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Although their scope and methodologies overlap somewhat, one can distinguish the following main concepts and tools: self-organization, nonlinear dynamics, synergetics, turbulence, dynamical systems, catastrophes, instabilities, stochastic processes, chaos, graphs and networks, cellular automata, adaptive systems, genetic algorithms and computational intelligence.

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Understanding Complex Systems

Founding Editor: J.A. Scott Kelso

Future scientific and technological developments in many fields will necessarily depend upon coming to grips with complex systems. Such systems are complex in both their composition – typically many different kinds of components interacting simultaneously and nonlinearly with each other and their environments on multiple levels – and in the rich diversity of behavior of which they are capable.

The Springer Series in Understanding Complex Systems series (UCS) promotes new strategies and paradigms for understanding and realizing applications of complex systems research in a wide variety of fields and endeavors. UCS is explicitly transdisciplinary. It has three main goals: First, to elaborate the concepts, methods and tools of complex systems at all levels of description and in all scientific fields, especially newly emerging areas within the life, social, behavioral, economic, neuro- and cognitive sciences (and derivatives thereof); second, to encourage novel applications of these ideas in various fields of engineering and computation such as robotics, nano-technology and informatics; third, to provide a single forum within which commonalities and differences in the workings of complex systems may be discerned, hence leading to deeper insight and understanding.

UCS will publish monographs, lecture notes and selected edited contributions aimed at communicating new findings to a large multidisciplinary audience.

Santo Banerjee • Lamberto Rondoni • Mala Mitra
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Applications of Chaos and Nonlinear Dynamics in Science and Engineering – Vol. 2

Springer

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SB: To my son, Sumangal
LR: To my wife, Gabriella
MM: To my parents, Sujata and Sukumar Mitra

Preface

This is the second volume of the collection of essays entitled *Applications of Chaos and Nonlinear Dynamics in Engineering*, meant to introduce the interested readers to the subject of the ever-growing field of engineering applications of the modern theory of dynamical systems. This purpose has been pursued by means of essays written in the form of tutorials. The 10 chapters published in the first volume were organized in five parts, each concerning one field of present-day engineering:

I. Nonlinearity and Computer Simulations
II. Chaos and Nonlinear Dynamics in Electrical Engineering
III. Chaos and Nonlinear Dynamics in Building Mechanism and Fluid Dynamics
IV. Chaos in Robotics
V. Chaos and Nonlinear Dynamics in Communication

The present volume also contains ten chapters, subdivided into the following five parts:

I. Nonlinearity in Control Systems and Geo Engineering
II. Nonlinear Dynamics and Chaos in Electronics
III. Nonlinear Dynamics in Stochastic Networks
IV. Nonlinear Dynamics in Transport and Mechanical Engineering
V. Chaos Theory in Communication and Cryptography

The first contribution, by Bingo Wing-Kuen Ling, consists of a numerical study of the dynamics of HIV, which provides indications on the effectiveness of therapies, for medical doctors to consider. The second contribution, by Devanjan Bhattacharya, J.K. Ghosh, and Swej Kumar Sharma, gives an application of fuzzy theory to the development of landslides. The third contribution, by Hamid Reza Karimi, concerns the *nonlinear control* method known as sliding mode control, with applications in chaotic dynamics. The fourth chapter, by M.P. Hanias, H.E. Nistazakis, and G.S. Tombras, addresses the classical and technological important issue of transistor circuits, which may be driven into chaotic states by external

perturbations. The fifth essay, Nicole Abaid and Maurizio Porfiri, deals with numerosity-constrained networks and their applications to consensus problems and to synchronization.

The sixth chapter, by Gianpiero Mastinu, Fabio Della Rossa, and Carlo Piccardi, investigates the stability of automobiles travelling on straight or curved roads. The seventh article, by Shane D. Ross and Phanindra Tallapragada, discusses the features of chaotic phase space transport in finite time, nonautonomous systems, which are of interest in many different situations, including the study of geophysical flows and mixing in microchannels. The eighth chapter, by Congxu Zhu and Kehui Sun, considers the problem of copyrights and digital watermarking, and explains how chaotic dynamics can be used for copyright protection. The ninth chapter, by M.R.K. Ariffin, N.M.G. Al-Saidi, M.R.M. Said, Z. Mahad, and M.A. Daud, concerns the use of chaos-based techniques for cryptosystems. The tenth chapter, by S. Banerjee, considers synchronization and introduces a robust method of digital cryptography based on genetic algorithms.

Like the chapters published in volume 1, we hope that also this second collection of chapter will be found useful by professionals as well as undergraduate and graduate students of applied sciences.

We wish to express our gratitude to the staff of Springer Verlag, for their invaluable help and support throughout this work. In particular, we would like to thank Dr. Christian Caron (editor, Springer Physics), Gabriele Hakuba (editorial assistant), Benjamin Feuchter, and Anitha Murugaiyan.

Torino, 4 November 2011

S. Banerjee, L. Rondoni, and M. Mitra

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