CS 420/594
(Advanced Topics in Machine Intelligence)

Complex Systems and Self-Organization

Bruce MacLennan
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Contact Information

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CS 420 vs. CS 594

• CS 420: Undergraduate credit (but graduate students can count one 400-level course)

• CS 594: Graduate credit, additional work
Grading

- You will conduct a series of computer experiments, which you will write up
- Some of these will be run on off-the-shelf simulators
- Others will be run on simulators that you will program
- Graduate students will do additional experiments and mathematical exercises
- No exams
Prerequisites

• CS 420 & 594: None per se, but you will be required to write some simulations (in Java, C++, or whatever)

• CS 594: Basic calculus through differential equations, linear algebra, basic probability and statistics
Textbooks


Figure 1.1 An association map of the contents of this book
Figure 1.1 An association map of the contents of this book that we will cover

Figure from: The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation. Copyright © 1998-2000 by Gary William Flake. All rights reserved. Permission granted for educational, scholarly, and personal use provided that this notice remains intact and unaltered. No part of this work may be reproduced for commercial purposes without prior written permission from the MIT Press.
Reading for Next Week

• Flake: Ch. 1 (Introduction)
• Flake: Ch. 15 (Cellular Automata)
• 594: Bar-Yam: Sec. 1.5 (Cellular Automata)
Course Web Site

- [www.cs.utk.edu/~mclennan/Classes/420](http://www.cs.utk.edu/~mclennan/Classes/420)
- Syllabus
- Link to Flake *CBN* site (with software etc.)
- Link to Bar-Yam (CS 594) online text
- Links to other interesting sites
- Handouts:
  - assignments
  - slides (after class) in powerpoint, html, other? formats
Discussion

• What is a complex system?
• What is an emergent property?
• What is self-organization?
Weaver’s Stages in the Progress of Science

- Simple systems
- Disorganized complexity
- Organized complexity
Complex vs. Simple Systems

• Have many parts
• Parts are interdependent in behavior
• Difficult to understand because:
  – behavior of whole understood from behavior of parts
  – behavior of parts depends on behavior of whole
Examples of Complex Systems

- government
- family
- person (physiology)
- brain
- world ecosystem
- local ecosystem (desert, rainforest, ocean)
- weather
- corporation
- computer
- ant colony
- university
Some Physical Systems

Some Systems of Human Knowledge

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<thead>
<tr>
<th>Physical Sciences</th>
<th>Life Sciences</th>
<th>Social Sciences</th>
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8/25/03 Fig. from NECSI
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What are the *universal properties* shared by all complex systems?
Central Properties

- Elements (& their numbers)
- Interactions (& their strengths)
- Formation/operation (& their timescales)
- Diversity/variability
- Environment (& its demands)
- Activities (& their objectives)