Book Review

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Nonlinear Dynamics, Mathematical Biology and Social Science. Joshua Epstein. (1997). Lecture Notes in Santa Fe Institute Studies in the Sciences of Complexity IV. Addison-Wesley. 164 pages. $34.38, paper.

Summary

Epstein has written a charming book about the dynamics of social change including the dramatic dynamics of competition, cooperation, arms race, war, revolutions, epidemics, and the spread of drugs. It is written in the language of dynamical systems and all the topics are presented in an ecological context as defined in contemporary mathematical biology. This gives a pleasing and unifying framework for the seemingly different topics and it also puts social dynamics into an appropriate and broader (human) ecological context.

It is a short book (about 160 pages) in which the topics are presented in an engaging and exciting manner. Each chapter is written as a lecture and Epstein has managed to present his message in clear text. The book also contains a topics index.

The first lecture starts out by stressing the strength and weaknesses of analogies as well as the caution that one (always) has to take when dealing with simple mathematical models of complex systems. Epstein also explains the importance of simple ("toy") models as metaphors and as an inspiration for further field work (data collection) and more detailed analysis. These are important points that cannot be repeated too often enough. Then Epstein summarizes the Lotka-Volterra equations, introduces the mathematical notion of competition and mutualism, defines war, revolution, epidemics, and how they are related. In the following four lectures we are taken by the hand and brought to understand important and fascinating details of the dynamics of combat, international security, revolutions, epidemics, and the spread of drugs. As you read you wish that some of Epstein's entertaining findings, his model definitions, and his analysis were given more space and details. But then you remember that it would have turned this nice, short book into a more lengthy and probably not so nice book. It is an art to write a short book.

The last chapter is an excursion into the classical field of nonlinear dynamical systems where some of the concepts and methods used in the former chapters are discussed. Also, results not used earlier in the book are summarized in this 45-page chapter.

Details

The first five lectures It is clear that Epstein's book is a great supplement for science and engineering students worldwide, both as a source for homework problems in

dynamical systems and simply as an engaging way to learn elements of social dynamics at the same time as you are taught dynamical systems. It makes a wonderful alternative to the many lame technical examples that every engineering student all over the world has to work through. I will certainly use it the next time I have to teach a course in dynamics. This book is also a must for the social science student and for the social scientist who is seriously interested in dynamics. However, I am worried that the average social science curriculum does not include enough math to make this book directly usable. But I view that as a problem with the social science teaching tradition and not with Epstein's book.

Let me say right away that I cannot find anything really bad to say about *Nonlinear Dynamics, Mathematical Biology and Social Science*. It is a wonderful little book that I am glad I took the time to read. I have two problems with the book: the disconnect between the last chapter on elements of nonlinear dynamics and the main text; and incomplete figure captions—the figures throughout the book do not tell enough of their own story.

The last lecture   Epstein says that this last chapter was included just for the joy of it—mathematics is its own reward—and this should certainly be reason enough. However, after having gone through Epstein's first five excellent lectures I came to expect more. This last chapter is too compact to be used as a primer if you are not familiar with nonlinear dynamics (e.g., a social science background) and it is familiar stuff for the most part if you already are familiar with nonlinear dynamics concepts and methods. I very much like the idea of an "appendix chapter" that summarizes the theoretical cornerstones and gives pointers to further reading or intuitive reasons for why things are as they are. But then this last chapter should have been written quite differently. Because the main chapters use concepts and theory fragments from ordinary differential equations, partial differential equations, and difference equations, the appendix chapter should cover these topics too—or at least give pointers for further reading on all of them. However, only the first topic is covered in this last chapter and that even in a non-stand-alone way. I think that Epstein should either have left this chapter out (and the book would be even nicer—now only 115 pages!) or made it into something more usable for the rest of the book, in particular for the social science student.

The figures   Although the figures are good, I personally like when a text and the associated figures each can tell a story. These figures cannot be read alone because the figure text is too sparse and incomprehensive.

Other Approaches

It should be noted that Epstein, together with Robert Axtell, has written another useful book entitled *Growing Artificial Societies*. The social (dynamical) systems in this book are formalized in quite a different framework. Here the social systems are modeled as systems of interacting objects, or agents, and the method of investigation is simulation (synthesis) and not analysis. This book was reviewed by Nicholas Gessler (*Artificial Life, 3*, 237–242), and the book is in many ways a natural complement to the book under review here. These two short books on social dynamics make a terrific couple. They should be on any reading list for social science studies, should be included in complex systems studies, and should be a complementary part of the traditional science and engineering curriculum.

Having appreciated both *Nonlinear Dynamics, Mathematical Biology and Social Science* and *Growing Artificial Societies*, I would ask Epstein to consider the following suggestion. Because he has proven to be an engaging and talented writer, I would like to see one or more of the following titles, Epstein-style, in the coming years: a) stochastic processes in social science, which includes random walks, Markov chains and processes, and time series analysis; b) chaos, noise, and social dynamics, which includes

some of the modern concepts form nonlinear dynamics and what they may mean in a social dynamics context; c) graphs in social science, which shows a couple of the many graph theory applications, for example, in transportation, telecommunications, and social interactions; d) spatial, social dynamics, which could also be called *Artificial Societies II*, where GIS (global information systems) are brought into focus, perhaps in connection to urban evolution, resource management, and regional economics and security. I envision short books in clear text, to the point mathematically and carried by exciting examples from sociopolitical and sociotechnical systems. If I were a publisher, I would go ahead and give Epstein an advance on one of these titles if he promises to make appropriate appendices and provide more complete figure captions.