Analysis Of Observed Chaotic Data Henry Abarbanel

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YULIANA PERKINS

Extracting Knowledge From Time Series Springer Science & Business Media
Lars Ahlfors's Lectures on Quasiconformal Mappings, based on a course he gave at Harvard University in the spring term of 1964, was first published in 1966 and was soon recognized as the classic it was shortly destined to become. These lectures develop the theory of quasiconformal mappings from scratch, give a self-contained treatment of the Beltrami equation, and cover the basic properties of Teichmuller spaces, including the Bers embedding and the Teichmuller curve. It isremarkable how Ahlfors goes straight to the heart of the matter, presenting major results with a minimum set of prerequisites. Many graduate students and other mathematicians have learned the foundations of the theories of quasiconformal mappings and Teichmuller spaces from these lecture notes. This editionincludes three new chapters. The first, written by Earle and Kra, describes further developments in the theory of Teichmuller spaces and provides many references to the vast literature on Teichmuller spaces and quasiconformal mappings. The second, by Shishikura, describes how quasiconformal mappings have revitalized the subject of complex dynamics. The third, by Hubbard, illustrates the role of these mappings in Thurston's theory of hyperbolic structures on 3-manifolds. Together, these threenew chapters exhibit the continuing vitality and importance of the theory of quasiconformal mappings. This book is a collection of research and expository papers reflecting the interfacing of two fields: nonlinear dynamics (in the physiological and biological sciences) and statistics. It presents theproceedings of a four-day workshop entitled ''Nonlinear Dynamics and Time Series: Building a Bridge Between the Natural and Statistical Sciences'' held at the Centre de Recherches Mathematiques (CRM) in Montreal in July 1995. The goal of the workshop was to provide an exchange forum and to create a link between two diverse groups with a common interest in the analysis of nonlinear time series data. The editors and peer reviewers of this work have attempted to minimize the problems ofmaintaining communication between the different scientific fields. The result is a collection of interrelated papers that highlight current areas of research in statistics that might have particular applicability to nonlinear dynamics and new methodology and open data analysis problems in nonlinear dynamicsthat might find their way into the toolkits and research interests of statisticians. Features: A survey of state-of-the-art developments in nonlinear dynamics time series analysis with open statistical problems and areas for further research. Contributions by statisticians to understanding and improving modern techniques commonly associated with nonlinear time series analysis, such as surrogate data methods and estimation of local Lyapunov exponents. Starting point for both scientists andstatisticians who want to explore the field. Expositions that are readable to scientists outside the featured fields of specialization. Information for our distributors: Titles in this series are copublished with the Fields Institute for Research in Mathematical Sciences (Toronto, Ontario,Canada).

Nonlinear Dynamics of Electronic Systems Springer Science & Business Media
Mathematical modelling is ubiquitous. Almost every book in exact science touches on mathematical models of a certain class of phenomena, on more or less speci?c approaches to construction and investigation of models, on their applications, etc. As many textbooks with similar titles, Part I of our book is devoted to general qu- tions of modelling. Part II re?ects our professional interests as physicists who spent much time to investigations in the ?eld of non-linear dynamics and mathematical modelling from discrete sequences of experimental measurements (time series). The latter direction of research is known for a long time as “system identi?cation” in the framework of mathematical statistics and automatic control theory. It has its roots in the problem of approximating experimental data points on a plane with a smooth curve. Currently, researchers aim at the description of complex behaviour (irregular, chaotic, non-stationary and noise-corrupted signals which are typical of real-world objects and phenomena) with relatively simple non-linear differential or difference model equations rather than with cumbersome explicit functions of time. In the second half of the twentieth century, it has become clear that such equations of a s- ?ciently low order can exhibit non-trivial solutions that promise suf?ciently simple modelling of complex processes; according to the concepts of non-linear dynamics, chaotic regimes can be demonstrated already by a third-order non-linear ordinary differential equation, while complex behaviour in a linear model can be induced either by random in?uence (noise) or by a very high order of equations.

Chaos World Scientific
Accurate predictions of storm surge are of importance in many coastal areas in the world to avoid and mitigate its destructive impacts. For this purpose the physically-based (process) numerical models are typically utilized. However, in data-rich cases, one may use data-driven methods aiming at reconstructing the internal patterns of the modelled processes and relationships between the observed descriptive variables. This book focuses on data-driven modelling using methods of nonlinear dynamics and chaos theory. First, some fundamentals of physical oceanography, nonlinear dynamics and chaos, computational intelligence and European operational storm surge models are covered. After that a number of improvements in building chaotic models are presented: nonlinear time series analysis, multi-step prediction, phase space dimensionality reduction, techniques dealing with incomplete time series, phase error correction, finding true neighbours, optimization of chaotic model, data assimilation and multi-model ensemble prediction. The major case study is surge prediction in the North Sea, with

some tests on a Caribbean Sea case. The modelling results showed that the enhanced predictive chaotic models can serve as an efficient tool for accurate and reliable short and mid-term predictions of storm surges in order to support decision-makers for flood prediction and ship navigation.

Semiconductor Lasers Nova Publishers

The pandemic, and our response to it, has shown how unpredictable, irrational, illogical, suddenly changing, and muddled human interactions can be in a time of crisis. How can we make sense of such confusing and baffling behavior? This book reveals how chaos and nonlinear dynamics can bring new understanding to everyday topics in social sciences. It brings together chapters from leaders at the intersection of psychology and chaos and complexity theories. Conceptual and user-friendly, it is built around six themes: 1) Seeing nonlinearity, 2) Finding patterns, 3) using Simple models, 4) Intervening nonlinearly, and 6) teaching a new Worldview. It takes no specialized study-although there is more sophisticated material and optional math for those wishing it. The techie will, in addition, find concepts and diagrams to ponder. The volume is engaging, at times startling-whether about the weather, Internet, organizations, family dynamics, health, evolution, or falling in love. It reveals how many social, personal, clinical, research, and life phenomena become understandable and can be modelled in the light of Nonlinear Dynamical Systems (NDS) theory. It even offers a broadening worldview, happening already in other sciences, toward a more dynamic, interconnected, and evolving picture, including process-oriented appreciation of one's own experience. The book offers those in the field of psychology and the social sciences a stunning new perspective on human behaviour.

Chaos in Real Data American Mathematical Soc.

"Describes the application of statistical methods in different environmental fields, with an emphasis on how to solve real-world problems in complex systems"--Provided by publisher.

Complex and Chaotic Nonlinear Dynamics Springer Science & Business Media

A new approach to understanding nonlinear dynamics and strange attractors The behavior of a physical system may appear irregular or chaotic even when it is completely deterministic and predictable for short periods of time into the future. How does one model the dynamics of a system operating in a chaotic regime? Older tools such as estimates of the spectrum of Lyapunov exponents and estimates of the spectrum of fractal dimensions do not sufficiently answer this question. In a significant evolution of the field of Nonlinear Dynamics, The Topology of Chaos responds to the fundamental challenge of chaotic systems by introducing a new analysis method-Topological Analysis-which can be used to extract, from chaotic data, the topological signatures that determine the stretching and squeezing mechanisms which act on flows in phase space and are responsible for generating chaotic data. Beginning with an example of a laser that has been operated under conditions in which it behaved chaotically, the authors convey the methodology of Topological Analysis through detailed chapters on: * Discrete Dynamical Systems: Maps * Continuous Dynamical Systems: Flows * Topological Invariants * Branched Manifolds * The Topological Analysis Program * Fold Mechanisms * Tearing Mechanisms * Unfoldings * Symmetry * Flows in Higher Dimensions * A Program for Dynamical Systems Theory Suitable at the present time for analyzing "strange attractors" that can be embedded in three-dimensional spaces, this groundbreaking approach offers researchers and practitioners in the discipline a complete and satisfying resolution to the fundamental questions of chaotic systems.

Adaptive Radar Signal Processing CRC Press

This book is intended for use in advanced graduate courses in statistics / machine learning, as well as for all experimental neuroscientists seeking to understand statistical methods at a deeper level, and theoretical neuroscientists with a limited background in statistics. It reviews almost all areas of applied statistics, from basic statistical estimation and test theory, linear and nonlinear approaches for regression and classification, to model selection and methods for dimensionality reduction, density estimation and unsupervised clustering. Its focus, however, is linear and nonlinear time series analysis from a dynamical systems perspective, based on which it aims to convey an understanding also of the dynamical mechanisms that could have generated observed time series. Further, it integrates computational modeling of behavioral and neural dynamics with statistical estimation and hypothesis testing. This way computational models in neuroscience are not only explanatory frameworks, but become powerful, quantitative data-analytical tools in themselves that enable researchers to look beyond the data surface and unravel underlying mechanisms. Interactive examples of most methods are provided through a package of MatLab routines, encouraging a playful approach to the subject, and providing readers with a better feel for the practical aspects of the methods covered. "Computational neuroscience is essential for integrating and providing a basis for understanding the myriads of remarkable laboratory data on nervous system functions. Daniel Durstewitz has excellently covered the breadth of computational neuroscience from statistical interpretations of data to biophysically based modeling of the neurobiological sources of those data. His presentation is clear, pedagogically sound, and readily useable by experts and beginners alike. It is a pleasure to recommend this very well crafted discussion to experimental neuroscientists as well as mathematically well versed Physicists. The book acts as a window to the issues, to the questions, and to the tools for finding the answers to interesting inquiries about brains and how they function." Henry D. I. Abarbanel Physics and Scripps Institution of Oceanography, University of California, San Diego “This book delivers a clear and thorough introduction to sophisticated analysis approaches useful in computational neuroscience. The models described and the examples provided will help readers develop critical intuitions into what the methods reveal about data. The overall approach of the book reflects the extensive experience Prof. Durstewitz has developed as a leading practitioner of computational neuroscience. “ Bruno B. Averbeck

Chaos in Dynamical Systems Springer Science & Business Media

A clear and systematic treatment of time series of data, regular and chaotic, found in nonlinear systems. The text leads readers from measurements of one or more variables through the steps of building models of the source as a dynamical system, classifying the source by its dynamical characteristics, and finally predicting and controlling the dynamical system. It examines methods for separating the signal of physical interest from contamination by unwanted noise, and for investigating the phase space of the chaotic signal and its properties. The emphasis throughout is on the use of modern mathematical tools for investigating chaotic behaviour to uncover properties of physical systems, requiring knowledge of dynamical systems at the advanced undergraduate level and some knowledge of Fourier transforms and other signal processing methods.

Applied Nonlinear Dynamics and Chaos of

Mechanical Systems with Discontinuities Cambridge University Press
Distinguishing chaoticity from regularity in deterministic dynamical systems and specifying the subspace of the phase space in which instabilities are expected to occur is of utmost importance in as disparate areas as astronomy, particle physics and climate dynamics. To address these issues there exists a plethora of methods for chaos detection and predictability. The most commonly employed technique for investigating chaotic dynamics, i.e. the computation of Lyapunov exponents, however, may suffer a number of problems and drawbacks, for example when applied to noisy experimental data. In the last two decades, several novel methods have been developed for the fast and reliable determination of the regular or chaotic nature of orbits, aimed at overcoming the shortcomings of more traditional techniques. This set of lecture notes and tutorial reviews serves as an introduction to and overview of modern chaos detection and predictability techniques for graduate students and non-specialists. The book covers theoretical and computational aspects of traditional methods to calculate Lyapunov exponents, as well as of modern techniques like the Fast (FLI), the Orthogonal (OFLI) and the Relative (RLI) Lyapunov Indicators, the Mean Exponential Growth factor of Nearby Orbits (MEGNO), the Smaller (SALI) and the Generalized (GALI) Alignment Index and the '0-1' test for chaos.
The Essence Of Chaos John Wiley & Sons
This third edition of "Semiconductor Lasers, Stability, Instability and Chaos" was significantly extended. In the previous edition, the dynamics and characteristics of chaos in semiconductor lasers after the introduction of the fundamental theory of laser chaos and chaotic dynamics induced by self-optical feedback and optical injection was discussed. Semiconductor lasers with new device structures, such as vertical-cavity surface-emitting lasers and broad-area semiconductor lasers, are interesting devices from the viewpoint of chaotic dynamics since they essentially involve chaotic dynamics even in their free-running oscillations. These topics are also treated with respect to the new developments in the current edition. Also the control of such instabilities and chaos control are critical issues for applications. Another interesting and important issue of semiconductor laser chaos in this third edition is chaos synchronization between two lasers and the application to optical secure communication. One of the new topics in this edition is fast physical number generation using chaotic semiconductor lasers for secure communication and development of chaos chips and their application. As other new important topics, the recent advance of new semiconductor laser structures is presented, such as quantum-dot semiconductor lasers, quantum-cascade semiconductor lasers, vertical-cavity surface-emitting lasers and physical random number generation with application to quantum key distribution. Stabilities, instabilities, and control of quantum-dot semiconductor lasers and quantum-cascade lasers are important topics in this field.
Environmental and Hydrological Systems Modelling CRC Press
This is the first conference dedicated to the understanding of the experimental aspects of chaotic behavior in several fields and to addressing the emerging areas of data analysis and applications of nonlinear phenomena. Areas covered are data analysis and signal processing techniques, optics, applications of chaotic behavior, magnetism, nonlinear electronic circuits, spatiotemporal chaos, semiconductors, and physiology. Each paper shows real data and what can be done with it. Emphasis is on the manifestation of chaos in real systems, measuring it, analyzing it, and using it in new and unique applications.
Predicting Storm Surges: Chaos, Computational Intelligence, Data Assimilation and Ensembles CRC Press
Mathematical modelling has become an indispensable tool for engineers, scientists, planners, decision makers and many other professionals to make predictions of future scenarios as well as real impending events. As the modelling approach and the model to be used are problem specific, no single model or approach can be used to solve all problems, and there are constraints in each situation. Modellers therefore need to have a choice when confronted with constraints such as lack of sufficient data, resources, expertise and time.
Environmental and Hydrological Systems Modelling provides the tools needed by presenting different approaches to modelling the water environment over a range of spatial and temporal scales. Their applications are shown with a series of case studies, taken mainly from the Asia-Pacific Region. Coverage includes: Population dynamics Reaction kinetics Water quality systems Longitudinal dispersion Time series analysis and forecasting Artificial neural networks Fractals and chaos Dynamical systems Support vector machines Fuzzy logic systems Genetic algorithms and genetic programming This book will be of great value to advanced students, professionals, academics and researchers working in the water environment.
Handbook of Applications of Chaos Theory CRC Press
This book introduces readers to the full range of current and background activity in the rapidly growing field of nonlinear dynamics. It uses a step-by-step introduction to dynamics and geometry in state space to help in understanding nonlinear dynamics and includes a thorough treatment of both differential equation models and iterated map models as well as a derivation of the famous Feigenbaum numbers. It is the only introductory book available that includes the important field of pattern formation and a survey of the controversial questions of quantum chaos. This second edition has been restructured for easier use and the extensive annotated references are updated through January 2000 and include many web sites for a number of the major nonlinear dynamics research centers. With over 200 figures and diagrams, analytic and computer exercises this book is a necessity for both the classroom and the lab.
Nonlinear Time Series Analysis World Scientific
Nonlinear Modeling: Advanced Black-Box Techniques discusses methods on Neural nets and related model structures for nonlinear system identification; Enhanced multi-stream Kalman filter training for recurrent networks; The support vector method of function estimation; Parametric density estimation for the classification of acoustic feature vectors in speech recognition; Wavelet-based modeling of nonlinear systems; Nonlinear identification based on fuzzy models; Statistical learning in control and matrix theory; Nonlinear time-series analysis. It also contains the results of the K.U. Leuven time series prediction competition, held within the framework of an international workshop at the K.U. Leuven, Belgium in July 1998.
Modelling and Forecasting Financial Data Wiley-VCH
20 papers included: tree ring records from Tasmania; evaluation of the relative importance of temperature and precipitation to major paleoenvironmental changes; link between volcanism and climate cooling; examination of decadel to century time-scale variability in the climate system; nonlinear time series analysis; deterministic chaos offers a new paradigm for understanding irregular fluctuations; summer temperature

reconstructions from tree-ring chronologies; paleoclimatic data for Mexico; South American hydrology; El Nino events; and more.

Measures of Complexity and Chaos Springer Science & Business Media

This volume collects together state-of-the-art contributions to the IEEE workshop on Nonlinear Dynamics of Electronic Systems. Contents:Applications of Chaotic Signal Processing Techniques to Multimedia Watermarking (N Nikolaidis et al.)Return Times and Mixing Properties (S Isola)Some Applications of Nonlinear Methods to Analysis and Design of Analog Circuits (M Ogorzalek)The Formulation of the Fundamental Matrix of a Second-Order Filter with Syllabic Companding Using Dynamic Eigenpairs (M de Anda et al.)Rake-Receivers for Chaos-Based Asynchronous DS-CDMA (G Mazzini et al.)Traffic Modeling and Queueing Performance Analysis Using Chaotic Maps (R J Mondragón et al.)Performance of CSMA Systems with Hidden Terminals and Capture Effects for Poisson and Self-Similar Traffics (M K Shahin et al.)Investigation of Spatio-Temporal Phenomena on Chaotic Oscillators Using Wien-Bridge Oscillator Coupled by One Resistor for Comparison with GCM (H Sekiya et al.)Chaotic Dynamics of Frequency Controlled Oscillator (A S Kuznetsov)Generic RC Realizations of Chua's Circuit (A S Elwakil & M P Kennedy)Kalman Filtering of Strange Attractors (O De Feo & T Schimming)Elaboration of System Specification for a WLAN FM-DCSK Telecommunications System (M P Kennedy & G Kis)Study of Existence of True Trajectories in the Dynamics of a Driven Circuit (S Mitrea)Suppression of Spatio-Temporal Chaos in Excitable Media (G V Osipov)Flash A/D Conversion Based on Wave Propagation: Parameter's Effect on Performance (K Doris et al.)Efficient Coding and Control in Canonical Neocortical Microcircuits (R Stoop)and other papers Readership: Researchers in nonlinear science, chaos, dynamical systems, control theory, electrical & electronic engineering and systems engineering. Keywords:

Proceedings of the IEEE Workshop on Nonlinear Dynamics of Electronic Systems World Scientific

The first unified presentation of new developments in the analysis and exploitation of chaotic systems... Mathematicians have been aware of chaotic dynamics since Poincar?'s work at the turn of the century. But, as the turn of yet another century approaches, physical scientists and engineers have begun to use their understanding of chaos theory to analyze chaotic experimental time series data. Some researchers have even used the presence of chaos to achieve practical goals. To do this, they have had to work with dynamical processes for which the equations were either not known or were too complex to be useful. In other words, they have been coping with chaos. Coping with Chaos is the first book to bring together recent advances in the interpretive and practical applications of chaos, which hold great promise for broad applicability throughout the physical sciences and engineering. Together with an introduction to chaos theory, this book provides detailed reports on methods of analyzing experimental time series data from chaotic systems and studies in which the unique attributes of chaos are put to practical use. Topics discussed in this book include: * Theory of chaotic dynamics * Embedding techniques for the analysis of experimental data * Calculation of dimension and Lyapunov exponents * Determination of periodic orbits and symbolic dynamics * Prediction of chaotic time series * Noise filtering of chaotic data * Control of chaotic systems * The use of chaotic signals for communication * And more

Chaos in Hydrology Springer Science & Business Media

Modelling and Forecasting Financial Data brings together a coherent and accessible set of chapters on recent research results on this topic. To make such methods readily useful in practice, the contributors to this volume have agreed to make available to readers upon request all computer programs used to implement the methods discussed in their respective chapters. Modelling and Forecasting Financial Data is a valuable resource for researchers and graduate students studying complex systems in finance, biology, and physics, as well as those applying such methods to nonlinear time series analysis and signal processing.

Oscillations, Waves and Interactions Springer

Chaos: from simple models to complex systems aims to guide science and engineering students through chaos and nonlinear dynamics from classical examples to the most recent fields of research. The first part, intended for undergraduate and graduate students, is a gentle and self-contained introduction to the concepts and main tools for the characterization of deterministic chaotic systems, with emphasis to statistical approaches. The second part can be used as a reference by researchers as it focuses on more advanced topics including the characterization of chaos with tools of information theory and applications encompassing fluid and celestial mechanics, chemistry and biology. The book is novel in devoting attention to a few topics often overlooked in introductory textbooks and which are usually found only in advanced surveys such as: information and algorithmic complexity theory applied to chaos and generalization of Lyapunov exponents to account for spatiotemporal and non-infinitesimal perturbations. The selection of topics, numerous illustrations, exercises and proposals for computer experiments make the book ideal for both introductory and advanced courses. Sample Chapter(s). Introduction (164 KB). Chapter 1: First Encounter with Chaos (1,323 KB). Contents: First Encounter with Chaos; The Language of Dynamical Systems; Examples of Chaotic Behaviors; Probabilistic Approach to Chaos; Characterization of Chaotic Dynamical Systems; From Order to Chaos in Dissipative Systems; Chaos in Hamiltonian Systems; Chaos and Information Theory; Coarse-Grained Information and Large Scale Predictability; Chaos in Numerical and Laboratory Experiments; Chaos in Low Dimensional Systems; Spatiotemporal Chaos; Turbulence as a Dynamical System Problem; Chaos and Statistical Mechanics: Fermi-Pasta-Ulam a Case Study. Readership: Students and researchers in science (physics, chemistry, mathematics, biology) and engineering.

Nonlinear Modeling Springer

In addition to explaining and modeling unexplored phenomena in nature and society, chaos uses vital parts of nonlinear dynamical systems theory and established chaotic theory to open new frontiers and fields of study. Handbook of Applications of Chaos Theory covers the main parts of chaos theory along with various applications to diverse areas. Expert contributors from around the world show how chaos theory is used to model unexplored cases and stimulate new applications. Accessible to scientists, engineers, and practitioners in a variety of fields, the book discusses the intermittency route to chaos, evolutionary dynamics and deterministic chaos, and the transition to phase synchronization chaos. It presents important contributions on strange attractors, self-exciting and hidden attractors, stability theory, Lyapunov exponents, and chaotic analysis. It explores the state of the art of chaos in plasma physics, plasma harmonics, and overtone coupling. It also describes flows and turbulence, chaotic interference versus decoherence, and an application of

microwave networks to the simulation of quantum graphs. The book proceeds to give a detailed presentation of the chaotic, rogue, and noisy optical dissipative solitons; parhelic-like circle and chaotic light scattering; and interesting forms of the hyperbolic prism, the Poincaré disc, and foams. It also covers numerous application areas, from the analysis of blood pressure data and clinical digital pathology to chaotic pattern recognition to economics to musical arts and research.