Practical Numerical Algorithms For Chaotic Systems

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Chaotic and Fractal Dynamics Elsevier
In this book, bifurcational mechanisms of the development, structure and properties of chaotic attractors are investigated by numerical and physical experiments based on the methods of the modern theory of nonlinear oscillations. The typical bifurcations of regular and chaotic attractors which are due to parameter variations are analyzed.Regularities of the transition to chaos via the collapse of quasiperiodic oscillations with two and three frequencies are investigated in detail. The book deals with the problems of chaotic synchronization, interaction of attractors and the phenomenon of stochastic resonance. The problems of fluctuation influence on the bifurcations and properties of chaotic attractors are investigated more closely.All principal problems are investigated by the comparison of theoretical and numerical results and data from physical experiments.
Suppression, Synchronization and Chaotification Springer
Covers advances in the field of computer techniques and algorithms in digital signal processing.
Theory, Applications, and Control Cambridge University Press
Chaos: A Program Collection for the PC presents an outstanding selection of executable programs with introductory texts to chaos theory and its simulation. Students in physics, mathematics, and engineering will find a thorough introduction to fundamentals and applications in this field. Many numerical experiments and suggestions for further studies help the reader to become familiar with this fascinating topic. The second edition includes one CD-ROM, the executable programs are Windows 95 compatible.
Chaos Springer Science & Business Media
Mem-elements for Neuromorphic Circuits with Artificial Intelligence Applications illustrates recent advances in the field of mem-elements (memristor, memcapacitor, meminductor) and their applications in nonlinear dynamical systems, computer science, analog and digital systems, and in neuromorphic circuits and artificial intelligence. The book is mainly devoted to recent results, critical aspects and perspectives of ongoing research on relevant topics, all involving networks of mem-elements devices in diverse applications. Sections contribute to the discussion of memristive materials and transport mechanisms, presenting various types of physical structures that can be fabricated to realize mem-elements in integrated circuits and device modeling. As the last decade has seen an increasing interest in recent advances in mem-elements and their applications in neuromorphic circuits and artificial intelligence, this book will attract researchers in various fields. Covers a broad range of interdisciplinary topics between mathematics, circuits, realizations, and practical applications related to nonlinear dynamical systems, nanotechnology, analog and digital systems, computer science and artificial intelligence Presents recent advances in the field of mem-elements (memristor, memcapacitor, meminductor) Includes interesting applications of mem-elements in nonlinear dynamical systems, analog and digital systems, neuromorphic circuits, computer science and artificial intelligence
Computational Methods for Translational Brain-Behavior Analysis World Scientific

Practical Numerical Algorithms for Chaotic SystemsSpringer Science & Business Media
Theory and Applications to Economics Springer Science & Business Media
The treatment of chaotic dynamics in mathematics and physics during last two decades has led to a number of new concepts for the investigation of complex behavior in nonlinear dynamical processes. The aim the CISM course Engineering Applications of Dynamics of Chaos of which this is the proceedings volume was to make these concepts available to engineers and applied scientists possessing only such modest knowledges in mathematics which are usual for engineers, for example graduating from a Technical University. The contents of the articles contributed by leading experts in this field cover not only theoretical foundations and algorithmic and computational aspects but also applications to engineering problems. In the first article an introduction into the basic concepts for the investigation of chaotic behavior of dynamical systems is given which is followed in the second article by an extensive treatment of approximative analytical methods to determine the critical parameter values describing the onset of chaos. The important relation between chaotic dynamics and the phenomenon of turbulence is treated in the third article by studying instabilities various fluid flows. In this contribution also an introduction into interesting phenomenon of pattern formation is given. The fourth and fifth articles present various applications to nonlinear oscillations including roll motions of ships, rattling oscillations in gear boxes, tumbling oscillations of satellites, flutter motions of fluid carrying pipes and vibrations of robot arms. In the final article a short treatment of hyperchaos is given.
Introduction for Applied Scientists and Engineers Springer
This book offers readers a clear guide to implementing engineering applications with FPGAs, from the mathematical description to the hardware synthesis, including discussion of VHDL programming and co-simulation issues. Coverage includes FPGA realizations such as: chaos generators that are described from their mathematical models; artificial neural networks (ANNs) to predict chaotic time series, for which a discussion of different ANN topologies is included, with different learning techniques and activation functions; random number generators (RNGs) that are realized using different chaos generators, and discussions of their maximum Lyapunov exponent values and entropies. Finally, optimized chaotic oscillators are synchronized and realized to implement a secure communication system that processes black and white and grey-scale images. In each application, readers will find VHDL programming guidelines and computer arithmetic issues, along with co-simulation examples with Active-HDL and Simulink. The whole book provides a practical guide to implementing a variety of engineering applications from VHDL programming and co-simulation issues, to FPGA realizations of chaos generators, ANNs for chaotic time-series prediction, RNGs and chaotic secure communications for image transmission.
Proceedings of the Estonian Academy of Sciences, Physics and Mathematics Springer Science & Business Media
Attractors, Bifurcations, & Chaos - now in its second edition - begins with an introduction to mathematical methods in modern nonlinear dynamics and deals with differential equations. Phenomena such as bifurcations and deterministic chaos are given considerable emphasis, both in the methodological part, and in the second part, containing various applications in economics and in regional science. Coexistence of attractors and the multiplicity of development paths in nonlinear systems are central topics. The applications focus on issues such as business cycles, oligopoly, interregional trade dynamics, and economic development theory.
Nonlinear Dynamical Economics and Chaotic Motion Bentham Science Publishers
This book details the simulation and optimization of integer and fractional-order chaotic systems, and how they can be implemented in the analog and digital domains using FPAAs and FPGAs. Design guidelines are provided to use commercially available electronic devices, and to perform hardware descriptions of integer/fractional-order chaotic systems programming in VHDL. Finally, several engineering applications oriented to cryptography, internet of things, robotics and chaotic communications, are detailed to highlight the usefulness of FPAA/FPGA based integer/fractional-order chaotic systems. Provides guidelines to implement fractional-order derivatives using commercially available devices; Describes details on using FPAAs to approach fractional-order chaotic systems; Includes details on using FPGAs to approach fractional-order chaotic systems, programming in VHDL and reducing hardware resources; Discusses applications to cryptography, internet of things, robotics and chaotic communications.
Advances in Theory and Applications Springer
Usually, the first edition of a book still contains a multiplicity of typographic, con ceptional, and computational errors even if one believes the opposite at the time of publication. As this book did not represent a counterexample to this rule, the current second edition offers a chance to remove at least the known shortcomings. The book has been partly re-organized. The previously rather long Chapter 4 has been split into two separate chapters dealing with discrete-time and continuous time approaches to nonlinear economic dynamics. The short summary of basic properties of linear dynamical systems has been banned to an appendix because the line of thought in the chapter seems to have been unnecessarily interrupted by these technical details and because the book concentrates on nonlinear systems. This appendix, which mainly deals with special formal properties of dynamical sys tems, also contains some new material on invariant subspaces and center-manifold reductions. A brief introduction into the theory of lags and operators is followed by a few remarks on the relation between the 'true' properties of dynamical systems and their behavior observable in numerical experiments. Additional changes in the main part of the book include a re-consideration of Popper's determinism vs. inde terminism discussion in the light of chaotic properties of deterministic, nonlinear systems in Chapter 1. An investigation of a simultaneous price-quantity adjustment process, a more detailed inquiry into the uniqueness property of limit cycles, and a short presentation of relaxation oscillations are included in Chapter 2.
Models and Experiments : Appearance Routes and Structure of Chaos in Simple Dynamical Systems World Scientific
Mathematicians have devised different chaotic systems that are modeled by integer or fractional-order differential equations, and whose mathematical models can generate chaos or hyperchaos. The numerical methods to simulate those integer and fractional-order chaotic systems are quite different and their exactness is responsible in the evaluation of characteristics like Lyapunov exponents, Kaplan-Yorke dimension, and entropy. One challenge is estimating the step-size to run a numerical method. It can be done analyzing the eigenvalues of self-excited attractors, while for hidden attractors it is difficult to evaluate the equilibrium points that are required to formulate the Jacobian matrices. Time simulation of fractional-order chaotic oscillators also requires estimating a memory length to achieve exact results, and it is associated to memories in hardware design. In this manner, simulating chaotic/hyperchaotic oscillators of integer/fractional-order and with self-excited/hidden attractors is quite important to evaluate their Lyapunov exponents, Kaplan-Yorke dimension and entropy. Further, to improve the dynamics of the oscillators, their main characteristics can be optimized applying metaheuristics, which basically consists of varying the values of the coefficients of a mathematical model. The optimized models can then be implemented using commercially available amplifiers, field-programmable analog arrays (FPAA), field-programmable gate arrays (FPGA), microcontrollers, graphic processing units, and even using nanometer technology of integrated circuits. The book describes the application of different numerical methods to simulate integer/fractional-order chaotic systems. These methods are used within optimization loops to maximize positive Lyapunov exponents, Kaplan-Yorke dimension, and entropy. Single and multi-objective optimization approaches applying metaheuristics are described, as well as their tuning techniques to generate feasible solutions that are suitable for electronic implementation. The book details several applications of chaotic oscillators such as in random bit/number generators, cryptography, secure communications, robotics, and Internet of Things.
Cellular Neural Networks, Multi-scroll Chaos and Synchronization Springer Science & Business Media
As the current millennium steams towards a close, one cannot help but look with amazement at the incredible amount of progress that has been achieved in medicine in just the last few decades. A key contributing factor to this success has been the importation and blending of ideas and techniques from disciplines outside the traditional borders of medical science. In recent years, the most well-known example is the cross-pollination between molecular biology and medicine. Advances driven by this potent combination have spawned the vision of a future where cures based on gene therapy become commonplace. Yet, as we continue our search for "magic bullets" in the quest to eradicate disease, it important to recognize the value of other less-heralded interdisciplinary efforts that have laid a large part of the foundation of present-day medicine. In pulmonary medicine, the contribution from the bioengineers (a diverse collection of individuals cross-bred to various degrees in mathematical modeling and experimental physiology) has been larger and more sustained than in many other medical specialties. It is easy to point to the vast array of ventilators, blood-gas analyzers, oximeters, pulmonary function devices, and respiration monitors that are present in any modern clinical setting as solid evidence of the successful synergy between engineering science and pulmonary medicine. However, one must not forget the less tangible, but perhaps more important, contributions that have been derived from mathematical modeling and computer simulation, without which many of these modern instruments would not have come into existence.
Electronic Design Automation of Multi-scroll Chaos Generators CRC Press
This book reports on the latest advances and applications of chaotic systems. It consists of 25 contributed chapters by experts who are specialized in the various topics addressed in this book. The chapters cover a broad range of topics of chaotic systems such as chaos, hyperchaos, jerk systems, hyperjerk systems, conservative and dissipative systems, circulant chaotic systems, multi-scroll chaotic systems, finance chaotic system, highly chaotic systems, chaos control, chaos synchronization, circuit realization and applications of chaos theory in secure communications, mobile robot, memristors, cellular neural networks, etc. Special importance was given to chapters offering practical solutions, modeling and novel control methods for the recent research problems in chaos theory. This book will serve as a reference book for graduate students and researchers with a basic knowledge of chaos theory and control systems. The resulting design procedures on the chaotic systems are emphasized using MATLAB software.
Analog/Digital Implementation of Fractional Order Chaotic Circuits and Applications CRC Press
This book is primarily concerned with the computational aspects of predictability of dynamical systems – in particular those where observation, modeling and computation are strongly interdependent. Unlike with physical systems under control in laboratories, for instance in celestial mechanics, one is confronted with the observation and modeling of systems without the possibility of altering the key parameters of the objects studied. Therefore, the numerical simulations offer an essential tool for analyzing these systems. With the widespread use of computer simulations to solve complex dynamical systems, the reliability of the numerical calculations is of ever-increasing interest and importance. This reliability is directly related to the regularity and instability properties of the modeled flow. In this interdisciplinary scenario, the underlying physics provide the simulated models, nonlinear dynamics provides their chaoticity and instability properties, and the computer sciences provide the actual numerical implementation. This book introduces and explores precisely this link between the models and their predictability characterization based on concepts derived from the field of nonlinear dynamics, with a focus on the finite-time Lyapunov exponents approach. The method is illustrated using a number of well-known continuous dynamical systems, including the Contopoulos, Hénon-Heiles and Rössler systems. To help students and newcomers quickly learn to apply these techniques, the appendix provides descriptions of the algorithms used throughout the text and details how to implement them in order to solve a given continuous dynamical system.
Chaos and Complexity in Nonlinear Electronic Circuits Springer Science & Business Media
For almost ten years chaos and fractals have been enveloping many areas of mathematics and the natural sciences in their power, creativity and expanse. Reaching far beyond the traditional bounds of mathematics and science to the realms of popular culture, they have captured the attention and enthusiasm of a worldwide audience. The fourteen chapters of the book cover the central ideas and concepts, as well as many related topics including, the Mandelbrot Set, Julia Sets, Cellular Automata, L-Systems, Percolation and Strange Attractors, and each closes with the computer code for a central experiment. In the two appendices, Yuval Fisher discusses the details and ideas of fractal image compression, while Carl J.G. Evertsz and Benoit Mandelbrot introduce the foundations and implications of multifractals.
A Comprehensive Introduction Springer Science & Business Media
Co-author J.A. Yorke developed an array of tools to help visualize the properties of dynamical systems, while Yorke found it useful to combine these various basic tools into one single package: Dynamics. The program together with this manual provides an introduction to and an overview of fundamental, sophisticated tools and numerical methods together with many simple examples. All numerical methods described in this handbook are implemented in the program, which is capable of, among others: iterating maps and solving differential equations; plotting trajectories; featuring an array of simple commands; printing a created picture in resolution higher than that of the screen. Requires a UNIX workstation running X11 graphics or a PC.
Semi-analytic Methods for the Navier-Stokes Equations Elsevier

This text aims to bridge the gap between non-mathematical popular treatments and the distinctly mathematical publications that non-mathematicians find so difficult to penetrate. The author provides understandable derivations or explanations of many key concepts, such as Kolmogrov-Sinai entropy, dimensions, Fourier analysis, and Lyapunov exponents.

Engineering Applications of FPGAs Springer Science & Business Media

The lectures collected for this volume were given during a workshop entitled, ``Semi-analytic Methods for the Navier Stokes Equations'' held at the CRM in Montreal. The title reflects the current reality in fluid dynamics: Navier-Stokes equations (NSE) describe the behavior of fluid in a wide range of physical situations, the solutions of these equations are sufficiently complicated, so that another level of analysis is clearly needed. The fundamental problem is not just to solve the NSE, but also to understand what the solutions mean. One of the goals of the workshop was to bring together people who, while working in different fields, share a common perspective on the nature of the problem to be solved. The lectures present a diverse set of techniques for modelling, computing, and understanding phenomena such as instabilities, turbulence and spatiotemporal chaos in fluids.

A Computer Graphical Journey CRC Press

These days computer-generated fractal patterns are everywhere, from squiggly designs on computer art posters to illustrations in the most serious of physics journals. Interest continues to grow among scientists and, rather surprisingly, artists and designers. This book provides visual demonstrations of complicated and beautiful structures that can arise in systems, based on simple rules. It also presents papers on seemingly paradoxical combinations of randomness and structure in systems of mathematical, physical, biological, electrical, chemical, and artistic interest. Topics include: iteration, cellular automata, bifurcation maps, fractals, dynamical systems, patterns of nature created through simple rules, and aesthetic graphics drawn from the universe of mathematics and art. Chaos and Fractals is divided into six parts: Geometry and Nature; Attractors; Cellular Automata, Gaskets, and Koch Curves; Mandelbrot, Julia and Other Complex Maps; Iterated Function Systems; and Computer Art. Additionally, information on the latest practical applications of fractals and on the use of fractals in commercial products such as the antennas and reaction vessels is presented. In short, fractals are increasingly finding application in practical products where computer graphics and simulations are integral to the design process. Each of the six sections has an introduction by the editor including the latest research, references, and updates in the field. This book is enhanced with numerous color illustrations, a comprehensive index, and the many computer program examples encourage reader involvement.

Practical Numerical Algorithms for Chaotic Systems Academic Press

One of the basic tenets of science is that deterministic systems are completely predictable-given the initial condition and the equations describing a system, the behavior of the system can be predicted 1 for all time. The discovery of chaotic systems has eliminated this viewpoint. Simply put, a chaotic system is a deterministic system that exhibits random behavior. Though identified as a robust phenomenon only twenty years ago, chaos has almost certainly been encountered by scientists and engi neers many times during the last century only to be dismissed as physical noise. Chaos is such a wide-spread phenomenon that it has now been reported in virtually every scientific discipline: astronomy, biology, biophysics, chemistry, engineering, geology, mathematics, medicine, meteorology, plasmas, physics, and even the social sci ences. It is no coincidence that during the same two decades in which chaos has grown into an independent field of research, computers have permeated society. It is, in fact, the wide availability of inex pensive computing power that has spurred much of the research in chaotic dynamics. The reason is simple: the computer can calculate a solution of a nonlinear system. This is no small feat. Unlike lin ear systems, where closed-form solutions can be written in terms of the system's eigenvalues and eigenvectors, few nonlinear systems and virtually no chaotic systems possess closed-form solutions.