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Book Review: *Modeling Complex Systems*

Modeling Complex Systems. Nino Boccara, Springer-Verlag, New York, 2004, 397 pp. ISBN 0-387-40462-7.

If you want to solve a problem in electromagnetism, you start with the Maxwell equations. If the problem is in quantum mechanics you could start with the Schroedinger equation. But where do you start if your problem involves a complex system?

First, what is a complex system? Boccara, in his text for advanced undergraduate students, writes that "most researchers would describe, as complex, a system of connected agents that exhibit an emergent global behavior not imposed by a central controller, but resulting from the interactions between the agents." Boccara begins his book with a discussion of the adjustable division of labor in ant colony as an example of adaptation to changing food supply conditions. Adaptation and evolution would qualify as belonging to complexity. But a refrigerator with its many parts and emergent behavior, i.e. "cooling", is a designed and engineered system and would not be considered a complex system.

The literature already has a collection of excellent books on topics deemed to be part of the complexity arena, including Ted Case "An Illustrated Guide to Theoretical Ecology", Steven Strogatz "Nonlinear Dynamics and Chaos", Stephen Wolfram "A New Science" and Andy Ilachinski "Cellular Automata: A Discrete Universe" and "Artificial War". None of these books were referenced. These books have more material in their focused areas than Boccara's, but Bocarra has written a self-contained textbook that covers topics from basic nonlinear mathematics to agent-based models for systems with spatiotemporal emergent behavior. His book is clearly written, (and carefully written, I did not find any typos except in my name on page 355), well illustrated and full of examples and good problems. The problem sets are fully worked out. This book is a welcome addition to the field and would make an excellent textbook for advanced undergraduates. I would also recommend it to those wanting to learn about nonlinear and complex systems.

The first part of the book covers mathematical background material on nonlinear equations that is useful for modeling complex systems. Topics include differential equations, differential-delay equations, discrete iterated maps, and a review of chaos. There is a focus on calculating the boundaries of stability regimes and on the creation of instabilities and the ensuing wide variety of bifurcations in dynamical behavior as parameters are changed. Several applications are given from the field of population dynamics. The second part of the book tackles cellular automata, networks, power laws, self-organized critical phenomena and places an emphasis on agent based models. There are many good examples from the topics of fractal growth, self-organized criticality, traffic flow, earthquakes, population biology, epidemics, and finance.

By the end of the book, there is no Newton's Law, Maxwell equations or Schroedinger equation for complex systems. This field is still a loosely collected selection of models and topics. But the collection of topics is rich, important and prime for further discovery, and Boccara's book is an excellent place to start to become acquainted with complex systems.

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