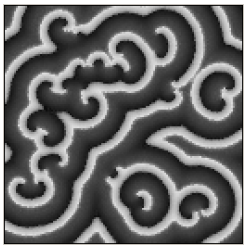
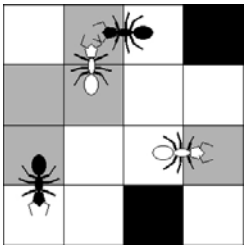


CS 790R SEMINAR: Computational Models of Complex Systems

Spring 2005



This course explores the cross-disciplinary field of complex systems, or "complexity", through modeling and numerical simulation. Complex systems are characterized by a large number of elements interacting locally and combining their simple individual behaviors to produce an *emergent* behavior at a macroscopic scale. While difficult to explain analytically, this emergence can often be reproduced in numerical models.

Processes of self-organization far from equilibrium are pervasive in nature (inanimate and living) and human structures. Yet, only recently did emergent systems become a major focus of inquiry and they now promise to be the leading scientific paradigm of this century. Increasing needs for prediction and control of geophysical, biological or societal structures have triggered rapid advances in the understanding of complexity at the transition between order and chaos. These insights were made possible by the dramatic progress of computer technology. Consequently, new algorithmic disciplines and solutions have been created, which make use of massively parallel, decentralized systems storing and processing information as single entities.

Goals of this seminar are to (a) become familiarized with the most prominent case studies and models of complex systems across a variety of topics, (b) understand the key abstract concepts that unify these phenomena and (c) introduce the theoretical fields of complexity and their important potential for applications.

(a) Cases of complex systems in nature & human structures

- excitable media & waves
- genes & cell differentiation
- animal patterns (coats, shells)
- insect societies (ants, termites)
- ecosystems & evolution
- neurons, brain & cognition
- cities, economy, Internet

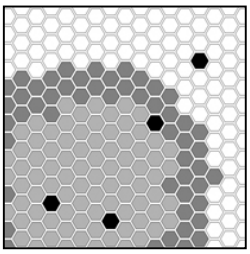
(b) Unifying concepts of complex systems

- ✓ emergence
- ✓ self-organization
- ✓ nonlinear dynamics
- ✓ order, chaos, complexity
- ✓ feedback
- ✓ phase transitions
- ✓ adaptation & criticality

(c) Theoretical & computational fields of complex systems

- ➢ cellular automata
- ➢ artificial life, virtual ants
- ➢ swarm intelligence
- ➢ pattern formation
- ➢ Boolean networks
- ➢ genetic algorithms
- ➢ small worlds

This advanced level interdisciplinary course welcomes graduate students in science and engineering, including: Computer Science & Eng., Mathematics, Physics, Electrical Eng., Chemistry, Biology, Biomedical Eng., Earth Sciences, and others. Following introductory lectures, students will choose and present papers, carry out "convince-yourself" experiments in the form of programming exercises, and complete a semester research project. Prerequisites: good scientific programming skills, knowledge of calculus and linear algebra, a curious mind for exploring other sciences and a willingness to share one's own domain of expertise.



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Call number: #32697 (3.0 credits) Max. enrollment: 20