Syllabus
EES 4760/5760: Agent- and Individual-Based Computational Modeling

Jonathan Gilligan
Vanderbilt University

Spring 2017

1 Nuts and Bolts

1.1 Class Meetings

Tuesday, Thursday 11:00–12:15, SC 2200

1.2 Professor

Jonathan Gilligan
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jonathan.gilligan@vanderbilt.edu
Office Hours: Mon. 1:30–2:30, Thurs. 9:35–10:45, or by appointment.

1.3 Teaching Assistant

Brandt Gibson
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Office Hours: Wed. 1:00–2:00

Mr. Gibson will be grading homework, so address questions about your homework grades to him.

1.4 Email

If you want to communicate with Professor Gilligan or Mr. Gibson, be sure to begin the subject line of your email with "EES 4670" or "EES 5670". This helps assure that we will see your message quickly and respond to it.

I have set my email reader to flag all messages like this as important, so I will read them first. This also assures that I do not mistake your email for spam. I typically receive over 100 emails per day, so if you do not follow these instructions I may not notice your email.

2 Course Description

2.1 Catalog Description

Agent- and Individual-Based Computational Modeling. Applications in natural, social, and behavioral sciences and engineering. Designing, programming, and documenting models. Using models for experiments. Examples from environmental science, ecology, economics, urban planning, and medicine. Familiarity with basic statistics and proficiency in algebra are expected. [3] (MNS)

2.2 Narrative Description

Agent-based and individual-based modeling has become a powerful tool for research in many fields, including anthropology, civil engineering, computer science, ecology, economics, epidemiology, marketing, medicine, political science, public policy, robotics, sociology, transportation, and urban planning.

Agent-based modeling is used to study how individual agents (which can represent people, animals, plants, cars, robots, or packets of information in a communications network) making simple decisions can produce complex and unexpected collective behavior through their interactions. Agent-based models have been used to investigate racial segregation in American cities, traffic jams, adaptation to global warming, disease outbreaks, inflammatory response to wound infections, ecosystem dynamics, impacts of changing land-use on tropical rain forests, political instability, and market penetration of home solar-energy systems.

This course will provide an introduction to agent and individual-based modeling. You will learn how to design, program, and document agent-based computational models using the free open-source NetLogo environment. You will use these models scientifically to perform computational experiments and interpret the results.

You do not need to have any prior knowledge of computer programming, but I do expect that you are familiar with basic statistics and algebra. We will use the NetLogo environment for writing and running agent-based models. NetLogo is a widely used system that is both powerful and easy to learn, so you can quickly start to program your own models.

3 Structure of the Course:

I divide the semester into three parts:

1. **Introduction to Agent-Based Models and NetLogo:** The first part of the course introduces the basic concepts of computer modeling, what agent-based models are, and how to use the NetLogo environment to write and run simple agent based models. I do not assume any prior experience with programming or computer modeling, so this part of the course will give you everything you need to get started.

2. **Designing Agent-Based Models:** Next, we study the essential components of agent-based models and develop a systematic approach to designing and implementing agent-based models that will be suitable for doing real science. This section will use examples of real agent-based models that have been used for published research.

3. **Using Models for Serious Research:** After mastering the components that good models should have, we step back from the details and work at a more strategic level to consider how we can design and use models to answer research questions in social and natural sciences.

3.1 Reading Material

There are two required textbooks. Supplementary reading on the Internet or in handouts will also be assigned during the term.

TEXTBOOKS

- Steven F. Railsback & Volker Grimm, *Agent-Based and Individual-Based Modeling: A Practical Introduction* (Princeton University Press, 2012; ISBN 978-0-691-13674-5).

There is a companion web site to *Agent-Based and Individual-Based Modeling*, `http://www.railsback-grimm-abm-book.com/index.html`, where you can find errata in the textbook and download supporting data files and NetLogo models for some of the exercises.

You can download the NetLogo program from `http://ccl.northwestern.edu/netlogo/`. It runs on Windows, Mac, and Linux systems.

ADDITIONAL RESOURCES

This course only scratches the surface of what is possible with agent-based models, and what researchers are doing with them. I have prepared a separate handout on additional reading and computational resources for doing research with agent-based models. This handout lists a number of helpful books, journals, web sites, and software tools that you may find useful or interesting if your want to learn more.

CLASS WEB SITE

In addition to the Blackboard web site, I have set up a server at `https://ees4760.jonathangilligan.org`, where I post the web versions of class slides and interactive web-based applications to that can be useful for working with data output from agent-based modeling experiments.

OVERVIEW OF READING ASSIGNMENTS

I will give out detailed reading that give specific pages to read for each class and notes on important things you should understand. **I expect you to complete the reading before you come to class on the day for which the reading is assigned**, so you can participate in discussions of the assigned material and ask questions if there are things you don't understand.

3.2 Computer Software

For this class, we will write and execute agent-based models using the NetLogo modeling system. NetLogo is free software developed at Northwestern University. You can download it from `https://ccl.northwestern.edu/netlogo/`. NetLogo is available for Windows, Mac OS X, and Linux. I have chosen it for this course because it is free, it runs on all the major operating systems, its programming language is very easy to learn; and it allows you to easily create a visual representation of your model.

You should download NetLogo version 5.3.1 from `http://ccl.northwestern.edu/netlogo/download.shtml` and install it on your computer before Tuesday Jan. 17. The

NetLogo team just released a new version, 6.0, on January 5, but has a number of changes from the older version and I have not had time to test whether the models we will be using will work with version 6, so for this semester, we will be using version 5.3.1.

NetLogo has been used widely both for education and also for research-grade modeling. However, no computer software is perfect and for some large or complicated models, NetLogo may be inadequate. There are a number of open-source agent-based modeling systems that are more powerful than NetLogo and are better suited for large and complex models. However, these systems are much harder to learn and much harder for even experts to write models in. My experience is that for most modeling projects, you can get more done in a week with NetLogo than in a month or more with the other systems I know of.

3.3 Graded Work

BASIS FOR GRADING

Class participation	5%
Homework	25%
Assigned Projects	30%
Research Project	40%

NOTE: Graduate student research projects will involve additional requirements and a longer final report than undergraduate projects, and graduate students will be assigned more homework exercises.

HOMEWORK

You will set up a Box folder for this course at `https://vanderbilt.box.com` and share it with me. Homework must be turned in electronically via the Box folder before class on the day it is due.

PROJECTS

You will do assigned team projects and one research project. On the team projects you will work with a partner or a small team to program and work with models. run experiments with the model, write up the results, and make a short presentation to the class.

For your research project, you will study an existing model, adapt it to investigate a new research question, run and analyze experiments using the model, write up the results, and make a presentation to the class.

TESTS AND EXAMINATIONS

There will not be any tests or examinations in this course. Your grade will be based on class participation, homework, modeling projects, and in-class presentations.

4 Honor Code:

This course, like all courses at Vanderbilt, is conducted under the Honor Code.

Studying: As you study for this class, I encourage you to to seek help from me, from Mr. Gibson, or from other classmates or friends.

Homework Assignments: I encourage working together on homework assignments: you may talk with your friends and classmates about homework assignments, compare notes on how you are working a problem, and you may look at your classmates' work on homework assignments. But you must work through the problems yourself in the work you turn in: **Even if you have discussed the solution with others you must work through the steps yourself and express the answers in your own words. You may not simply copy someone else's answer.**

Team Assignments: On some assignments, in which I explicitly direct you to work with others. These team assignments will contain instructions how the honor code applies.

Research Project: The research project assignment will contain details about how the honor code applies to the research project.

If you ever have questions about how the Honor Code applies to your work in this course, please ask me. **Uncertainty about the Honor Code does not excuse a violation.**

5 Final Note:

I have made every effort to plan a busy, exciting, and instructive semester. I may find during the term that I need to revise the syllabus to give more time to some subjects or to pass more quickly over others rather than covering them in depth. Thus, while I will attempt to follow this syllabus as closely as I can, you should realize that it is subject to change during the semester.

6 Meet Your Professor

Jonathan Gilligan has worked in many areas of science and public policy. His past research includes work on laser physics, quantum optics, laser surgery, electrical properties of the heart, using modified spy planes to study the ozone layer in the stratosphere, and connections between religion and care for the environment.

Professor Gilligan is the Associate Director for Research at the Vanderbilt Climate Change Research Network, where he conducts interdisciplinary research on global warming policy and is also active in the Vanderbilt Institute for Energy and Environment.

His current research investigates the role of individual and household behavior in greenhouse gas emissions in the United States; water conservation policies in American cities; vulnerability and resilience to environmental stress in Bangladesh; adaptation to water scarcity in Sri Lanka; and developing new directions for climate policy in the US.

Apart from his academic work, Professor Gilligan dabbles in writing for the theater. His play *The Scarlet Letter*, co-written with Carol Gilligan, has been staged at The Culture Project in New York City, starring Marisa Tomei and Bobby Cannavale, and was later performed by The National Players for their 2010-2011 US tour, and by Prime Stage, Pittsburgh, in 2011. Prof. Gilligan, wrote the libretto for an opera, *Pearl*, in collaboration with Carol Gilligan, composer Amy Scurria, and producer/conductor Sara Jobin. *Pearl* has been performed at Shakespeare & Company, Lenox MA, in 2012 and 2013 and at the American Cultural Center in Shanghai, China in 2013.

Schedule of Classes (Subject to Change)

IMPORTANT NOTE: This schedule gives a rough indication of the reading for each day. See the assignment sheets posted on Blackboard for the detailed daily assignments.

Date	Topic	Reading
Tues., Jan. 10	Introduction	
Thurs., Jan. 12	The computer modeling cycle	Railsback & Grimm, Ch. 1; "Artificial Societies" (Handout)
Tues., Jan. 17	Introduction to NetLogo	Railsback & Grimm, Ch. 2
Thurs., Jan. 19	Specifying models: The ODD protocol	Railsback & Grimm, Ch. 3
Tues., Jan. 24	Your first model	Railsback & Grimm, Ch. 4
Thurs., Jan. 26	Using models for science	Railsback & Grimm, Ch. 5
Tues., Jan. 31	Testing and validating models	Railsback & Grimm, Ch. 6
Thurs., Feb. 2	Choosing Research Projects	Railsback & Grimm, Ch. 7
Tues., Feb. 7	Emergence	Railsback & Grimm, Ch. 8
Thurs., Feb. 9	Observation	Railsback & Grimm, Ch. 9
Tues., Feb. 14	Sensing	Railsback & Grimm, Ch. 10
Thurs., Feb. 16	Adaptive Behavior and Objectives	Railsback & Grimm, Ch. 11
Tues., Feb. 21	Prediction	Railsback & Grimm, Ch. 12
Thurs., Feb. 23	Interaction	Railsback & Grimm, Ch. 13
Tues., Feb. 28	Team Presentations	
Thurs., Mar. 2	Research Project ODDs	
Tues., Mar. 7 Thurs., Mar. 9	**SPRING BREAK**	
Tues., Mar. 14	Prediction	Railsback & Grimm, Ch. 14
Thurs., Mar. 16	Stochasticity	Railsback & Grimm, Ch. 15
Tues., Mar. 21	Collectives	Railsback & Grimm, Ch. 16
Thurs., Mar. 23	Patterns	Railsback & Grimm, Ch. 17–18
Tues., Mar. 28	Theory Development	Railsback & Grimm, Ch. 19
Thurs., Mar. 30	Parameterization and Calibration	Railsback & Grimm, Ch. 20
Tues., Apr. 4	Parameterization and Calibration 2	
Thurs., Apr. 6	Analyzing ABMs	Railsback & Grimm, Ch. 22
Tues., Apr. 11	Sensitivity and Robustness	Railsback & Grimm, Ch. 23
Thurs., Apr. 13	Looking Ahead: ABMs Beyond this Course	Railsback & Grimm, Ch. 24
Tues., Apr. 18	Presentations	
Thurs., Apr. 20	Presentations	