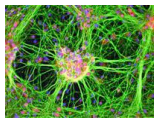


Computation, Complexity, and Emergence: An Interdisciplinary Approach to Engineering Education

Marie desJardins
University of Maryland Baltimore County


Course website: http://www.cs.umbc.edu/~mariedj/complexity/

Abstract

Topic: Innovation and expertise at teaching students leading edge engineering knowledge and skills

In Spring 2011, I developed a new interdisciplinary Honors seminar on "Computation, Complexity, and Emergence." The course explores the nature and effects of complexity in natural and artificial systems, using these topics to teach students computational modeling skills and an understanding of the dynamic nature of complex systems in a range of real-world contexts.

Introduction and Objectives

At the end of the course, students from many different disciplinary backgrounds should:

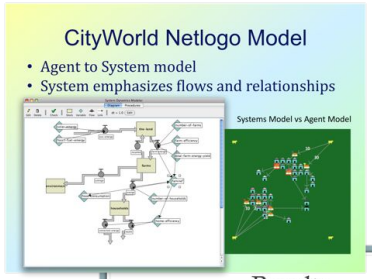
- Understand how simple local actions and decisions can lead to complex and meaningful global behaviors.
- Be able to identify and analyze the sources and effects of complexity in natural and artificial systems.
- Have gained experience with the dynamics of complexity by designing, modifying, and experimenting with artificial complex systems.
- Be able to identify and design examples of iterative, recursive, parallel, and adaptive patterns in complex systems.

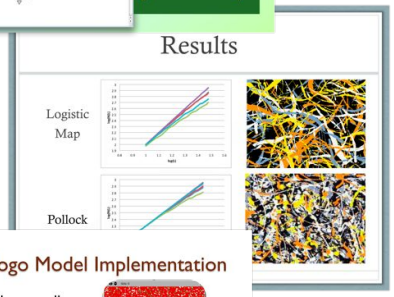
Developmental History of Innovation

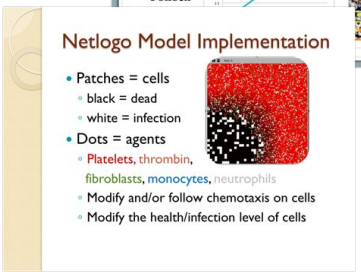
- The course arose from a desire to share the power and beauty of complex systems and agent-based modeling techniques with students from many different disciplines.
- The course is part of UMBC's Honors College Seminar series.
- The course is taught in a seminar format and is discussion-based and writing-intensive.
- Course activities include hands-on labs and projects, group work, reflective writing, and peer review of writing.

Learning Activities and Materials

- The textbook (*The Computational Beauty of Nature,* by Gary Flake (MIT Press, 1998)) is supplemented with articles on a variety of topics.
- The NetLogo modeling environment is used extensively to study, experiment with, design, and build models of complex systems.
- The NetLogo labs, syllabus, reading assignments, project descriptions, and PowerPoint slides are available at the course website.
- The NetLogo labs were adapted for a Google-sponsored high school teacher professional development workshop in October 2011.





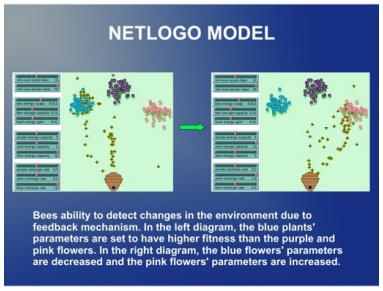


Execution

- What worked well:
  - Online discussions of the reading material (required and self-graded).
  - A "game day" that included students "flocking" on the library lawn!
  - Final project: each student chooses a real-world complex system to model.
  - Group work for activities inside and outside the classroom.
  - Outside speakers from a range of disciplinary perspectives.
- What I will do differently this spring:
  - Recruit more students from different majors.
  - Design the early NetLogo labs more intentionally.
  - Supplement the textbook with outside reading and videos earlier in the semester.

Challenges

- Ensuring that students gain knowledge, ideas, and perspectives that change the way they think *after* the course is over.
- Creating a discussion environment in which all students contribute equally.



Discussion

- An interdisciplinary class is a powerful learning experience for students:
  - It enables non-engineers to see the relevance of engineering principles to their discipline.
  - It enables engineers to see the impact that their work can have on real-world applications and societal challenges.
- Leading this class has made me embrace the idea that my role as educator is not to "teach" but to facilitate the students' learning.
- The use of NetLogo and other modeling languages in the K-12 curriculum opens up a broad range of possibilities for teaching computational thinking to younger students.
- We hope to use NetLogo as the basis for a design experience in a course for freshman computing majors (for which we are seeking funding from NSF's Transforming Undergraduate Education in STEM (TUES) program).

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