

MATHEMATICAL MODELLING: THEORY AND APPLICATIONS

THE FITZHUGH- NAGUMO MODEL

Bifurcation and Dynamics

C. Roşoreanu, A. Georgescu and N. Giurgiţeanu

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Fitzhugh Nagumo Model Bifurcation And Dynamics

Shuangming Yang, Badong Chen



Fitzhugh Nagumo Model Bifurcation And Dynamics:

The FitzHugh-Nagumo Model C. Rocsoreanu, A. Georgescu, N. Giurgiteanu, 2012-12-06 The present monograph analyses the FitzHugh Nagumo F N model Le the Cauchy problem for some generalized Van der Pol equation depending on three real parameters a and c This model given in [1, 17] governs the initiation of the cardiac impulse The presence of the three parameters leads to a large variety of dynamics each of them responsible for a specific functioning of the heart For physiologists it is highly desirable to have a global view of all possible qualitatively distinct responses of the F N model for all values of the parameters This reduces to the knowledge of the global bifurcation diagram So far only a few partial results appeared and they were spread throughout the literature Our work provides a more or less complete theoretical and numerical investigation of the complex phase dynamics and bifurcations associated with the F N dynamical system This study includes the static and dynamic bifurcations generated by the variation of a and c and the corresponding oscillations of special interest for applications It enables one to predict all possible types of initiations of heart beats and the mechanism of transformation of some types of oscillations into others by following the dynamics along transient phase space trajectories Of course all these results hold for the F N model The global phase space picture enables one to determine the domain of validity of this model

Analysis and Optimization of Differential Systems Viorel Barbu, Irena Lasiecka, Dan Tiba, Constantin Varsan, 2013-06-05 Analysis and Optimization of Differential Systems focuses on the qualitative aspects of deterministic and stochastic differential equations Areas covered include Ordinary and partial differential systems Optimal control of deterministic and stochastic evolution equations Control theory of Partial Differential Equations PDEs Optimization methods in PDEs with numerous applications to mechanics and physics Inverse problems Stability theory Abstract optimization problems Calculus of variations Numerical treatment of solutions to differential equations and related optimization problems These research fields are under very active development and the present volume should be of interest to students and researchers working in applied mathematics or in system engineering This volume contains selected contributions presented during the International Working Conference on Analysis and Optimization of Differential Systems which was sponsored by the International Federation for Information Processing IFIP and held in Constanta Romania in September 2002 Among the aims of this conference was the creation of new international contacts and collaborations taking advantage of the new developments in Eastern Europe particularly in Romania The conference benefited from the support of the European Union via the EURROMAT program

11th Chaotic Modeling and Simulation International Conference Christos H. Skiadas, Ihor Lubashevsky, 2019-05-28 Gathering the proceedings of the 11th CHAOS2018 International Conference this book highlights recent developments in nonlinear dynamical and complex systems The conference was intended to provide an essential forum for Scientists and Engineers to exchange ideas methods and techniques in the field of Nonlinear Dynamics Chaos Fractals and their applications in General Science and the Engineering Sciences The respective chapters address key

methods empirical data and computer techniques as well as major theoretical advances in the applied nonlinear field Beyond showcasing the state of the art the book will help academic and industrial researchers alike apply chaotic theory in their studies

Study Of Linear And Nonlinear Models With "Mathematica" Czeslaw Maczka, Sergii Skurativskiy, Vsevolod Vladimirov, 2022-12-28 The book is devoted to the problems of modeling physical systems and fields using the tools and capabilities of the Mathematica software package In the process of teaching classical courses in mechanics and mathematical physics one often has to overcome significant difficulties associated with the cumbersomeness of the mathematical apparatus which more than once distracts from the essence of the problems under consideration The use of the Mathematica package which has a rich set of analytical and graphic tools makes the presentation of classic issues related to modeling and interpretation of physical processes much more transparent This package enables the visualization of both analytical solutions of nonlinear differential equations and solutions obtained in the form of infinite series or special functions The textbook consists of two parts that can be studied independently of each other The first part deals with the issues of nonlinear mechanics and the theory of oscillations The second part covers linear problems of classical mathematical physics and nonlinear evolution models describing inter alia transport phenomena and propagation of waves The book contains the codes of programs written in the Mathematica package environment Supplementary materials of programs illustrating and often complementing the presented material are available on the publisher's website

Dynamical Systems with Applications Using Mathematica® Stephen Lynch, 2017-10-12 This book provides an introduction to the theory of dynamical systems with the aid of the Mathematica computer algebra package The book has a very hands on approach and takes the reader from basic theory to recently published research material Emphasized throughout are numerous applications to biology chemical kinetics economics electronics epidemiology nonlinear optics mechanics population dynamics and neural networks Theorems and proofs are kept to a minimum The first section deals with continuous systems using ordinary differential equations while the second part is devoted to the study of discrete dynamical systems

Mathematics of Complexity and Dynamical Systems Robert A. Meyers, 2011-10-05 Mathematics of Complexity and Dynamical Systems is an authoritative reference to the basic tools and concepts of complexity systems theory and dynamical systems from the perspective of pure and applied mathematics Complex systems are systems that comprise many interacting parts with the ability to generate a new quality of collective behavior through self organization e g the spontaneous formation of temporal spatial or functional structures These systems are often characterized by extreme sensitivity to initial conditions as well as emergent behavior that are not readily predictable or even completely deterministic The more than 100 entries in this wide ranging single source work provide a comprehensive explication of the theory and applications of mathematical complexity covering ergodic theory fractals and multifractals dynamical systems perturbation theory solitons systems and control theory and related topics Mathematics of Complexity and Dynamical Systems is an essential reference for all those interested in

mathematical complexity from undergraduate and graduate students up through professional researchers

Dynamical Systems with Applications Using MATLAB® Stephen Lynch, 2025-09-09 This textbook now in its third edition provides a broad and accessible introduction to both continuous and discrete dynamical systems the theory of which is motivated by examples from a wide range of disciplines It emphasizes applications and simulation utilizing MATLAB Simulink the Image Processing Toolbox the Symbolic Math Toolbox and the Deep Learning Toolbox The text begins with a tutorial introduction to MATLAB that assumes no prior programming knowledge Discrete systems are covered in the first part after which the second part explores the study of continuous systems using delay ordinary and partial differential equations The third part considers chaos control and synchronization binary oscillator computing Simulink and the Deep Learning Toolbox A final chapter provides examination and coursework type MATLAB questions for use by instructors and students For the Third Edition all the material has been thoroughly updated in line with the most recent version of MATLAB R2025a New chapters have been added on artificial neural networks delay differential equations numerical methods for ordinary and partial differential equations and the Deep Learning Toolbox MATLAB program files Simulink model files and other materials are available to download from the author's website and through GitHub The hands on approach of Dynamical Systems with Applications using MATLAB has minimal prerequisites only requiring familiarity with ordinary differential equations It will appeal to advanced undergraduate and graduate students applied mathematicians engineers and researchers in a broad range of disciplines such as population dynamics biology chemistry computing economics nonlinear optics neural networks and physics Praise for the Second Edition This book is a valuable reference to the existing literature on dynamical systems especially for the remarkable collection of examples and applications selected from very different areas as well as for its treatment with MATLAB of these problems Fernando Casas zbMATH The vast compilation of applications makes this text a great resource for applied mathematicians engineers physicists and researchers Instructors will be pleased to find an aims and objectives section at the beginning of each chapter where the author outlines its content and provides student learning objectives Stanley R Huddy MAA Reviews *Dynamical Systems with Applications using Maple™* Stephen Lynch, 2009-12-23 Excellent reviews of the first edition Mathematical Reviews SIAM Reviews UK Nonlinear News The Maple Reporter New edition has been thoroughly updated and expanded to include more applications examples and exercises all with solutions Two new chapters on neural networks and simulation have also been added Wide variety of topics covered with applications to many fields including mechanical systems chemical kinetics economics population dynamics nonlinear optics and materials science Accessible to a broad interdisciplinary audience of readers with a general mathematical background including senior undergraduates graduate students and working scientists in various branches of applied mathematics the natural sciences and engineering A hands on approach is used with Maple as a pedagogical tool throughout Maple worksheet files are listed at the end of each chapter and along with commands programs and output may be viewed in

color at the author's website with additional applications and further links of interest at Maplesoft's Application Center

Introduction to Modern Dynamics David D. Nolte, 2019-09-18 The best parts of physics are the last topics that our students ever see. These are the exciting new frontiers of nonlinear and complex systems that are at the forefront of university research and are the basis of many high tech businesses. Topics such as traffic on the World Wide Web, the spread of epidemics through globally mobile populations or how the synchronization of global economies are governed by universal principles just as profound as Newton's laws. Nonetheless, the conventional university physics curriculum reserves most of these topics for graduate study because of the assumed need for advanced mathematics. However, by using only linear algebra and calculus combined with exploratory computer simulations, all of these topics become accessible to advanced undergraduate students. The structure of this book combines the three main topics of modern dynamics: chaos theory, dynamics on complex networks, and general relativity into a coherent framework. By taking a geometric view of physics, concentrating on the time evolution of physical systems as trajectories through abstract spaces, these topics share a common and simple mathematical language through which any student can gain a unified physical intuition. Given the growing importance of complex dynamical systems in many areas of science and technology, this text provides students with an up-to-date foundation for their future careers. This second edition has an updated introductory chapter and has added key topics to help students prepare for their GRE physics subject exam. It also has expanded chapters on Hamiltonian dynamics, Hamiltonian chaos, and Econophysics, while increasing the number of homework problems at the end of each chapter. The second edition is designed to fulfill the textbook needs of any advanced undergraduate course in mechanics.

Computational Electrophysiology Shinji Doi, Junko Inoue, Zhenxing Pan, Kunichika Tsumoto, 2010-03-10 Biological systems inherently possess much ambiguity or uncertainty. Computational electrophysiology is the one area from among the vast and rapidly growing discipline of computational and systems biology in which computational or mathematical models have succeeded. This textbook provides a practical and quick guide to both computational electrophysiology and numerical bifurcation analysis. Bifurcation analysis is a very powerful tool for the analysis of such highly nonlinear biological systems. Bifurcation theory provides a way to analyze the effect of a parameter change on a system and to detect a critical parameter value when the qualitative nature of the system changes. Included in this work are many examples of numerical computations of bifurcation analysis of various models as well as mathematical models with different abstraction levels from neuroscience and electrophysiology. This volume will benefit graduate and undergraduate students as well as researchers in diverse fields of science.

Cellular Biophysics and Modeling Greg Conradi Smith, 2019-03-14 What every neuroscientist should know about the mathematical modeling of excitable cells. Combining empirical physiology and nonlinear dynamics, this text provides an introduction to the simulation and modeling of dynamic phenomena in cell biology and neuroscience. It introduces mathematical modeling techniques alongside cellular electrophysiology. Topics include membrane transport and

diffusion the biophysics of excitable membranes the gating of voltage and ligand gated ion channels intracellular calcium signalling and electrical bursting in neurons and other excitable cell types It introduces mathematical modeling techniques such as ordinary differential equations phase plane and bifurcation analysis of single compartment neuron models With analytical and computational problem sets this book is suitable for life sciences majors in biology to neuroscience with one year of calculus as well as graduate students looking for a primer on membrane excitability and calcium signalling

Recent Developments on Structural Equation Models Kees van Montfort, Johan Oud, Albert Satorra, 2004-04-30 After Karl J reskog s first presentation in 1970 Structural Equation Modelling or SEM has become a main statistical tool in many fields of science It is the standard approach of factor analytic and causal modelling in such diverse fields as sociology education psychology economics management and medical sciences In addition to an extension of its application area Structural Equation Modelling also features a continual renewal and extension of its theoretical background The sixteen contributions to this book written by experts from many countries present important new developments and interesting applications in Structural Equation Modelling The book addresses methodologists and statisticians professionally dealing with Structural Equation Modelling to enhance their knowledge of the type of models covered and the technical problems involved in their formulation In addition the book offers applied researchers new ideas about the use of Structural Equation Modeling in solving their problems Finally methodologists mathematicians and applied researchers alike are addressed who simply want to update their knowledge of recent approaches in data analysis and mathematical modelling *Plausible Neural Networks for Biological Modelling* H.A. Mastebroek, J.E. Vos, 2012-12-06 The expression Neural Networks refers traditionally to a class of mathematical algorithms that obtain their proper performance while they learn from examples or from experience As a consequence they are suitable for performing straightforward and relatively simple tasks like classification pattern recognition and prediction as well as more sophisticated tasks like the processing of temporal sequences and the context dependent processing of complex problems Also a wide variety of control tasks can be executed by them and the suggestion is relatively obvious that neural networks perform adequately in such cases because they are thought to mimic the biological nervous system which is also devoted to such tasks As we shall see this suggestion is false but does not do any harm as long as it is only the final performance of the algorithm which counts Neural networks are also used in the modelling of the functioning of sub systems in the biological nervous system It will be clear that in such cases it is certainly not irrelevant how similar their algorithm is to what is precisely going on in the nervous system Standard artificial neural networks are constructed from units roughly similar to neurons that transmit their activity similar to membrane potentials or to mean firing rates to other units via weight factors similar to synaptic coupling efficacies **Mem-elements for Neuromorphic Circuits with Artificial Intelligence Applications** Christos Volos, Viet-Thanh Pham, 2021-06-17 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

Physics of Biological Oscillators Aneta Stefanovska, Peter V. E. McClintock, 2021-05-05 This book based on a selection of invited presentations from a topical workshop focusses on time variable oscillations and their interactions The problem is challenging because the origin of the time variability is usually unknown In mathematical terms the oscillations are non autonomous reflecting the physics of open systems where the function of each oscillator is affected by its environment Time frequency analysis being essential recent advances in this area including wavelet phase coherence analysis and nonlinear mode decomposition are discussed Some applications to biology and physiology are described Although the most important manifestation of time variable oscillations is arguably in biology they also crop up in e g astrophysics or for electrons on superfluid helium The book brings together the research of the best international experts in seemingly very different disciplinary areas

Algorithmic Methods in Non-Commutative Algebra J.L. Bueso, José Gómez-Torrecillas, A. Verschoren, 2003-07-31 The already broad range of applications of ring theory has been enhanced in the eighties by the increasing interest in algebraic structures of considerable complexity the so called class of quantum groups One of the fundamental properties of quantum groups is that they are modelled by associative coordinate rings possessing a canonical basis which allows for the use of algorithmic structures based on Groebner bases to study them This book develops these methods in a self contained way concentrating on an in depth study of the notion of a vast class of non commutative rings encompassing most quantum groups the so called Poincaré Birkhoff Witt rings We include algorithms which treat essential aspects like ideals and bi modules the calculation of homological dimension and of the Gelfand Kirillov dimension the Hilbert Samuel polynomial primality tests for prime ideals etc

Dynamics of Neural Networks Michel J.A.M. van Putten, 2020-12-18 This book treats essentials from neurophysiology Hodgkin Huxley equations synaptic transmission prototype networks of neurons and related mathematical concepts dimensionality reductions equilibria bifurcations limit

cycles and phase plane analysis This is subsequently applied in a clinical context focusing on EEG generation ischaemia epilepsy and neurostimulation The book is based on a graduate course taught by clinicians and mathematicians at the Institute of Technical Medicine at the University of Twente Throughout the text the author presents examples of neurological disorders in relation to applied mathematics to assist in disclosing various fundamental properties of the clinical reality at hand Exercises are provided at the end of each chapter answers are included Basic knowledge of calculus linear algebra differential equations and familiarity with MATLAB or Python is assumed Also students should have some understanding of essentials of clinical neurophysiology although most concepts are summarized in the first chapters The audience includes advanced undergraduate or graduate students in Biomedical Engineering Technical Medicine and Biology Applied mathematicians may find pleasure in learning about the neurophysiology and clinic essentials applications In addition clinicians with an interest in dynamics of neural networks may find this book useful too Advances in Cognitive Neurodynamics (II) Rubin Wang,Fanji Gu,2011-01-06 Within our knowledge the series of the International Conference on Cognitive Neurodynamics ICCN is the only conference series dedicating to cognitive neurodynamics This volume is the proceedings of the 2nd International Conference on Cognitive Neurodynamics held in 2009 which reviews the progress in this field since the 1st ICCN 2007 The topics include Neural coding and realistic neural network dynamics Neural population dynamics Firing Oscillations and Patterns in Neuronal Networks Brain imaging EEG MEG Sensory and Motor Dynamics Global cognitive function Multi scalar Neurodynamics from Physiology to Systems Theory Neural computing Emerging Technologies for Brain Computer Interfaces Neural dynamics of brain disorders *Neurodynamics* Stephen Coombes,Kyle C. A. Wedgwood,2023-05-09 This book is about the dynamics of neural systems and should be suitable for those with a background in mathematics physics or engineering who want to see how their knowledge and skill sets can be applied in a neurobiological context No prior knowledge of neuroscience is assumed nor is advanced understanding of all aspects of applied mathematics Rather models and methods are introduced in the context of a typical neural phenomenon and a narrative developed that will allow the reader to test their understanding by tackling a set of mathematical problems at the end of each chapter The emphasis is on mathematical as opposed to computational neuroscience though stresses calculation above theorem and proof The book presents necessary mathematical material in a digestible and compact form when required for specific topics The book has nine chapters progressing from the cell to the tissue and an extensive set of references It includes Markov chain models for ions differential equations for single neuron models idealised phenomenological models phase oscillator networks spiking networks and integro differential equations for large scale brain activity with delays and stochasticity thrown in for good measure One common methodological element that arises throughout the book is the use of techniques from nonsmooth dynamical systems to form tractable models and make explicit progress in calculating solutions for rhythmic neural behaviour synchrony waves patterns and their stability This book was

written for those with an interest in applied mathematics seeking to expand their horizons to cover the dynamics of neural systems It is suitable for a Masters level course or for postgraduate researchers starting in the field of mathematical neuroscience *Neuromorphic Intelligence* Shuangming Yang,Badong Chen,2024-05-14 This book provides a valuable resource on the design of neuromorphic intelligence which serves as a computational foundation for building compact and low power brain inspired intelligent systems The book introduces novel spiking neural network learning algorithms including spike based learning based on the multi compartment model and spike based learning with information theory These offer important insights and academic value for readers to grasp the latest advances in neural inspired learning Additionally the book presents insights and approaches to the design of scalable neuromorphic architectures which are crucial foundations for achieving highly cognitive and energy efficient computing systems Furthermore the book introduces representative large scale neuromorphic systems and reviews several recently implemented large scale digital neuromorphic systems by the authors providing corresponding application scenarios

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