Applied Chaos

Edited by

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PREFACE

Chaos umpire sits, . . . , Chance governs all.

John Milton, *Paradise Lost*

Over the past few decades, many exciting and interesting ideas have been developed in nonlinear dynamics. In particular, the birth of the science of chaotic dynamics has been a source of great excitement in the scientific community. Chaos has been a subject of intense curiosity, but the activity has been largely confined to a small community of academicians and research scientists. Surely, some popular books on chaos (such as *Chaos*, by James Gleick, Viking Press, 1987) have enlightened the laity about the science of chaos, but chaos has been largely a fertile garden for theoreticians and natural philosophers. Their main interest has been to identify and describe chaotic phenomena or to investigate the fundamental nature of chaos in terms of their own familiar languages. Practical implications of these ideas in engineering, biology, medicine, and other technological fields have not been widely perceived or appreciated. We have often heard many practical-minded people expressing a curt question about chaos: "So what?" This volume is an attempt to answer partially the mundane but nontrivial question, What can we say about applications of chaos? What opportunities does it present to the engineers and applied scientists to understand better the way systems work—or fail—and, ultimately, what can they do about it?

As a first step toward enhancing the awareness of the potential applications of chaotic dynamics and related subjects, the Electric Power Research Institute (EPRI) sponsored the International Workshop on Applications of Chaos, held in San Francisco, December 4–7, 1990. This volume contains the lectures presented at the workshop, as well as some of the very vigorous

discussion that the presentations engendered. Although EPRI's long-term objective is to apply chaotic dynamics to problems in the electric utility industry and other energy-related areas, the scope of the workshop was not confined to these topics. Our theme was applications, regardless of the areas. Our strategy was to make the meeting as chaotic as possible—but with order! Experts from all disciplines of chaos were invited—physicists, chemists, mathematicians, engineers (electrical, mechanical, chemical, nuclear, and civil), physiologists, information and computer scientists, material scientists, and others—and were encouraged to speak freely, but about applications of chaos (occasional gentle reminders and guidance were in order to keep them on track). The only constraint—that they should speak about the applications —served rather well to achieve order within chaos! The result was revealing and rewarding. Many participants, who never thought of chaos in terms of practical applications, were presenting specific examples of applications and expounding them with great fascination and enthusiasm. It became clear that applied chaotic dynamics would play an increasingly important role in many branches of science and technology precisely because of its ubiquitous nature. Transition from regular behavior to chaotic behavior is not an exception but rather a norm in many real systems. It was also interesting to see that although in many practical systems a transition to chaos is undesirable, in others it is the preferred mode of operation—this result was even surprising to some of the active investigators in the field. The workshop has also shown that many seemingly disparate fields are connected through the common concepts and language of chaos, proving again the interdisciplinary nature of chaotic phenomena.

The topics contained in this volume are as diverse as the participants, running the gamut from the dynamics of electrocardiograph data and the instability of conveyor belts to the time series modeling and control of chaos. The common thread among them, however, is that, with a few exceptions, they all address some applications aspect of chaos, be it practical or theoretical. We believe this is a main contribution of the workshop to the technical and scientific community.

We thank the authors, speakers, and all participants of the workshop for making the meeting a worthy event. Useful suggestions for the workshop were provided by Bruce Stewart. The workshop was sponsored by the Office of Exploratory Research of EPRI, and we thank Fritz Kalhammer, John Maulbetsch, and Walter Esselman for support and advice.

JONG HYUN KIM
JOHN STRINGER

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PART I

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