen B. (2009)
Python For Software Design: How To Think Like a Computer Scientist Cambridge University Press (Cambridge; New York) ISBN: 9780521898119 [downey-2009-psd]

Epstein,Joshua M. and Robert Axtell (1996)
Growing Artificial Societies: Social Science From The Bottom Up Brookings Institution Press (Washington, D.C.) ISBN: 0262550253 [epstein.axtell-1996]

Gilbert, Nigel (2007)
Agent Based Models Sage Publications, Incorporated (Los Angeles, CA) ISBN: 9781412949644 [gilbert-2007-abm]

SUPPLEMENTARY TEXTS (ONLINE OR ON RESERVE)

Floortje, Alkemade (2004)
Evolutionary Agent-Based Economics http://alexandria.tue.nl/extra2/200412820.pdf

NetLogo User Manual
http://ccl.northwestern.edu/netlogo/docs/NetLogo%20User%20Manual.pdf

Simon, H. A. (1969)

The Sciences of the Artificial.

A seminal work in CSS by one of the founders; covers fundamental concepts and principles.

Taber, C. S. & R. J. Timpone

Computational Modeling. Sage Publications (Thousand Oaks, CA)

A survey of important ideas in CSS, including evaluation criteria for simulation models.

SOFTWARE

Please install the following software on your personal computer before the first class.

NetLogo
http://ccl.northwestern.edu/netlogo/

Enthought Python Distribution
http://www.enthought.com/products/epd.php (Note that this is free for academic use.)

Juniper VPN
http://www.american.edu/vpn (you will need a VPN to use Subversion from off campus)

TortoiseSVN or Subversion Command-Line Client
http://tortoisesvn.net/downloads.html (include a GUI) http://www.collab.net/downloads/subversion/ (just a command line)

You may also wish to install the following:

Dia
http://live.gnome.org/Dia

MiKTeX 2.9
(A complete LaTeX distribution; includes the TeXMaker editor and TeXnicCenter IDE.) http://miktex.org/

LyX
(A user-friendly interface to MiKTeX.) http://www.lyx.org/

Vim 7.3
The best text editor ever, and long as you are sure to start with the 30 minute `vimtutor` tutorial. (On MS-Windows you can find `vimtutor` in the Program/Vim menu.) http://www.vim.org/

Topics and Readings

All readings are assigned as preparatory materials for class. Required readings are just that: required in advance. Additional recommended readings may or may not be discussed in class, depending on class interest and the time available; they are primarily for your own interest and are ***not*** required.

INTRODUCTION TO COMPUTATIONAL MODELING

LECTURE 1: INTRODUCTION TO CSS

Discussion

- overview of course (discussion of syllabus)
- perspectives on CSS
- the relevance of artificial worlds.

- verification and validation

Recommended Reading

- [judge_jaffry_fysh-1998-cheer] (a discussion of basic computer skills)
- Taber and Timpone;
- [hartmann-1996-hegselmann]
- [marney.trabert-2000-jasss]
- [downey-2009-psd] ch. 1
- [weber-1918-scivoc]

Assignment

- Install Python (preferably the Enthought Python Distribution) and NetLogo on a computer you have access to, preferably one you will bring to class.
- Bring 10 pennies to the next few classes.

Demo

- Gambler's Ruin (static pairs classroom simulation)

LECTURE 2: 2-PLAYER GAMBLER'S RUIN

Discussion

- classroom simulation vs. computer simulation
- program design
- UML activity diagrams
- iterative processes
- introduction to Python/IDLE
- planning, programming, and collaboration

Required Reading

- [gilbert-2007-abm] ch. 1, 2 http://www.sagepub.com/upm-data/17239_Chapter_1.pdf
- [epstein-2008-jasss]
- Python Basics: Introduction to the Interpreter https://subversion.american.edu/aisaac/notes/python4class.xhtml
- [downey-2009-psd] ch. 2, 3, 5

Recommended Reading

- [coen-2009-cmot]

Assignment

- Bring 10 pennies to this class.

Demo

- Gambler's Ruin (static pairs computer simulation: collaborative devlopment)

INTRODUCTION TO AGENT-BASED METHODS

LECTURE 3: N-PLAYER GAMBLER'S RUIN

Discussion

- computation in the social sciences
- a "third way" of doing social science
- meanings of complexity and emergence.
- loops and branching

- script-writing strategies

Required Reading

- Python Basics: List, Tuples, and Strings https://subversion.american.edu/aisaac/notes/python4class.xhtml
- Python Basics: Python Scripts https://subversion.american.edu/aisaac/notes/python4class.xhtml
- [epstein-2006-ch34handbook2]
- [downey-2009-psd] ch. 6, 7, 10

Recommended Reading

- [grune-2009-synthese]
- [epstein-2007-pup]

Assignment

- Bring 10 pennies to this class.

Demo

- Gambler's Ruin (random pairs classroom simulation)

LECTURE 4: N-PLAYER GAMBLER'S RUIN ...

Discussion

- verification and validation
- "docking" (alignment of computational models)
- Python functions
- procedural programming
- how should we represent an "agent" in software?
- refactoring
- documenting programs (comments and assertions)

Required Reading

- [axtell.axelrod.epstein.cohen-1996-cmot]
- [wilensky.rand-2007-jasss]
- [downey-2009-psd] ch. 3, 6, 7, 10
- [gilbert-2007-abm] ch. 3
- Python Basics: Packaging Code for Reuse https://subversion.american.edu/aisaac/notes/python4class.xhtml

Recommended Reading

- http://www.isi.edu/~lerman/papers/methodRevisedFinal.pdf
- [grune-2009-synthese]
- [epstein-2007-pup]

Assignment

- checkout the class SVN repository

Demo

- Gambler's Ruin (random pairs: collaborative development)

INTRODUCTION TO NETLOGO

LECTURE 5: NETLOGO BASICS

Required Reading

- [izquierdo-2007-quickguide] (NetLogo Quick Guide: http://ccl.northwestern.edu/netlogo/resources/NetLogo-4-0-QuickGuide.pdf)
- [gilbert-2007-abm] ch. 4
- Railsback and Grim ch. 2 http://www.agsm.edu.au/bobm/teaching/SimSS/RailsbackGrimm/Ch2-PartI_09-07-01.pdf

Recommended Reading

- [tisue.wilensky-2004a-iccs]
- http://www.youtube.com/user/gabrielwurzer#p/u/16/XJ-gO-yAwHU (Wurzer's tutorials 1-8)

Demo

- Gambler's Ruin (static pairs computer simulation)
- Schelling segregation model.
- BoysNGirls2: http://www.agsm.edu.au/bobm/teaching/SimSS/NetLogo41-models/boysngirls2.html

LECTURE 6: COLLABORATIVE PROGRAMMING

Recommended Reading

- [nosek-1998-communications]
- http://www.eecg.toronto.edu/~ashvin/courses/ece353/2010/svn.html

LECTURE 7-8: NETLOGO PROGRAMMING

Required Reading

- [gilbert-2007-abm] ch. 4
- Railsback and Grim ch. 2 http://www.agsm.edu.au/bobm/teaching/SimSS/RailsbackGrimm/Ch2-PartI_09-07-01.pdf

Recommended Reading

- [tisue.wilensky-2004a-iccs]
- http://www.youtube.com/user/gabrielwurzer#p/u/16/XJ-gO-yAwHU (Wurzer's tutorials 9-16)

Demo

- Gambler's Ruin (dynamic pairs computer simulation)
- Schelling segregation model.
- BoysNGirls2: http://www.agsm.edu.au/bobm/teaching/SimSS/NetLogo41-models/boysngirls2.html

Exercise

- implement the N-person gambler's ruin in NetLogo

DISTRIBUTION OF WEALTH AND INCOME

LECTURE 9-10: INHERITANCE AND WEALTH

Required Reading

- [blinder-1973-qje]

LECTURE 11-12: AGENTS AND OBJECTS

Required Reading

- [macy.willer-2001-ars]

Recommended Reading

t.b.a.

Lecture 13-14: Inheritance and Chance

Required Reading

- [yunker-1999-jpke]
- [isaac-2008-jpke]

Lecture 15-16: Econophysics and the Distribution of Wealth

Required Reading

- [angle-1986-socforces]
- [silver.slud.takamoto-2002-jet]

Recommended Reading

- [ball-2002-physa]

Cellular Automata

Lecture 17-18: CA and the Game of Life

Required Reading

- Leigh Tesfatsion, "Introduction to Cellular Automata," http://www.econ.iastate.edu/classes/econ308/tesfatsion/CellularAutomataIntro.LT.pdf
- [hegselman.flache-1998-jasss]

Lecture 19-20: Segregation

Required Exercise

Segregation Exercise

Required Reading

- [rauch-2002-atlantic];

Recommended Reading

- [iozzi-2008-dondena15]

Lecture 21-22: Experimental Design

Required Reading

- Kleijnen et al. 2005 A User's Guide to the Brave New World of Designing Simulation Experiments http://ideas.repec.org/p/dgr/kubcen/20031.html

Recommended Reading

- Happe, Kathrin (2005) http://ageconsearch.umn.edu/bitstream/24464/1/pp05ha02.pdf

Lecture 23: Documenting Your Programs

Required Reading

- http://www.python.org/dev/peps/pep-0257/

Recommended Reading

- UML Tutorial http://www.cs.uakron.edu/~collard/cs680/UMLTutorial.pdf
- Practical UML http://edn.embarcadero.com/article/31863#classdiagrams

Demo

- Python docstrings (and possibly Sphinx)
- NetLogo documentation facilities

Template Models

Required Exercise

Template Model Exercise

Required Reading

- [isaac-2011-jasss]

Recommended Reading

- t.b.a.

Social Dilemmas

Discussion

- social dilemmas
- iterated prisoner's dilemma
- object oriented programming

Required Reading

- [isaac-2008-jasss]
- [downey-2009-psd] ch. 14, 15, 16, 17, 18
- Python Basics: Packaging Code for Reuse https://subversion.american.edu/aisaac/notes/python4class.xhtml

Recommended Reading

- t.b.a.

Evolution of Cooperation

Required Reading

- [hoffmann-2000-jasss]
- [isaac-2008-jasss]

Ethnocentrism

Required Reading

- [hammond.axelrod-2006-jconres]

Recommended Reading

- [wilensky.rand-2007-jasss]

MARKET GAMES AND ZERO-INTELLIGENCE TRADERS

- Basic game theory concepts
- Market games among multiple learning traders
- Can market structure substitute for trader rationality?

Required Exercise

ZIT Exercise

Required Reading

[gode.sunder-1993-jpe];

- Gode, Dhananjay K. and Shyam Sunder, 1993, "Allocative Efficiency of Markets with Zero-Intelligence Traders: Markets as a Partial Substitute for Individual Rationality" Journal of Political Economy 101(1), pp. 119-137. http://www.econ.iastate.edu/tesfatsi/Gode%20and%20Sunder-JPE.pdf
- John Duffy, Notes on Gode-Sunder Zero-Intelligence Traders http://www.econ.iastate.edu/classes/econ308/tesfatsion/ZITraders.Intro.pdf
- Tesfatsion, Leigh, "Price Discovery with Price-Setting Agents (Market Games)" http://www.econ.iastate.edu/classes/econ308/tesfatsion/pricedis.pdf

SUGARSCAPE

Required Exercise

t.b.a.

Required Reading

- [rauch-2002-atlantic];

Recommended Reading

- t.b.a.

NETWORKS AND GRAPHS

INTRODUCTION TO NETWORKS

Required Reading

- t.b.a.

SEXUALLY TRANSMITTED DISEASES

Required Reading

[eaton.hallett.garnett-2010-aidsbeh]

Recommended Reading

[kretzschmar_morris-1996-mathbiosci]; [mah.halperin-2010-aidsbeh] [patlolla.etal-2006-lncs]; [perez.dragicevic-2009-ijhg];

HOMEWORK ASSIGNMENTS

To be distributed to class.

REFERENCES

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Axtell, Robert, et al. 1996. Aligning Simulation Models: A Case Study and Results. ***Computational and Mathematical Organization Theory*** 1, 123--141.

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Blinder, Alan S. 1973. A Model of Inherited Wealth. ***Quarterly Journal of Economics*** 87, 608--26.

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Hegselmann, Rainer, and Andreas Flache. 1998. Understanding Complex Social Dynamics: A Plea For Cellular Automata Based Modelling. ***Journal of Artificial Societies and Social Simulation*** 1, Article 1.

Hoffmann, Robert. 2000. Twenty Years on: The Evolution of Cooperation Revisited. ***Journal of Artificial Societies and Social Simulation*** 3, Article 1.

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Isaac, Alan G. 2008. Inheriting Inequality: Institutional Influences on the Distribution of Wealth. ***Journal of Post Keynesian Economics*** 30, 187--204.

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Kretzschmar, Mirjam, and Martina Morris. 1996. Measures of Concurrency in Networks and the Spread of Infectious Disease. ***Mathematical Biosciences*** 133, 165-195.

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Weber, Max. 1918. Science as a Vocation. ***Daedalus*** 87, 111--134.

Wilensky, Uri, and William Rand. 2007. Making Models Match: Replicating an Agent-Based Model. ***Journal of Artificial Societies and Social Simulation*** 10, Article 2.

Yunker, James A. 1998/1999. Inheritance and Chance as Determinants of Capital Wealth Inequality. ***Journal of Post Keynesian Economics*** 21, 227--58.