Editorial

Nonlinear Dynamics and Entropy of Complex Systems: Advances and Perspectives

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Biological, engineering, economic, social, medical, environmental, and other systems exhibit time evolution. These observable objects can be either naturally inspired or artificial, isolated or non-autonomous, and truly deterministic or stochastic. Some of them can be, after appropriately executed simplification, modelled by suitable mathematical expressions, usually in the form of ordinary differential equations. Since global models need to be treated as nonlinear, complicated types of dynamical behavior that include multistability and chaos represent possible solutions.

In addition to its application in information theory, entropy is a general measure frequently used for the qualitative analysis of complex systems. Aside from its mathematical definition, entropy describes the complexity of dynamics with respect to internal system parameters, initial conditions, external forcing, time instances, or other factors that affect system dynamics.

Using our knowledge of mathematical models, powerful modern personal computers can be used to localize specific types of dynamic behaviors. For example, Petrzela [1] investigated a fundamental single-stage amplifier with resonant load where the only active element is a bipolar transistor with nonlinear (both polynomial and piecewise-linear) backward trans-conductance. The derived and analyzed mathematical model is an autonomous third-order deterministic dynamical system. By considering the large six-dimensional hyperspace of internal system parameters dedicated to the searching-for-chaos routine, up to eleven different configurations of values turned out to be chaotic. The existence of strange attractors was proven via standard numerical algorithms such as surface-contour plots of the largest Lyapunov exponents. Geometrical structures of the typical chaotic attractors were quantified using the capacity and Kaplan–Yorke dimension and by calculating the approximate entropy using a generated time sequence. The long-term structural stability of numerically integrated chaotic attractors was confirmed by the construction of a flow–equivalent chaotic oscillator and experimental measurements. The captured oscilloscope screenshots are in good agreement with the theory. Although the bias point that characterizes the admittance parameters of the transistor model is hypothetical and probably unreachable in real life amplifier application, the discovered chaotic systems can be marked as novel due to their many interestingly shaped strange attractors.

There are many analog functional blocks that take advantage of the production of signals with increased entropy. True random bits generators (TRNGs) are examples of such electronic systems. Stoller et al. [2] introduce a novel TRNG and compare the randomness of its output signals with two other existing TRNG structures using tests established by the National Institute of Standards and Technology. A common feature of each investigated TRNG is the presence of W-SDC memristors as integrated circuits (developed and fabricated by Knowm Inc., Santa Fe, NM, USA). Memristors are key circuit elements and a source of the entropic properties of output data sequences. In the first TRNG, using Jiang's topology, entropy is captured within a single memristor device during the transition time between its on and off state (represented by its low and high resistance, respectively). The same principle, but with the use of two memristors, is adopted in Rai's TRNG structure. The final

Dynamics Of Complex Systems Studies In Nonlinearity

Rafael Martinez-Guerra,Juan Luis Mata-Machuca

Dynamics Of Complex Systems Studies In Nonlinearity:

   Dynamics Of Complex Systems Yaneer Bar-yam,2019-03-04 This book aims to develop models and modeling techniques that are useful when applied to all complex systems It adopts both analytic tools and computer simulation The book is intended for students and researchers with a variety of backgrounds   Applications of Nonlinear Dynamics Visarath In,Patrick Longhini,Antonio Palacios,2009-02-11 The eld of applied nonlinear dynamics has attracted scientists and engineers across many different disciplines to develop innovative ideas and methods to study c plex behavior exhibited by relatively simple systems Examples include population dynamics uidization processes applied optics stochastic resonance ocking and ightformations lasers andmechanicalandelectricaloscillators Acommontheme among these and many other examples is the underlying universal laws of nonl ear science that govern the behavior in space and time of a given system These laws are universal in the sense that they transcend the model speci c features of a system and so they can be readily applied to explain and predict the behavior of a wide ranging phenomena natural and arti cial ones Thus the emphasis in the past decades has been in explaining nonlinear phenomena with signi cantly less att tion paid to exploiting the rich behavior of nonlinear systems to design and fabricate new devices that can operate more ef ciently Recently there has been a series of meetings on topics such as Experimental Chaos Neural Coding and Stochastic Resonance which have brought together many researchers in the eld of nonlinear dynamics to discuss mainly theoretical ideas that may have the potential for further implementation In contrast the goal of the 2007 ICAND International Conference on Applied Nonlinear Dynamics was focused more sharply on the implementation of theoretical ideas into actual vices and systems   *Chaotic, Fractional, and Complex Dynamics: New Insights and Perspectives* Mark Edelman,Elbert E. N. Macau,Miguel A. F. Sanjuan,2017-11-17 The book presents nonlinear chaotic and fractional dynamics complex systems and networks together with cutting edge research on related topics The fifteen chapters written by leading scientists working in the areas of nonlinear chaotic and fractional dynamics as well as complex systems and networks offer an extensive overview of cutting edge research on a range of topics including fundamental and applied research These include but are not limited to aspects of synchronization in complex dynamical systems universality features in systems with specific fractional dynamics and chaotic scattering As such the book provides an excellent and timely snapshot of the current state of research blending the insights and experiences of many prominent researchers   *Nonlinear Dynamics in Complex Systems* Armin Fuchs,2012-09-23 With many areas of science reaching across their boundaries and becoming more and more interdisciplinary students and researchers in these fields are confronted with techniques and tools not covered by their particular education Especially in the life and neurosciences quantitative models based on nonlinear dynamics and complex systems are becoming as frequently implemented as traditional statistical analysis Unfamiliarity with the terminology and rigorous mathematics may discourage many scientists to adopt these methods for their own work even though such reluctance in most cases is not justified This book bridges this

gap by introducing the procedures and methods used for analyzing nonlinear dynamical systems In Part I the concepts of fixed points phase space stability and transitions among others are discussed in great detail and implemented on the basis of example elementary systems Part II is devoted to specific non trivial applications coordination of human limb movement Haken Kelso Bunz model self organization and pattern formation in complex systems Synergetics and models of dynamical properties of neurons Hodgkin Huxley Fitzhugh Nagumo and Hindmarsh Rose Part III may serve as a refresher and companion of some mathematical basics that have been forgotten or were not covered in basic math courses Finally the appendix contains an explicit derivation and basic numerical methods together with some programming examples as well as solutions to the exercises provided at the end of certain chapters Throughout this book all derivations are as detailed and explicit as possible and everybody with some knowledge of calculus should be able to extract meaningful guidance follow and apply the methods of nonlinear dynamics to their own work This book is a masterful treatment one might even say a gift to the interdisciplinary scientist of the future With the authoritative voice of a genuine practitioner Fuchs is a master teacher of how to handle complex dynamical systems What I find beautiful in this book is its clarity the clear definition of terms every step explained simply and systematically J A Scott Kelso excerpts from the foreword   Thinking in Complexity Klaus Mainzer,2013-03-09 The second edition of Thinking in Complexity like the first edition was also sold out in less than one year Meanwhile Japanese and Chinese translations of the sec ond editon have been published Once more I have taken the opportunity provided by a new edition to revise and extend the text A new Sect 2 5 Complex Systems and the Self Construction of Materials is included in order to ana lyze the role of complex systems in the dramatic success of supramolecular chemistry nanotechnology and the technology of smart intelligent materials These top ics lie at the boundary between materials science and life science In recent years life science and computer science have been growing together in a common field of research called artificial life A further new Sect 5 5 From Artificial Intelligence to Artificial Life has been added in which the role of complex systems in the field of arti ficiallife is discussed I also use the opportunity of the new edition to make some remarks about the relationship between the Santa Fe approach to complex systems and the methods of synergetics and order parameters which are key concepts in this book Research into complex systems continues world wide I have to thank the readers who have written friendly and inspiring letters from all over the world Some months ago a German Society of Complex Sys tems and Nonlinear Dynamics was founded   **From Hamiltonian Chaos to Complex Systems** Xavier Leoncini,Marc Leonetti,2013-07-14 From Hamiltonian Chaos to Complex Systems A Nonlinear Physics Approach collects contributions on recent developments in non linear dynamics and statistical physics with an emphasis on complex systems This book provides a wide range of state of the art research in these fields The unifying aspect of this book is demonstration of how similar tools coming from dynamical systems nonlinear physics and statistical dynamics can lead to a large panorama of research in various fields of physics and beyond most notably with the perspective of application in

complex systems **Foundations of Complex Systems** Gregoire Nicolis,Cathy Nicolis,2007 A geometric process is a simple monotone process that was first introduced by the author in 1988 It is a generalization of renewal process This book captures the extensive research work on geometric processes that has been done since then in both probability and statistics theory and various applications Some results are published for the first time A reference book for researchers and a handbook for practioners it is also a useful textbook for postgraduate or senior undergraduate students *A Mathematical Modeling Approach from Nonlinear Dynamics to Complex Systems* Elbert E. N. Macau,2018-06-14 This book collects recent developments in nonlinear and complex systems It provides up to date theoretic developments and new techniques based on a nonlinear dynamical systems approach that can be used to model and understand complex behavior in nonlinear dynamical systems It covers symmetry groups conservation laws risk reduction management barriers in Hamiltonian systems and synchronization and chaotic transient Illustrating mathematical modeling applications to nonlinear physics and nonlinear engineering the book is ideal for academic and industrial researchers concerned with machinery and controls manufacturing and controls Introduces new concepts for understanding and modeling complex systems Explains risk reduction management in complex systems Examines the symmetry group approach to understanding complex systems Illustrates the relation between transient chaos and crises Nonlinear Systems, Vol. 1 Victoriano Carmona,Jesús Cuevas-Maraver,Fernando Fernández-Sánchez,Elisabeth García- Medina,2018-09-15 This book is part of a two volume set which presents the analysis of nonlinear phenomena as a long standing challenge for research in basic and applied science as well as engineering It discusses nonlinear differential and differential equations bifurcation theory for periodic orbits and global connections The integrability and reversibility of planar vector fields and theoretical analysis of classic physical models are sketched This first volume concentrates on the mathematical theory and computational techniques that are essential for the study of nonlinear science a second volume deals with real world nonlinear phenomena in condensed matter biology and optics **Nonlinear Systems, Vol. 2** Juan F. R. Archilla,Faustino Palmero,M. Carmen Lemos,Bernardo Sánchez-Rey,Jesús Casado-Pascual,2017-12-21 This book presents an overview of the most recent advances in nonlinear science It provides a unified view of nonlinear properties in many different systems and highlights many new developments While volume 1 concentrates on mathematical theory and computational techniques and challenges which are essential for the study of nonlinear science this second volume deals with nonlinear excitations in several fields These excitations can be localized and transport energy and matter in the form of breathers solitons kinks or quodons with very different characteristics which are discussed in the book They can also transport electric charge in which case they are known as polarobreathers or solectrons Nonlinear excitations can influence function and structure in biology as for example protein folding In crystals and other condensed matter they can modify transport properties reaction kinetics and interact with defects There are also engineering applications in electric lattices Josephson junction arrays waveguide arrays photonic crystals and optical fibers Nonlinear

excitations are inherent to Bose Einstein Condensates constituting an excellent benchmark for testing their properties and providing a pathway for future discoveries in fundamental physics *Deterministic Nonlinear Systems* Vadim S. Anishchenko,Tatyana E. Vadivasova,Galina I. Strelkova,2014-06-16 This text is a short yet complete course on nonlinear dynamics of deterministic systems Conceived as a modular set of 15 concise lectures it reflects the many years of teaching experience by the authors The lectures treat in turn the fundamental aspects of the theory of dynamical systems aspects of stability and bifurcations the theory of deterministic chaos and attractor dimensions as well as the elements of the theory of Poincare recurrences Particular attention is paid to the analysis of the generation of periodic quasiperiodic and chaotic self sustained oscillations and to the issue of synchronization in such systems This book is aimed at graduate students and non specialist researchers with a background in physics applied mathematics and engineering wishing to enter this exciting field of research *Frequency Domain Analysis and Design of Nonlinear Systems based on Volterra Series Expansion* Xingjian Jing,Ziqiang Lang,2015-02-17 This book is a systematic summary of some new advances in the area of nonlinear analysis and design in the frequency domain focusing on the application oriented theory and methods based on the GFRF concept which is mainly done by the author in the past 8 years The main results are formulated uniformly with a parametric characteristic approach which provides a convenient and novel insight into nonlinear influence on system output response in terms of characteristic parameters and thus facilitate nonlinear analysis and design in the frequency domain The book starts with a brief introduction to the background of nonlinear analysis in the frequency domain followed by recursive algorithms for computation of GFRFs for different parametric models and nonlinear output frequency properties Thereafter the parametric characteristic analysis method is introduced which leads to the new understanding and formulation of the GFRFs and nonlinear characteristic output spectrum nCOS and the nCOS based analysis and design method Based on the parametric characteristic approach nonlinear influence in the frequency domain can be investigated with a novel insight i e alternating series which is followed by some application results in vibration control Magnitude bounds of frequency response functions of nonlinear systems can also be studied with a parametric characteristic approach which result in novel parametric convergence criteria for any given parametric nonlinear model whose input output relationship allows a convergent Volterra series expansion This book targets those readers who are working in the areas related to nonlinear analysis and design nonlinear signal processing nonlinear system identification nonlinear vibration control and so on It particularly serves as a good reference for those who are studying frequency domain methods for nonlinear systems *Chaos and Complexity Theory for Management: Nonlinear Dynamics* Banerjee, Santo,2012-11-30 Although chaos theory refers to the existence between seemingly random events it has been gaining the attention of science technology and managements fields The shift from traditional procedures to the dynamics of chaos and complexity theory has resulted in a new element of complexity thinking allowing for a greater capability for analyzing and understanding key business processes Chaos and Complexity

Theory for Management Nonlinear Dynamics explores chaos and complexity theory and its relationship with the understanding of natural chaos in the business environment Utilizing these theories aids in comprehending the development of businesses as a complex adaptive system   *An Introduction to Complex Systems* Paul Fieguth,2016-11-26 This undergraduate text explores a variety of large scale phenomena global warming ice ages water poverty and uses these case studies as a motivation to explore nonlinear dynamics power law statistics and complex systems Although the detailed mathematical descriptions of these topics can be challenging the consequences of a system being nonlinear power law or complex are in fact quite accessible This book blends a tutorial approach to the mathematical aspects of complex systems together with a complementary narrative on the global ecological societal implications of such systems Nearly all engineering undergraduate courses focus on mathematics and systems which are small scale linear and Gaussian Unfortunately there is not a single large scale ecological or social phenomenon that is scalar linear and Gaussian This book offers students insights to better understand the large scale problems facing the world and to realize that these cannot be solved by a single narrow academic field or perspective Instead the book seeks to emphasize understanding concepts and ideas in a way that is mathematically rigorous so that the concepts do not feel vague but not so technical that the mathematics get in the way The book is intended for undergraduate students in a technical domain such as engineering computer science physics mathematics and environmental studies   **Algorithms of Estimation for Nonlinear Systems** Rafael Martínez-Guerra,Christopher Diego Cruz-Ancona,2017-04-04 This book acquaints readers with recent developments in dynamical systems theory and its applications with a strong focus on the control and estimation of nonlinear systems Several algorithms are proposed and worked out for a set of model systems in particular so called input affine or bilinear systems which can serve to approximate a wide class of nonlinear control systems These can either take the form of state space models or be represented by an input output equation The approach taken here further highlights the role of modern mathematical and conceptual tools including differential algebraic theory observer design for nonlinear systems and generalized canonical forms   **Nonlinear Resonances** Shanmuganathan Rajasekar,Miguel A. F. Sanjuan,2015-11-30 This introductory text presents the basic aspects and most important features of various types of resonances and anti resonances in dynamical systems In particular for each resonance it covers the theoretical concepts illustrates them with case studies and reviews the available information on mechanisms characterization numerical simulations experimental realizations possible quantum analogues applications and significant advances made over the years Resonances are one of the most fundamental phenomena exhibited by nonlinear systems and refer to specific realizations of maximum response of a system due to the ability of that system to store and transfer energy received from an external forcing source Resonances are of particular importance in physical engineering and biological systems they can prove to be advantageous in many applications while leading to instability and even disasters in others The book is self contained providing the details of mathematical

derivations and techniques involved in numerical simulations Though primarily intended for graduate students it can also be considered a reference book for any researcher interested in the dynamics of resonant phenomena **Fault Detection and Diagnosis in Nonlinear Systems** Rafael Martinez-Guerra,Juan Luis Mata-Machuca,2013-11-19 The high reliability required in industrial processes has created the necessity of detecting abnormal conditions called faults while processes are operating The term fault generically refers to any type of process degradation or degradation in equipment performance because of changes in the process s physical characteristics process inputs or environmental conditions This book is about the fundamentals of fault detection and diagnosis in a variety of nonlinear systems which are represented by ordinary differential equations The fault detection problem is approached from a differential algebraic viewpoint using residual generators based upon high gain nonlinear auxiliary systems observers A prominent role is played by the type of mathematical tools that will be used requiring knowledge of differential algebra and differential equations Specific theorems tailored to the needs of the problem solving procedures are developed and proved Applications to real world problems both with constant and time varying faults are made throughout the book and include electromechanical positioning systems the Continuous Stirred Tank Reactor CSTR bioreactor models and belt drive systems to name but a few Nonlinear and Complex Dynamics José António Tenreiro Machado,Dumitru Baleanu,Albert C. J. Luo,2011-08-28 Nonlinear Dynamics of Complex Systems describes chaos fractal and stochasticities within celestial mechanics financial systems and biochemical systems Part I discusses methods and applications in celestial systems and new results in such areas as low energy impact dynamics low thrust planar trajectories to the moon and earth to halo transfers in the sun earth and moon Part II presents the dynamics of complex systems including bio systems neural systems chemical systems and hydro dynamical systems Finally Part III covers economic and financial systems including market uncertainty inflation economic activity and foreign competition and the role of nonlinear dynamics in each *Nonlinear Dynamics, Complexity and Public Policy* Euel W. Elliott,L. Douglas Kiel,1999 Introduces those with an interest in the policy sciences to the field of non linear dynamics and complex systems and their applications to problems of public policy Four of the nine contributions concentrate on the implications of nonlinear dynamics and complexity for understanding the evolution of economic systems or instruments of economic policymaking Three papers explore a set of non economic related policy areas involving dynamics at a reduced level of aggregations from macroeconomic phenomena The final contributions consider information technology and the challenge of time *Weakly Nonlinear Systems* Federico Beffa,2023-10-26 The open access book covers a large class of nonlinear systems with many practical engineering applications The approach is based on the extension of linear systems theory using the Volterra series In contrast to the few existing treatments our approach highlights the algebraic structure underlying such systems and is based on Schwartz s distributions rather than functions The use of distributions leads naturally to the convolution algebras of linear time invariant systems and the ones suitable for weakly nonlinear systems emerge as simple extensions to higher order

distributions without having to resort to ad hoc operators The result is a much simplified notation free of multiple integrals a conceptual simplification and the ability to solve the associated nonlinear differential equations in a purely algebraic way The representation based on distributions not only becomes manifestly power series alike but it includes power series as the description of the subclass of memory less time invariant weakly nonlinear systems With this connection many results from the theory of power series can be extended to the larger class of weakly nonlinear systems with memory As a specific application the theory is specialised to weakly nonlinear electric networks The authors show how they can be described by a set of linear equivalent circuits which can be manipulated in the usual way The authors include many real world examples that occur in the design of RF and mmW analogue integrated circuits for telecommunications The examples show how the theory can elucidate many nonlinear phenomena and suggest solutions that an approach entirely based on numerical simulations can hardly suggest The theory is extended to weakly nonlinear time varying systems and the authors show examples of how time varying electric networks allow implementing functions unfeasible with time invariant ones The book is primarily intended for engineering students in upper semesters and in particular for electrical engineers Practising engineers wanting to deepen their understanding of nonlinear systems should also find it useful The book also serves as an introduction to distributions for undergraduate students of mathematics

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