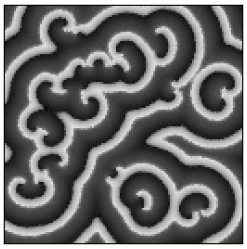
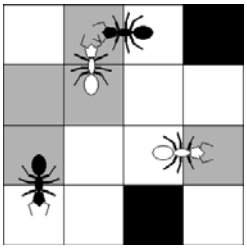


CS 790R SEMINAR: Computational Models of Complex Systems

Spring 2006



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.

Self-organized, decentralized and adaptive systems, whether physical, biological or human-made, are pervasive in the environment. Yet, only recently did they become a major focus of inquiry and they now promise to be the leading scientific paradigm of the 21st 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, distributed 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 potential for novel 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, market, Internet

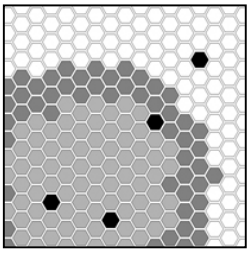
(b) Unifying concepts of complex systems

- ✓ emergence
- ✓ self-organization
- ✓ nonlinear dynamics
- ✓ order, chaos, complexity
- ✓ positive 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
- ➢ complex nets, small worlds

This advanced-level interdisciplinary course welcomes all graduate students in science and engineering, including: Computer Science & Eng., Mathematics, Physics, Electrical Eng., Chemistry, Biology, Biomedical Eng., Earth Sciences, and others. Beside lectures by the instructor, students will present scientific papers (1.0 credit) and can also elect to complete modeling & simulation programming exercises and a term research project (3.0 credits). Faculty members will also be invited to give talks and co-supervise student projects, with potential for publications. Prerequisites: a curious scientific mind and, if elected, good programming skills.



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Call number: #28013 (1.0 – 3.0 credits)
Class: MW, 2:30 – 3:45pm (PE 205)