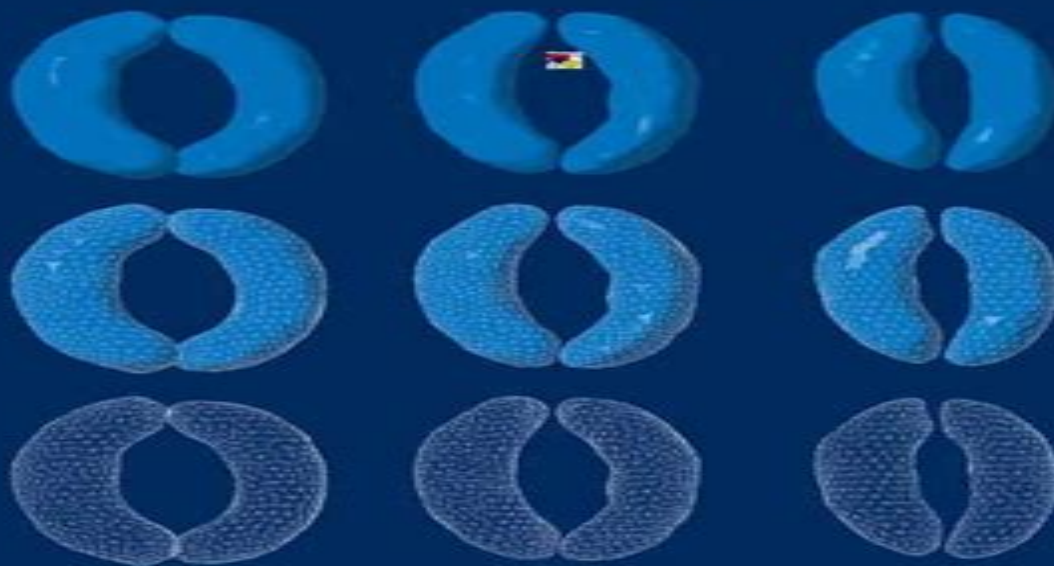


JAMES W. HAEFNER

MODELING BIOLOGICAL SYSTEMS

Principles and Applications



 Springer

Modeling Biological Systems

Stilianos Louca



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text which grew out of a class taught at Carnegie Mellon University covers models for optimization simulation and sampling and parameter tuning These topics provide a general framework for learning how to formulate mathematical models of biological systems what techniques are available to work with these models and how to fit the models to particular systems Their application is illustrated by many examples drawn from a variety of biological disciplines and several extended case studies that show how the methods described have been applied to real problems in biology

Dynamic Systems Biology Modeling and Simulation Joseph DiStefano III, 2015-01-10 Dynamic Systems Biology Modeling and Simulation consolidates and unifies classical and contemporary multiscale methodologies for mathematical modeling and computer simulation of dynamic biological systems from molecular cellular organ system on up to population levels The book pedagogy is developed as a well annotated systematic tutorial with clearly spelled out and unified nomenclature derived from the author's own modeling efforts publications and teaching over half a century Ambiguities in some concepts and tools are clarified and others are rendered more accessible and practical The latter include novel qualitative theory and methodologies for recognizing dynamical signatures in data using structural multicompartmental and network models and graph theory and analyzing structural and measurement data models for quantification feasibility The level is basic to intermediate with much emphasis on biomodeling from real biodata for use in real applications Introductory coverage of core mathematical concepts such as linear and nonlinear differential and difference equations Laplace transforms linear algebra probability statistics and stochastics topics The pertinent biology biochemistry biophysics or pharmacology for modeling are provided to support understanding the amalgam of math modeling with life sciences Strong emphasis on quantifying as well as building and analyzing biomodels includes methodology and computational tools for parameter identifiability and sensitivity analysis parameter estimation from real data model distinguishability and simplification and practical bioexperiment design and optimization Companion website provides solutions and program code for examples and exercises using Matlab Simulink VisSim SimBiology SAAMII AMIGO Copasi and SBML coded models A full set of PowerPoint slides are available from the author for teaching from his textbook He uses them to teach a 10 week quarter upper division course at UCLA which meets twice a week so there are 20 lectures They can easily be augmented or stretched for a 15 week semester course Importantly the slides are editable so they can be readily adapted to a lecturer's personal style and course content needs The lectures are based on excerpts from 12 of the first 13 chapters of DSBMS They are designed to highlight the key course material as a study guide and structure for students following the full text content The complete PowerPoint slide package 25 MB can be obtained by instructors or prospective instructors by emailing the author directly at joed@cs.ucla.edu

[Modeling Biological Systems](#) James W Haefner, 1996-07-01 **Mathematical modeling of biological systems** Andreas Deutsch, *Symbolic Approaches to Modeling and Analysis of Biological Systems* Cedric Lhoussaine, Elisabeth Remy, 2023-07-31 Systems Biology is an approach to biology that involves understanding the complexity of interactions among biological entities within a systemic

whole The goal is to understand the emergence of physiological or functional properties Symbolic Approaches to Modeling and Analysis of Biological Systems presents contributions of formal methods from computer science for modeling the dynamics of biological systems It deals more specifically with symbolic methods i e methods that can establish the qualitative properties of models This book presents different approaches related to semantics language modeling and their link with data and allows us to examine the fundamental problems and challenges that biological systems are facing The first part of the book presents works that rely on various available data to build models while the second part gathers contributions surrounding issues of semantics and formal methods

Mathematical Modeling of Biological Systems, Volume II

Andreas Deutsch,Rafael Bravo de la Parra,Rob J. de Boer,Odo Diekmann,Peter Jagers,Eva Kisdi,Mirjam Kretzschmar,Petr Lansky,Hans Metz,2007-10-12 Volume II of this two volume interdisciplinary work is a unified presentation of a broad range of state of the art topics in the rapidly growing field of mathematical modeling in the biological sciences Highlighted throughout are mathematical and computational approaches to examine central problems in the life sciences ranging from the organization principles of individual cells to the dynamics of large populations The chapters are thematically organized into the following main areas epidemiology evolution and ecology immunology neural systems and the brain and innovative mathematical methods and education The work will be an excellent reference text for a broad audience of researchers practitioners and advanced students in this rapidly growing field at the intersection of applied mathematics experimental biology and medicine computational biology biochemistry computer science and physics

Computational Modeling of Biological Systems Nikolay V Dokholyan,2012-02-12 Computational modeling is emerging as a powerful new approach to study and manipulate biological systems Multiple methods have been developed to model visualize and rationally alter systems at various length scales starting from molecular modeling and design at atomic resolution to cellular pathways modeling and analysis Higher time and length scale processes such as molecular evolution have also greatly benefited from new breeds of computational approaches This book provides an overview of the established computational methods used for modeling biologically and medically relevant systems

Dynamical Systems for Biological Modeling Fred

Brauer,Christopher Kribs,2015-12-23 Dynamical Systems for Biological Modeling An Introduction prepares both biology and mathematics students with the understanding and techniques necessary to undertake basic modeling of biological systems It achieves this through the development and analysis of dynamical systems The approach emphasizes qualitative ideas rather than explicit computa

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Byrne,Gerda de Vries,Hanspeter Herzel,2007-06-15 Volume I of this two volume interdisciplinary work is a unified presentation of a broad range of state of the art topics in the rapidly growing field of mathematical modeling in the biological sciences The chapters are thematically organized into the following main areas cellular biophysics regulatory networks developmental biology biomedical applications data analysis and model validation The work will be an excellent reference

text for a broad audience of researchers practitioners and advanced students in this rapidly growing field at the intersection of applied mathematics experimental biology and medicine computational biology biochemistry computer science and physics

Dynamical Modeling of Biological Systems Stilianos Louca, 2023-06-07 This book introduces concepts and practical tools for dynamical mathematical modeling of biological systems Dynamical models describe the behavior of a system over time as a result of internal feedback loops and external forcing based on mathematically formulated dynamical laws similarly to how Newton's laws describe the movement of celestial bodies Dynamical models are increasingly popular in biology as they tend to be more powerful than static regression models This book is meant for undergraduate and graduate students in physics applied mathematics and data science with an interest in biology as well as students in biology with a strong interest in mathematical methods The book covers deterministic models for example differential equations stochastic models for example Markov chains and autoregressive models and model independent aspects of time series analysis Plenty of examples and exercises are included often taken or inspired from the scientific literature and covering a broad range of topics such as neuroscience cell biology genetics evolution ecology microbiology physiology epidemiology and conservation The book delivers generic modeling techniques used across a wide range of situations in biology and hence readers from other scientific disciplines will find that much of the material is also applicable in their own field Proofs of most mathematical statements are included for the interested reader but are not essential for a practical understanding of the material The book introduces the popular scientific programming language MATLAB as a tool for simulating models fitting models to data and visualizing data and model predictions The material taught is current as of MATLAB version 2022b The material is taught in a sufficiently general way that also permits the use of alternative programming languages

Modeling Dynamic Biological Systems Bruce Hannon, Matthias Ruth, 2014-07-05 Many biologists and ecologists have developed models that find widespread use in theoretical investigations and in applications to organism behavior disease control population and metapopulation theory ecosystem dynamics and environmental management This book captures and extends the process of model development by concentrating on the dynamic aspects of these processes and by providing the tools such that virtually anyone with basic knowledge in the Life Sciences can develop meaningful dynamic models Examples of the systems modeled in the book range from models of cell development the beating heart the growth and spread of insects spatial competition and extinction to the spread and control of epidemics including the conditions for the development of chaos Key features easy to learn and easy to use software examples from many subdisciplines of biology covering models of cells organisms populations and metapopulations no prior computer or programming experience required Key benefits learn how to develop modeling skills and system thinking on your own rather than use models developed by others be able to easily run models under alternative assumptions and investigate the implications of these assumptions for the dynamics of the biological system being modeled develop skills to assess the dynamics of biological systems

Introduction to Modeling Biological

Systems Robert I. Macey, George F. Oster, 2008 The authors begin with simple examples and gradually add complexity Each chapter focuses on one discipline and begins each example with a brief overview of the biology followed by presentation of the model with accompanying illustrations and flow chart with a detailed discussion of results to illustrate key modeling concepts The chapters cover a broad span of biological problems including pharmacokinetics pharmacodynamics circulation biochemical switches cell division and synaptic transmission The text provides a step by step practical introduction on How to Build a Model Again the level is suitable for students without advanced training in math but provides enough depth to allow readers to emerge with the ability to build their own models Non technical presentation explicitly aimed at those without special math training Uses Berkeley Madonna the most user friendly fast and powerful modeling tool available Elegantly elucidates key modeling principles through carefully explained examples Examples taken from across biology including immunology cell biology pharmacology biochemistry and neuroscience Includes end of chapter exercises

Mathematical Modeling of Biological Systems Harvey J. Gold, 1977 The modeling process an overview Dimension and similarity Probability models Dynamic processes Interacting dynamic processes Feedback control and stability of biological systems Curve fitting estimating the parameters Computing **Modeling Biological Systems:** James W. Haefner, 2005-05-06 I Principles 1 1 Models of Systems 3 1 1 Systems Models and Modeling 3 1 2 Uses of Scientific Models 4 1 3 Example Island Biogeography 6 1 4 Classifications of Models 10 1 5 Constraints on Model Structure 12 1 6 Some Terminology 12 1 7 Misuses of Models The Dark Side 13 1 8 Exercises 15 2 The Modeling Process 17 2 1 Models Are Problems 17 2 2 Two Alternative Approaches 18 2 3 An Example Population Doubling Time 24 2 4 Model Objectives 28 2 5 Exercises 30 3 Qualitative Model Formulation 32 3 1 How to Eat an Elephant 32 3 2 Forrester Diagrams 33 3 3 Examples 36 3 4 Errors in Forrester Diagrams 44 3 5 Advantages and Disadvantages of Forrester Diagrams 44 3 6 Principles of Qualitative Formulation 45 3 7 Model Simplification 47 3 8 Other Modeling Problems 49 viii Contents 3 9 Exercises 53 4 Quantitative Model Formulation I 4 1 From Qualitative to Quantitative Finite Difference Equations and Differential Equations 4 2 4 3 Biological Feedback in Quantitative Models 4 4 Example Model 4 5 Exercises 5 Quantitative Model Formulation II 81 5 1 Physical Processes 81 5 2 Using the Toolbox of Biological Processes 89 5 3 Useful Functions 96 5 4 Examples 102 5 5 Exercises 104 6 Numerical Techniques 107 6 1 Mistakes Computers Make 107 6 2 Numerical Integration 110 6 3 Numerical Instability and Stiff Equations 115 Systems Biology Andreas Kremling, 2013-11-12 Drawing on the latest research in the field Systems Biology Mathematical Modeling and Model Analysis presents many methods for modeling and analyzing biological systems in particular cellular systems It shows how to use predictive mathematical models to acquire and analyze knowledge about cellular systems It also explores how the models are sy Managing Complexity, Reducing Perplexity Marcello Delitala, Giulia Ajmone Marsan, 2014-06-04 Managing Complexity Reducing Perplexity is devoted to an overview of the status of the art in the study of complex systems with particular focus on the analysis of systems pertaining to living

matter Both senior scientists and young researchers from diverse and prestigious institutions with a deliberately interdisciplinary cut were invited in order to compare approaches and problems from different disciplines The common aim of the contributions was to analyze the complexity of living systems by means of new mathematical paradigms that are more adherent to reality and which are able to generate both exploratory and predictive models that are capable of achieving a deeper insight into life science phenomena

Introduction to Modeling for Biosciences David J. Barnes, Dominique Chu, 2010-07-23 Mathematical modeling can be a useful tool for researchers in the biological scientists Yet in biological modeling there is no one modeling technique that is suitable for all problems Instead different problems call for different approaches Furthermore it can be helpful to analyze the same system using a variety of approaches to be able to exploit the advantages and drawbacks of each In practice it is often unclear which modeling approaches will be most suitable for a particular biological question a problem which requires researchers to know a reasonable amount about a number of techniques rather than become experts on a single one Introduction to Modeling for Biosciences addresses this issue by presenting a broad overview of the most important techniques used to model biological systems In addition to providing an introduction into the use of a wide range of software tools and modeling environments this helpful text reference describes the constraints and difficulties that each modeling technique presents in practice enabling the researcher to quickly determine which software package would be most useful for their particular problem Topics and features introduces a basic array of techniques to formulate models of biological systems and to solve them intersperses the text with exercises throughout the book includes practical introductions to the Maxima computer algebra system the PRISM model checker and the Repast Symphony agent modeling environment discusses agent based models stochastic modeling techniques differential equations and Gillespie's stochastic simulation algorithm contains appendices on Repast batch running rules of differentiation and integration Maxima and PRISM notation and some additional mathematical concepts supplies source code for many of the example models discussed at the associated website <http://www.cs.kent.ac.uk/imb> This unique and practical guide leads the novice modeler through realistic and concrete modeling projects highlighting and commenting on the process of abstracting the real system into a model Students and active researchers in the biosciences will also benefit from the discussions of the high quality tried and tested modeling tools described in the book Dr David J Barnes is a lecturer in computer science at the University of Kent UK with a strong background in the teaching of programming Dr Dominique Chu is a lecturer in computer science at the University of Kent UK He is an internationally recognized expert in agent based modeling and has also in depth research experience in stochastic and differential equation based modeling

Mathematical Modeling of Dynamic Biological Systems Ludwik Finkelstein, Ewart R. Carson, 1979

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