NO SIMPLE MODEL FOR COMPLEX SYSTEMS

1989 Lectures in Complex Systems

Edited by Erica Jen
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Reviewed by Philip Holmes

Several "new" sciences have recently swept through the pages of magazines and have even spawned their own research journals. Funding agencies have promoted "emerging fields" and fostered the creation of interdisciplinary centers. The three C's come to mind: catastrophes, chaos and now complex systems. Are these really new sciences or merely public relations stunts designed to attract attention and funding? I agreed to review this book partly in the hope of finding an answer. I failed, but found much of interest nonetheless.

The papers in this book, edited by Erica Jen, fall into two categories: those that address particular problems in "conventional" fields, such as solid-state physics and neurobiology (the papers of David Sherrington and William Bialek, for example); and those that concern modeling and analytical techniques, such as cellular automata and dynamical systems (Bruce Boghosian, Jen, H. Chen and coworkers, Stephen Eubank and Doyne Farmer). The latter range from the limited and rigorous (Lenore Blum on complexity, Jen on simple cellular automata) to the more speculative (W. H. Zurek on information and entropy and Seth Lloyd on measures of complexity).

Some of the papers in the book satisfy Thomas Kuhn's paradigm of "normal science," being increments to established fields (D. David and coworkers on nonlinear optics, George Oster and coworkers on morphogenesis), while others are lengthy reviews that raise more general questions than they answer (Alan Perelson on mathematical models in immunology, Bialek on reductivism and universality in physics versus the accumulation of detail in biology). Some papers present mathematical models with virtually no reference to the world outside (Jen, Eubank and Farmer on dynamical systems, Aviv Bergman on "simulated evolution"). Blum's paper on the theory of computation over the real numbers needs no world beyond its own. Others are rich in experimental detail: fluid flows, chemical reactions, optics, phase transitions, immunology, neurobiology—all are represented.

I sought in vain a common intellectual ground among this riot. There is no shared set of problems or analytical techniques. Deterministic chaos and nonlinearity are not the key: Most of Bialek's fascinating piece uses linear filtering and probability methods to address neural processing in fly vision. In the best papers, like this one, which address specific questions, the "systems" generally consist of many massively interconnected, but relatively simple units. There is often a concern with learning and adaptation.

But perhaps the key is supplied by Perelson's remark that "one hallmark of a complex system is that its essence cannot be captured by a single model." This brings to mind a remark of Michael Fisher: Interdisciplinary research cannot exist without the disciplines. With easy, cheap computation, the temptation to play simulation games with "floating models" is hard to resist. Established fields are necessary to keep us honest and direct our taste.

Happily, this collection shows that *some* complexity enthusiasts are paying attention to detail. In spite of his admission that "there is no general technique for going from P[artial] D[ifferential] E[quations] to L[attice] G[ases] or vice versa," Boghosian's article shows that rational connections can be made between certain partial differential equations of continuum mechanics and cellular automata, and hence that the latter are interesting as physical models. Jen's rigorous analysis of specific automata shows that they are also interesting mathematical objects.

In collections like this, each paper is usually too sketchy to serve alone as true instructional material: At best it stimulates us to further reading. Eubank and Farmer's "Introduction to Chaos and Prediction" cannot replace a textbook. But the best papers (Perelson on immunology, Blum on complexity, Bialek on neurobiology, Epstein on oscillating chemical reactions) succeed admirably in their lesser goal. There is much of interest here, even if this volume fails to justify its editor's claim that "complex systems [has emerged] as a distinct field... equipped with its own tenets, precepts, standards and ambitions."

The book's production seems better than that of many recent electronic proceedings, but there are occasional lapses. Most of Sherrington's bibliography is missing, and the time series on page 129 of Eubank and Farmer's article are transposed. The price is reasonable and the book provides accessible and stimulating introductions to several areas. However, it should be hidden from any aspiring researcher until he or she has trained in one of its disciplines, be it mathematics, physics, chemistry or biology.

Philip Holmes works on dynamical systems in fluid and solid mechanics. His relation to the field of complex systems remains unclear, since even after reading this book he does not know what one is.

The Nuclear Energy Option: An Alternative for the 90s

Bernard L. Cohen
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