REVIEW

Complex Adaptive Systems: Views from the Physical, Natural, and Social Sciences

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This monograph is part of the Springer Complexity series "Understanding Complex Systems" focusing on the various applications of complexity. It consists of eleven chapters ranging from basic definitions, agent-based models, diffusion, Markov models of tipping points, simulation of suspicious activity in a security setting, simulation of ridesharing, stigmergy in spatial modeling, swarms, and teaching complexity. The topics are wide-ranging and unrelated to one another. As one might expect from a collection of unrelated papers, there is considerable duplication of definitions and fore matter.

The title, *Complex Adaptive Systems*, is too generic and does not say much about the content. Google returns 44 million items under "Complex Adaptive Systems" and Amazon.com lists a number of books with Complex Adaptive Systems in their titles. Perhaps a better title would be: *Some Applications of Agent-based Models*. Agent-based models generally incorporate properties of complexity such as emergence, self-organization, evolution, critical or tipping points, and flocking behavior.

Chapter one defines agents, adaptation, feedback, emergence, and self-organization and claims they are fundamental to complex adaptive systems. I would add diffusion, stigmergy, and decentralized control to the list. The knowledgeable reader may skip this chapter.

Chapters two, three, and four describe agent-based simulations that exhibit emergence. A Cognitive-Consistency Based Model of Population Wide Attitude Change describes a model of attitude diffusion across people that includes social and cognitive factors—how long does it take for attitudes to change and what do they change to? In An Application of Agent Based Social Modeling in the DoD, a geospatial social agent-based simulation, capable of examining the interactions of more than 60,000 agents, models adverse agents which have harmful intent and goals to spread negative sentiment and acquire intelligence. Will adverse agents emerge from the crowd by simulating person-to-person interactions? Finally, Agent-Based Behavior Precursor Model of Insider IT Sabotage describes a model and simulation of the use of information technology to cause harm to an organization or an individual. The specific behavioral precursors include the individual's predisposition, disgruntlement, stress levels, technical skill levels and the level of access to the computer systems. The simulation provides a framework for exploring the emergence and development of insider IT sabotage within organizations for different turnover rates.

The topic turns away from security oriented simulations to a general model of robustness, sustainability, and tipping points in Formal Measures of Dynamical Properties: Tipping Point, Robustness, and Sustainability. The idea is simple—use Markov models to describe the complex system and then analyse that Markov model to determine concepts such as robustness, etc. For each concept derive a probabilistic definition based on a Markov model generated from time-series data. Using reachability and other properties of the Markov model one can define robustness and sustainability, etc.

The topic veers off again with Simulating the Ridesharing Economy: The Individual Agent Metro-Washington Area Ridesharing Model. The model proposes an interesting application of Voronoi polygons to optimization of drivers profit. Given driver's locations, a Voronoi polygon encloses all points closest to the driver, and not other drivers. The Voronoi model improves profitability under certain conditions versus a random model.

Stigmergy for Biological Spatial Modeling describe computer simulations collaboration within a predator-prey system, and angiogenesis in cancer growth. The author says:

> For predator-prey, we create a cellular automata model to study the use of emotions in prey collaboration. To study cancer cell growth we create an agent-based model of tumors with angiogenesis, to enhance our understanding of the role angiogenesis plays in tumor growth. Although they seem initially different, both utilize stigmergy for self-organization, although they utilize stigmergy in different ways (172).

Strategic Group Formation in the El Farol Bar Problem is a simulation of multiple decision-making agents trying to outwit each other and only attend the bar when it is not overcrowded. Agents strategically form groups to give them access to a larger strategy pool. However, too large a group will be undesirable because the group's attendance to the bar might cause it to become overcrowded. The conclusion from this work is that individuals should not form groups when wishing to be in the minority.

Another application of stigmergy is found in SwarmFSTaxis: Borrowing a Swarm Communication Mechanism from Fireflies and Slime Mold. The authors present an algorithm to move a group of robots from a starting point to a predefined goal. Flocking behavior results from a combination or "attract" and "repel".

The final chapter, Teaching Complexity as Transdisciplinarity, will be of interest to educators. The authors argue that teaching complexity gets students out of their single-disciple rut:

> This essay argues that teaching complexity provides a unique opportunity for showing undergraduates the value of interdisciplin arity but also of transdisciplinarity, where disciplinary perspectives are applied in new ways to help answer questions traditionally pursued in other disciplines. Complexity can be defined as the study of the emergence and self-organization of networks of interacting agents. It has led to the development of concepts that together create a new perspective on such things as art, music, communication, governance, markets, language, consciousness, life, and the evolution of the universe. We urge professors and administrators to consider adopting complexity studies as a central topic of study for undergraduate students (224).

The monograph does not have an index or glossary. It is 250 pages of diverse content with plenty of references at the end of each chapter.

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