

GEOG 5226 Spatial Simulation and Modeling in GIS	
Instructor	Harvey J. Miller
Class meetings	Tuesday, Thursday 2:20 PM – 3:40 PM Derby 0135
Office hours	Tuesday 3:40 PM – 5:00 PM Thursday 12:30 PM – 2:00 PM or by appointment Derby 1176
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Teaching Associates	Hui Kong (kong.174@osu.edu). Ms. Kong is a Geography PhD student focusing on quantitative urban studies, urban development, and spatial simulation and modeling.

Readings	
Required	O’Sullivan, D. and Perry, G. (2013) <i>Spatial Simulation: Exploring Pattern and Process</i> , Wiley. Available at university bookstore; also available in e-book format from Amazon.
Optional	Additional readings and webpages will be posted at the Canvas course website. These resources will provide additional background material as well as deeper dives into the science behind the models discussed in class.

Course Description	
<p>This course is about the use of computational techniques to simulate the evolution of complex spatial systems such as ecosystems, transportation, weather/climate, cities, economies, societies and landscapes. These and other complex systems have a multitude of relatively simple parts interacting over space and time to create surprising, emergent behaviors. Powerful computational techniques, often linked with GIS software, allow the simulation of realistically large systems at a fine-level of granularity, providing new insights that were unavailable through traditional modeling techniques</p> <p>We will explore three major types of “building-blocks” at the core of many dynamic spatial models: i) spatial aggregation and segregation processes; ii) random walks and mobile entities, and; iii) percolation and growth processes. We will also discuss issues such as the role of spatial simulation in geographic information science, representation of space and time, how to build more complete models of human, physical and linked human-physical dynamic spatial processes, and how to evaluate model performance and uncertainty.</p> <p>We will learn how to build dynamic spatial simulation models with NetLogo, a <i>free, open source</i> programming language and software environment that is well-suited for simulating dynamic spatial processes. Netlogo is available on all major platforms (Windows, Mac and Linus). Netlogo also has an extensive library of open source</p>	

models, many of which we will explore this semester. Despite being free, Netlogo is not a toy: you can use it for sophisticated scientific investigations. It can also read ArcGIS shapefiles, so you can import GIS data into your simulation.

Learning Objectives

1. **Think like a spatial scientist:** The ability to conceptualize real-world phenomena as comprised of fundamental spatio-temporal processes occurring in specific geographic contexts
2. Understand spatial simulation as a tool for scientific investigation: The ability to translate theory into simulation models and design experiments for investigating theory; an understanding of the strengths and weaknesses of this approach to scientific investigation.
3. Understand common spatial simulation techniques: A basic understanding of techniques that are especially well-suited for simulating physical and human geographic processes.
4. Design and use of spatial simulation techniques: The ability to design a spatial simulation based on a real-world process and experiment with the model to understand that process.
5. Spatial simulation software skills: The ability to program and conduct experiments within the NetLogo software environment.

Evaluation

Weights

Assignments 50% of final grade
Examinations 50% of final grade

Grading scale (OSU standard scale) A 93-100%; A- 90-92%; B+ 87-89%; B 83-86%; B- 80-82%; C+ 77-79%; C 73-76%; C- 70-72%; D+ 67-69%; D 60-66%; E 0-59%

Assignments

There will be a series of NetLogo-based lab assignments throughout the semester. I will announce these via Canvas and in class. Assignments are due at 12pm (noon) on the designated due date. **I will penalize late assignments by 15% per day (starting with any portion of the due date after 12pm). I will not accept late assignments after 48 hours from the due date and time.**

Examinations

There will be 5 short examinations (20 -25 questions) during the semester. Exam questions will be drawn both from the lectures and readings. Exams will be online using Carmen, but will occur during normal class times using the computers in our normal classroom. **Exams must be taken at the place and time designated unless you have made prior, approved arrangements.**

Policies

Disability services. Students with disabilities that have been certified by the Office for Disability Services will be appropriately

accommodated and should inform the instructor as soon as possible of their needs. The Office for Disability Services is located in 150 Pomerene Hall, 1760 Neil Avenue; telephone 292-3307, TDD 292-0901; <http://www.ods.ohio-state.edu/>

Academic misconduct. It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term “academic misconduct” includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487).

For additional information, see the Code of Student Conduct:

http://studentlife.osu.edu/pdfs/csc_12-31-07.pdf

Technology. This is the 21st century, so I will not ban the use of laptops, tablets and other digital devices. However, there are some guidelines and restrictions:

1. **Be mindful** – when you are emailing, tweeting, texting, updating, surfing, etc. you are not paying attention. Research shows that no one can multitask that well – not even you. Paying attention and taking good notes is essential to success in this course. Why are you here?
2. **Be courteous** – your use of digital devices should not distract other students in the class. It is unlikely that taking notes or searching class-relevant topics will be distracting. However, viewing videos of kittens or ice bucket challenges will likely distract others. Complaints about inappropriate technology use in class will result in your privileges being curtailed or revoked.
3. **Be honest** - emailing, surfing, and the use of any other applications or technologies is not allowed during the computer-based examinations. Be aware that your activity on the lab desktop computers may be monitored during exams.
4. **Be aware** – An experienced instructor can tell if you are paying attention, or not.

Canvas

This course will make use of the Canvas online learning system. I will be posting slides from my lectures, readings, interesting websites, assignments and project milestones. Students are responsible for all material and announcements posted at Canvas.

NetLogo software

NetLogo will be available on the computers in our lab. However, since it is free and open source, you can download and install NetLogo on your personal machines: <https://ccl.northwestern.edu/netlogo/> *However, note that you are on your own with installations on personal machines; we cannot provide technical support.*

The basic Netlogo install is simple, but some of the programs we will look at this semester will use the *gradient* extension. Installing the gradient extension is easy: go to this [link](#), download and unzip the folder called *gradient* containing a single file called *gradient.jar*. Copy the entire folder to the same folder as your Netlogo models, or to the Netlogo *extensions* folder. (Some NetLogo models also require an R extension for data analysis and reporting, but we will not be using these models.) For more details on these extensions, see the textbook authors' website: <http://patternandprocess.org/>

You can also follow Netlogo on Twitter: <https://twitter.com/NetLogo>

Netlogo models

Since it is open source, Netlogo comes with a wealth of freely available models (programs) across a wide range of applications. Models sources include:

1. Models Library - available in the Netlogo software itself; look under "Files" → "Models Library"
2. NetLogo user community: <https://ccl.northwestern.edu/netlogo/models/community/>
3. NetLogo Modeling Commons: <http://modelingcommons.org/>

Netlogo models discussed in the O'Sullivan and Perry text

The O'Sullivan and Perry text references and discusses a large number of Netlogo models. The appropriate models for each course topic are listed in the course outline below. You should experiment with these models as part of your study *prior to class*. We will also work with these models in class.

Windows versions of the Netlogo models are available at the Canvas site: unzip the archive and copy the entire directory (including the gradient subdirectory) to your laptop or to a portable storage device for use during class.

Other sources for the Netlogo models, including Mac versions, include:

1. The authors' website, **Pattern and Process**: <http://patternandprocess.org/>.
2. O'Sullivan also maintains the most up-to-date versions of these models at a github repository: <https://github.com/DOSull/model-zoo>. (Note that the github repository may be incomplete: some models from the textbook may be missing.)

Course outline and schedule – Autumn 2017

Date	Topics	Textbook (read prior to class)	NetLogo models (study prior to class)
0. Course Overview and Netlogo			
8/22 (T)	Course overview		
8/24 (R)	Lab 1 – Experimenting with NetLogo		
1. Spatial Simulation Models: What? Why? How?			

8/29 (T)	1.1. What are simulation models? 1.2. How do we use simulation models?	OP Chp. 1	
8/31 (R)	1.3. Why do we use simulation models? 1.4. Why dynamic and spatial models?	OP Chp. 1	1.1-life 1.2-galtonBoard-Additive 1.3-galtonBoard-Multiplicative
9/5 (T)	Lab 2 – Netlogo world and agents		
2. Pattern, Process and Scale			
9/7 (R)	2.1 What is a pattern? 2.2. Using models to explore spatial patterns and process	OP Chp. 2	2.1-scale 2.2-flugge-2012-spatial-bd-noR 2.3-csr 2.4-inhomPoisson
9/12 (T)	2.2. Using models to explore pattern and process (continued)	OP Chp. 2	2.5-inhibition 2.6-cluster 2.7-double-cluster
9/14 (R)	<i>Exam 1</i>		
3. Aggregation and Segregation			
9/19 (T)	Lab 3 - Programming with NetLogo		
9/21 (R)	3.1. Background 3.2. Local averaging	OP Chp. 3	3.1-local-average 3.2-vicsek-galaxy-formation
9/26 (T)	3.3. Totalistic automata	OP Chp. 3	3.3-totalistic_automata
9/28 (R)	3.4. Interacting particle systems	OP Chp. 3	3.4-BasicContactProcess2D 3.5-CompetingContactProcess2D 3.6-simple-grass-brush-trees 3.7-simpleRSP 3.8-voter-model 3.9-voter-model-with-mutation
10/3 (T)	3.5. Schelling models 3.6. Spatial partitioning 3.7. More complicated models	OP Chp. 3	3.10-schelling 3.11-schelling-as-IPS 3.12-subdivision 3.13-iterated-voronoi 3.14-spots-and-stripes 3.15-Nowak-May-1992 3.16-IPD
10/5 (R)	<i>Exam 2</i>		
10/10 (T)	Lab 4 - Variables and Breeds		
10/12 (R)	<i>No class – Autumn break</i>		
4. Random Walks and Mobile Entities			
10/17 (T)	4.1. Background 4.2. The random walk	OP Chp. 4	4.1-random-walks 4.2-correlation-length-walks
10/19 (R)	4.3. Foraging and searching	OP Chp. 4	4.3-Simon-lattice-forager 4.4-manhattan-sausages 4.5-monkeys-foraging
10/24 (T)	4.4. Moving entities and landscape interaction 4.5. Entity-entity interaction	OP Chp. 4	4.6-foraging-with-regrowth 4.7-flocking
10/26 (R)	<i>Exam 3</i>		
10/31 (T)	Lab 5 - NetLogo and GIS data		

5. Percolation and Growth			
11/2 (R)	5.1. Motivating example 5.2. Percolation models	OP Chp. 5	5.1-sitePercolation 5.2-antLabyrinth 5.3-firePercolation 5.4-percolationBackBone 5.5- invasionPercolationWithTrap ping 5.6- invasionPercolationStarkDrai nageModel
11/7 (T)	5.3. Growth models	OP Chp. 5	5.7-edenSimple 5.8-edenSimpleInverse 5.9-edenTree 5.10-edenTip 5.11-edenWilliamsBjerknes 5.12-edenSingleOnLine 5.13-edenEpidemic 5.14-benguiguiP 5.15-edenSingleOnLineLDD 5.16-onlattice-dla
11/9 (R)	5.3. Growth models (continued) 5.4. Applying the framework	OP Chp. 5	5.17-simpleNeutral 5.18-simmap 5.19-dsFFM 5.20-FFM-ContLsp 5.21-starkGullying
11/14 (T)	Lab 6 - Agent-based modeling		
11/16 (R)	Exam 4		
6. Representing Time and Space			
11/21 (T)	6.1. Representing time 6.2. Basics of spatial representation 6.3. Spatial relationships 6.4. Coordinate space 6.5. Complicated spatial structure without spatial data structures 6.6 Temporal and spatial representations can make a difference	OP Chp. 6	6.1-life-under-different- update-models 6.2-majority-rule-under- different-update-models 6.3-event-queue-simple 6.4-hex-array-voter 6.5-voronoi-voter 6.6-infinite-life
11/23 (R)	<i>No class – Thanksgiving holiday</i>		
11/28 (T)	Lab 7: Using BehaviorSpace to manage experiments		
7. Model Uncertainty and Evaluation			
11/30 (R)	7.1. Introducing uncertainty 7.2. Coping with uncertainty 7.3 Assessing and quantifying model- related uncertainty	OP Chp. 7	7.1-dispersal-fragmentation
12/5 (T)	7.4. Confronting models predictions with observed data 7.5. Frameworks for selecting between competing models 7.6. Pattern-oriented modeling 7.7. More to models than prediction	OP Chp. 7	
12/8 (F)	Exam 5 (4:00 PM – 5:45 PM)		

Assignments		
Topic	Assigned date	Due date (by 12pm)
1 – Experimenting with NetLogo	8/24	8/31
2 – Netlogo world and agents	9/5	9/12
3 - Programming with NetLogo	9/19	9/26
4 - Variables and Breeds	10/10	10/24
5 - NetLogo and GIS data	10/31	11/7
6 - Agent-based modeling	11/14	11/21
7 - Using BehaviorSpace to manage experiments	11/28	12/5