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Book Review

Dynamics of Complex Systems. By Yaneer Bar-Yam. Addison-Wesley, Reading, MA 1997 xvi + 848. ISBN 0-201-55748-7.

The present work by Bar-Yam fills a much needed gap in the literature of complex systems, namely, a textbook suitable for the teaching of novices to the field. Bar-Yam succeeds in doing so with a minimum of mathematical rigor, extensive discussion and exploration of eminently relevant problems, and a remarkable breadth of topics. Most useful is his attention to subjects drawn from outside of the confines of physics, making the book accessible to a much wider audience, especially those within the social sciences and humanities.

The introductory sections are by far the most difficult to master, but benefit from the inclusion of many problems to assist the student in consolidating their understanding of the material. These sections are the most mathematical and do draw heavily upon examples from the physical sciences. This is unfortunate, though understandable, but it does demand a great deal of patient effort from the student. Nevertheless, the student who perseveres will be rewarded in the long run. These introductory chapters cover such topics as: iterated maps, deterministic and stochastic modeling, thermodynamics, spin glasses, cellular automata, statistical fields, computer simulation techniques, information, computation, and fractality. The discussion is thorough and these sections, totaling almost 300 pages by themselves, could provide the material for an introductory course on mathematical methods for complex systems theory. The mathematics used is accessible to any student with a basic background in calculus and linear algebra but as the examples are mostly from physics, the social and life science major is likely going to find themselves struggling to develop an intuitive grasp of the material. Yet that is clearly the major audience towards whom this book is directed. This section would definitely require supplementation by tutorial material.

In the next section Bar-Yam discusses neural networks. He provides a thorough introduction to the Hopfield style neural network, which is a simple extension of the spin glass models so popular in physics. These

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models receive much attention in the journal *Institute of Physics Press*, but are less widely embraced within the more psychologically oriented literature on account of their biological naivety. Bar-Yam attempts to correct for this problem through a discussion of subdivided networks but the arguments will seem rather weak to anyone who has a knowledge of neurophysiology. He fails to discuss sparse networks and temporal networks which have been attempts to render these models more plausible. My major quibble with this section though is the lack of attention paid to the work of Stephen Grossberg. Grossberg has been developing sophisticated neural network models since the early 1970's. His models are informed by a thorough attention to both neurophysiological and psychological research and have been widely embraced by both the psychological and engineering communities, precisely because of their explanatory and predictive power. I suspect that the omission is due to the bias towards models of complex systems which are rooted in physics, to which the Hopfield models are kin. However in a book directed towards students of psychology and the social sciences I find it a serious historical and scientific omission.

Bar-Yam applies these models to explain a variety of psychological processes. The models presented will, I am sure, seem overly simplistic to students of psychology and the discussion of background material reflects a lack of experience with the psychological literature, again, I think, a serious shortcoming. In using this for teaching I would highly recommend supplementing the material with the work of Grossberg, especially a discussion of his ART architecture. I think these two chapters may be useful for stimulating discussion but they certainly could not serve as the final word on the application of complex systems theory to psychology. I suspect that the non–psychologist may be easily misled by the apparent simplicity of the explanations offered and this would be most unfortunate.

The next two sections on Protein Folding are well written, but likely will appeal to a rather limited audience. The first chapter on Life, in fact, says little about life per se, but does offer a thorough exploration of the Kauffman landscape model of evolution. There is very little formal here, apart from a fairly standard discussion of predator-prey models. This chapter could well be supplemented by a reading of Stuart Kauffman's *Origins of Order* (1993). The second chapter on Life provides a discussion of various mechanisms of pattern formation and is quite accessible. I think that the use of the heading, Life, might be overstating things just a little. Still, this section was an enjoyable read.

He ends with two chapters on Human Civilization. The first again seems to be mis-titled, since it seems to provide a rather detailed discussion of the varied definitions of complexity being discussed in the theoretical literature. In this Bar-Yam does an excellent job. However he undermines

himself somewhat by extending his reach into theology and metaphysics. I found the section on the complexity of the human soul both trivial and irritating. The second chapter provides a metaphorical discussion of the application of complexity theory to the study of society. I found this to be interesting and a good setting for stimulating discussion. However I thought that he again overstates when he suggests that having finished this book, the reader will find themselves to be an expert in the field of complex systems theory. I think that the reader will have received a clear and cogent introduction to the literature on complex systems, but much work lies ahead before they should consider themselves as experts. There is simply too much metaphor and too little formal substance here to really satisfy. I felt as though I had sampled a delightful assortment of appetizers and now longed for the main course.

Still, in writing the first textbook to embrace the very broad field of complex systems theory, I think that Bar-Yam has done a laudable job and has set a high standard indeed for those who follow in his footsteps. This is certainly a text that I can recommend highly for an introductory course.

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