Book Review

Nonlinearity and Chaos in Engineering Dynamics, edited by J. M. T. Thompson and S. R. Bishop. Published by John Wiley & Sons, Inc., New York, 1994, ISBN 0-471-94458-0, 454 pp.

Chaos is a well-recognized mathematical field of study that has revolutionalized the concepts of nonlinear dynamics. Its extension to more practical topics, specifically in engineering dynamics, is the subject of the collection of articles presented in the book under review. This book is the result of a symposium under the same title, sponsored by the International Union of Theoretical and Applied Mechanics (IUTAM). The symposium was held in July 1993 at University College, London. The widespread international research interest was evident from the 78 participants, who were experts in the field from 23 countries. The proceedings include full texts of all the lectures presented at the symposium. Abstracts of the posters are given in an Appendix. The impressive printing and hard binding for long-term use allow it to be called a book rather than proceedings, which are usually in paperback binding distributed during a conference or a symposium.

"Chaos is a generic term for the complex, seemingly irregular motions of deterministic systems characterized by a sensitive dependence on initial conditions and a broad-band spectrum," as defined by Professor J. M. T. Thompson, one of the editors of the book, in the opening chapter specifically written to introduce basic concepts of nonlinear dynamics. Nonlinearity is inevitable in the dynamical models and in the experiments that exhibit chaotic motion, and this idea is found and reiterated in the articles presented in the book.

The book includes 30 articles in addition to the introductory chapter. A review of each article is not appropriate here, mainly because these were presented at the symposium and reprocessed for consistency rather than rewritten as expanded chapters for the publication. The articles are grouped in seven parts namely, Experiments, Impact and Friction, Control, Engineering Applications, Random Vibration, Mathematical Techniques, and Uses of Chaos. Editors introduce the contents of the papers in a page or two, with comments on the subject at the beginning of each part. The applications presented in the articles provide an overview of current developments in the research in chaotic motion applicable to mechanics in general. Experimental coverage in these parts include cutting tool vibration, magnetomechanical beam oscillators, electrical circuits, lasers, impacting pendulums, a double-well potential duffing cart, and beam systems. These limited examples are the result of the requirement of sustained vibration and refined specialized measurements in the experimental setup together with the difficulty in characterizing or quantifying the chaotic motion experimentally. Subsequently, more research is focused on the theoretical models and their characterization. The examples include mechanical models of a turbine blade damper, inverted single and double pendulums, a dynamical absorber and its circuit analogy, a centrifugal pendulum vibration absorber, a simplified wheel set of a railway cart, 3-dimensional motion of a satellite influenced by solar radiation torques, cable dynamics, internal and external fluid flow induced vibration, etc. Almost all equations for the models carry certain generic features such as nonlinearity and/or discontinuous flexibility, time derivatives or iterative maps, periodic

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forcing functions, and some dissipative terms. The part on the topic of control is strictly the control of chaotic motion by parametric variation. This new area of interest is in identifying and in avoidance of chaos by adjustments of parameters adaptively. The last three parts of the book involve mathematical treatment of the subject. The other topics of current research are briefly summarized in the 12 abstracts given in Appendix I. Because these were included as display posters, some of them fall in the work in progress category and may be beneficial for extending research interests. Addresses of participants together with a wide-angled photograph, reminiscent of archival photographs of high level scientists or pioneers in the area of basic sciences, are given in Appendix II. Author and subject indices provide easy access of the subject matter.

The authors of the articles in the book consist of a specialized group of researchers and engineers. The value of the book lies in bringing together different categories under the field of engineering dynamics. Based on the limited mathematical coverage, it is certainly not a textbook or a tutorial on the subject but a collection of relevant articles. It could be considered as a starting point for research after one has understood the basic concepts of the geometrical theory of nonlinear dynamics and fractals from some other introductory books.* The book offers a wide variety of topics along with the cross section of sponsors of the research in chaotic dynamics. Some of the US sponsors are: National Science Foundation (NSF), Air Force Office of Scientific Research (AFOSR), Army Research Office (ARO), Department of Energy (DOE), and Office of Naval Research (ONR); in Canada: Natural Sciences and Engineering Council; in Europe: Science and Engineering Research Council of the U.K., Hungarian Scientific Research Foundation, Austrian Science Foundation, The Royal Society of the U.K., Danish Council for Scientific and Industrial Research, Alexander von Humboldt Foundation of Germany; in Russia: Russian Academy of Sciences; and other unspecified institutes and university supported centers.

The variety of applications presented in the book suggest that chaos is no more just a thrilling experience of seeing the existence of strange behavior in the solution of standard deterministic equations. It is, however, still under the category of basic sciences that is evident from the involvement of more researchers from universities. For a practicing engineer, however, the publication is not directly useful except to satisfy curiosity and to understand the extent of subjects covered as current research in the field of chaos.

It would have been appropriate, considering the efforts in bringing a refined publication in attractive format, to include the opening address by Sir James Lighthill, then president of IUTAM, and a general lecture by Philip Holmes of Cornell, both being well known in the fields of mechanics and nonlinear dynamics. In addition, a summary of discussion, which was held during the symposium, intended to "identify desirable developments and lines of research," should have been considered. Such inclusion would have given direct or wishful ideas for future trends in the field, influencing the subject from a practical standpoint. The variety of subject matters treated in the articles and introductions to the parts, however, provide a pointer toward future reseach.

Most of the time, the proceedings of symposia or conferences are distributed only to the attendees or later made available at a relatively high price. Considering this practice, the edited book form of the proceedings of the symposium, available at a reasonable price for a bound volume, is a welcome effort and useful to those who want to pursue research in one of the young, growing fields of engineering dynamics.

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*Some useful books for a start are *Nonlinear Dynamics and Chaos* by J.M.T. Thompson and H.B. Stewart (1986); *Chaotic Vibrations* by Professor F.C. Moon (1987); and *Dynamics: The Geometry of Behaviour* by R.H. Abraham and C.D. Shaw (1992).