

Richard A. Holmgren

A First Course in Discrete Dynamical Systems



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First Course In Discrete Dynamical Systems

Jürgen Jost



First Course In Discrete Dynamical Systems:

A First Course in Discrete Dynamical Systems Richard A. Holmgren, 2012-09-05 Discrete dynamical systems are essentially iterated functions. Given the ease with which computers can do iteration, it is now possible for anyone with access to a personal computer to generate beautiful images whose roots lie in discrete dynamical systems. Images of Mandelbrot and Julia sets abound in publications both mathematical and not. The mathematics behind the pictures are beautiful in their own right and are the subject of this text. The level of the presentation is suitable for advanced undergraduates with a year of calculus behind them. Students in the author's courses using this material have come from numerous disciplines; many have been majors in other disciplines who are taking mathematics courses out of general interest. Concepts from calculus are reviewed as necessary. Mathematica programs that illustrate the dynamics and that will aid the student in doing the exercises are included in an appendix.

A First Course in Discrete Dynamical Systems Richard A. Holmgren, 2012-12-06 An increasing number of colleges and universities are offering undergraduate courses in discrete dynamical systems. This growth is due in part to the proliferation of inexpensive and powerful computers which have provided access to the interesting and complex phenomena that are at the heart of dynamics. A second reason for introducing dynamics into the undergraduate curriculum is that it serves as a bridge from concrete, often algorithmic calculus courses to the more abstract concepts of analysis and topology. Discrete dynamical systems are essentially iterated functions, and if there is one thing computers do well, it is iteration. It is now possible for anyone with access to a personal computer to generate beautiful images whose roots lie in discrete dynamical systems. The mathematics behind the pictures are beautiful in their own right and are the subject of this text. Every effort has been made to exploit this opportunity to illustrate the beauty and power of mathematics in an interesting and engaging way. This work is first and foremost a mathematics book. Individuals who read it and do the exercises will gain not only an understanding of dynamical systems but an increased understanding of the related areas in analysis as well.

A First Course in Discrete Dynamical Systems Richard A. Holmgren, 1996-08-01 *A First Course in Fuzzy Logic, Fuzzy Dynamical Systems, and Biomathematics* Laécio Carvalho de Barros, Rodney Carlos Bassanezi, Weldon Alexander Lodwick, 2016-09-13 This book provides an essential introduction to the field of dynamical models. Starting from classical theories such as set theory and probability, it allows readers to draw near to the fuzzy case. On one hand, the book equips readers with a fundamental understanding of the theoretical underpinnings of fuzzy sets and fuzzy dynamical systems. On the other, it demonstrates how these theories are used to solve modeling problems in biomathematics and presents existing derivatives and integrals applied to the context of fuzzy functions. Each of the major topics is accompanied by examples, worked-out exercises, and exercises to be completed. Moreover, many applications to real problems are presented. The book has been developed on the basis of the authors' lectures to university students and is accordingly primarily intended as a textbook for both upper-level undergraduates and graduates in applied mathematics, statistics, and

engineering It also offers a valuable resource for practitioners such as mathematical consultants and modelers and for researchers alike as it may provide both groups with new ideas and inspirations for projects in the fields of fuzzy logic and biomathematics

A First Course In Chaotic Dynamical Systems Robert L. Devaney, 2020-04-21 A First Course in Chaotic Dynamical Systems Theory and Experiment Second Edition The long anticipated revision of this well liked textbook offers many new additions In the twenty five years since the original version of this book was published much has happened in dynamical systems Mandelbrot and Julia sets were barely ten years old when the first edition appeared and most of the research involving these objects then centered around iterations of quadratic functions This research has expanded to include all sorts of different types of functions including higher degree polynomials rational maps exponential and trigonometric functions and many others Several new sections in this edition are devoted to these topics The area of dynamical systems covered in A First Course in Chaotic Dynamical Systems Theory and Experiment Second Edition is quite accessible to students and also offers a wide variety of interesting open questions for students at the undergraduate level to pursue The only prerequisite for students is a one year calculus course no differential equations required students will easily be exposed to many interesting areas of current research This course can also serve as a bridge between the low level often non rigorous calculus courses and the more demanding higher level mathematics courses Features More extensive coverage of fractals including objects like the Sierpinski carpet and others that appear as Julia sets in the later sections on complex dynamics as well as an actual chaos game More detailed coverage of complex dynamical systems like the quadratic family and the exponential maps New sections on other complex dynamical systems like rational maps A number of new and expanded computer experiments for students to perform About the Author Robert L Devaney is currently professor of mathematics at Boston University He received his PhD from the University of California at Berkeley under the direction of Stephen Smale He taught at Northwestern University and Tufts University before coming to Boston University in 1980 His main area of research is dynamical systems primarily complex analytic dynamics but also including more general ideas about chaotic dynamical systems Lately he has become intrigued with the incredibly rich topological aspects of dynamics including such things as indecomposable continua Sierpinski curves and Cantor bouquets

An Invitation to Algebraic Geometry Karen Smith, Lauri Kahanpää, Pekka Kekäläinen, William Traves, 2004-01-27 This is a description of the underlying principles of algebraic geometry some of its important developments in the twentieth century and some of the problems that occupy its practitioners today It is intended for the working or the aspiring mathematician who is unfamiliar with algebraic geometry but wishes to gain an appreciation of its foundations and its goals with a minimum of prerequisites Few algebraic prerequisites are presumed beyond a basic course in linear algebra

Dynamical Systems Jürgen Jost, 2005-08-01 Breadth of scope is unique Author is a widely known and successful textbook author Unlike many recent textbooks on chaotic systems that have superficial treatment this book provides explanations of the deep underlying mathematical ideas No technical

proofs but an introduction to the whole field that is based on the specific analysis of carefully selected examples Includes a section on cellular automata

An Introduction to Sequential Dynamical Systems Henning Mortveit, Christian Reidys, 2007-11-27 This introductory text to the class of Sequential Dynamical Systems SDS is the first textbook on this timely subject Driven by numerous examples and thought provoking problems throughout the presentation offers good foundational material on finite discrete dynamical systems which then leads systematically to an introduction of SDS From a broad range of topics on structure theory equivalence fixed points invertibility and other phase space properties thereafter SDS relations to graph theory classical dynamical systems as well as SDS applications in computer science are explored This is a versatile interdisciplinary textbook

Boolean Systems Serban E. Vlad, 2023-01-06 The Boolean functions may be iterated either asynchronously when their coordinates are computed independently of each other or synchronously when their coordinates are computed at the same time In *Boolean Systems* Topics in Asynchronicity a book addressed to mathematicians and computer scientists interested in Boolean systems and their use in modelling author Serban E Vlad presents a consistent and original mathematical theory of the discrete time Boolean asynchronous systems The purpose of the book is to set forth the concepts of such a theory resulting from the synchronous Boolean system theory and mostly from the synchronous real system theory by analogy and to indicate the way in which known synchronous deterministic concepts generate new asynchronous nondeterministic concepts The reader will be introduced to the dependence on the initial conditions periodicity path connectedness topological transitivity and chaos A property of major importance is invariance which is present in five versions In relation to it the reader will study the maximal invariant subsets the minimal invariant supersets the minimal invariant subsets connectedness separation the basins of attraction and attractors The stability of the systems and their time reversal symmetry end the topics that refer to the systems without input The rest of the book is concerned with input systems The most consistent chapters of this part of the book refer to the fundamental operating mode and to the combinational systems systems without feedback The chapter Wires Gates and Flip Flops presents a variety of applications The first appendix addresses the issue of continuous time and the second one sketches the important theory of Daizhan Cheng which is put in relation to asynchronicity The third appendix is a bridge between asynchronicity and the symbolic dynamics of Douglas Lind and Brian Marcus Presents a consistent and original theory of the discrete time Boolean asynchronous systems which are useful for mathematicians and computer scientists interested in Boolean Networks dynamical systems and modeling Studies the flows and equations of evolution nullclines dependence on initial conditions periodicity path connectedness topological transitivity chaos nonwandering points invariance connectedness and separation as well as the basins of attraction attractors stability and time reversal symmetry Explains the fundamental operating mode of the input systems and the combinational systems systems without feedback Includes a chapter of applications of the Boolean systems and their modeling techniques Makes use of the unbounded delay model of computation of the Boolean functions

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Introduction to Mathematical Population Dynamics Mimmo Iannelli, Andrea Pugliese, 2015-01-23 This book is an introduction to mathematical biology for students with no experience in biology but who have some mathematical background The work is focused on population dynamics and ecology following a tradition that goes back to Lotka and Volterra and includes a part devoted to the spread of infectious diseases a field where mathematical modeling is extremely popular These themes are used as the area where to understand different types of mathematical modeling and the possible meaning of qualitative agreement of modeling with data The book also includes a collections of problems designed to approach more advanced questions This material has been used in the courses at the University of Trento directed at students in their fourth year of studies in Mathematics It can also be used as a reference as it provides up to date developments in several areas

Handbook of Dynamic System Modeling Paul A. Fishwick, 2007-06-01 The topic of dynamic models tends to be splintered across various disciplines making it difficult to uniformly study the subject Moreover the models have a variety of representations from traditional mathematical notations to diagrammatic and immersive depictions Collecting all of these expressions of dynamic models the Handbook of Dynamic Sy

Elements of Dynamical Systems Anima Nagar, Riddhi Shah, Shrihari Sridharan, 2022-11-11 This book stems from lectures that were delivered at the three week Advanced Instructional School on Ergodic Theory and Dynamical Systems held at the Indian Institute of Technology Delhi from 4 23 December 2017 with the support of the National Centre for Mathematics National Board for Higher Mathematics Department of Atomic Energy Government of India The book discusses various aspects of dynamical systems Each chapter of this book specializes in one aspect of dynamical systems and thus begins at an elementary level and goes on to cover fairly advanced material The book helps researchers be familiar with and navigate through different parts of ergodic theory and dynamical systems

Applications of Advanced Optimization Techniques in Industrial Engineering Abhinav Goel, Anand Chauhan, A. K. Malik, 2022-03-09 This book provides different approaches used to analyze draw attention and provide an understanding of the advancements in the optimization field across the globe It brings all of the latest methodologies tools and techniques related to optimization and industrial engineering into a single volume to build insights towards the latest advancements in various domains Applications of Advanced Optimization Techniques in Industrial Engineering includes the basic concept of optimization techniques and applications related to industrial engineering Concepts are introduced in a sequential way along with explanations illustrations and solved examples The book goes on to explore applications of operations research and covers empirical properties of a variety of engineering disciplines It presents network scheduling production planning industrial and manufacturing system issues and their implications in the real world The book caters to academicians researchers professionals in inventory analytics business analytics investment managers finance firms storage related managers and engineers working in engineering industries and data management fields

Neural Network Modeling and Identification of Dynamical Systems Yury Tiumentsev, Mikhail Egorchev, 2019-05-17

Neural Network Modeling and Identification of Dynamical Systems presents a new approach on how to obtain the adaptive neural network models for complex systems that are typically found in real world applications The book introduces the theoretical knowledge available for the modeled system into the purely empirical black box model thereby converting the model to the gray box category This approach significantly reduces the dimension of the resulting model and the required size of the training set This book offers solutions for identifying controlled dynamical systems as well as identifying characteristics of such systems in particular the aerodynamic characteristics of aircraft Covers both types of dynamic neural networks black box and gray box including their structure synthesis and training Offers application examples of dynamic neural network technologies primarily related to aircraft Provides an overview of recent achievements and future needs in this area

Dynamical Systems with Applications using Python Stephen Lynch, 2018-10-09 This textbook provides a broad introduction to continuous and discrete dynamical systems With its hands on approach the text leads the reader from basic theory to recently published research material in nonlinear ordinary differential equations nonlinear optics multifractals neural networks and binary oscillator computing Dynamical Systems with Applications Using Python takes advantage of Python's extensive visualization simulation and algorithmic tools to study those topics in nonlinear dynamical systems through numerical algorithms and generated diagrams After a tutorial introduction to Python the first part of the book deals with continuous systems using differential equations including both ordinary and delay differential equations The second part of the book deals with discrete dynamical systems and progresses to the study of both continuous and discrete systems in contexts like chaos control and synchronization neural networks and binary oscillator computing These later sections are useful reference material for undergraduate student projects The book is rounded off with example coursework to challenge students programming abilities and Python based exam questions This book will appeal to advanced undergraduate and graduate students applied mathematicians engineers and researchers in a range of disciplines such as biology chemistry computing economics and physics Since it provides a survey of dynamical systems a familiarity with linear algebra real and complex analysis calculus and ordinary differential equations is necessary and knowledge of a programming language like C or Java is beneficial but not essential

Dynamical Systems with Applications using MATLAB® Stephen Lynch, 2014-07-22 This textbook now in its second edition provides a broad 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 and the Symbolic Math toolbox including MuPAD Features new to the second edition include sections on series solutions of ordinary differential equations perturbation methods normal forms Gröbner bases and chaos synchronization chapters on image processing and binary oscillator computing hundreds of new illustrations examples and exercises with solutions and over eighty up to date MATLAB program files and Simulink model files available online These files were voted MATLAB Central Pick of the Week in July 2013 The hands on approach of

Dynamical Systems with Applications using MATLAB Second Edition 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 first edition: Summing up, it can be said that this text allows the reader to have an easy and quick start to the huge field of dynamical systems theory. MATLAB/SIMULINK facilitate this approach under the aspect of learning by doing. OR News: Operations Research Spectrum. The MATLAB programs are kept as simple as possible, and the author's experience has shown that this method of teaching using MATLAB works well with computer laboratory classes of small sizes. I recommend *Dynamical Systems with Applications using MATLAB* as a good handbook for a diverse readership: graduates and professionals in mathematics, physics, science, and engineering. *Mathematica*

Ordinary Differential Equations and Dynamical Systems Gerald Teschl, 2024-01-12. This book provides a self-contained introduction to ordinary differential equations and dynamical systems suitable for beginning graduate students. The first part begins with some simple examples of explicitly solvable equations and a first glance at qualitative methods. Then the fundamental results concerning the initial value problem are proved: existence, uniqueness, extensibility, dependence on initial conditions. Furthermore, linear equations are considered, including the Floquet theorem and some perturbation results. As somewhat independent topics, the Frobenius method for linear equations in the complex domain is established, and Sturm-Liouville boundary value problems, including oscillation theory, are investigated. The second part introduces the concept of a dynamical system. The Poincaré-Bendixson theorem is proved, and several examples of planar systems from classical mechanics, ecology, and electrical engineering are investigated. Moreover, attractors, Hamiltonian systems, the KAM theorem, and periodic solutions are discussed. Finally, stability is studied, including the stable manifold and the Hartman-Grobman theorem for both continuous and discrete systems. The third part introduces chaos, beginning with the basics for iterated interval maps and ending with the Smale-Birkhoff theorem and the Melnikov method for homoclinic orbits. The text contains almost three hundred exercises. Additionally, the use of mathematical software systems is incorporated throughout, showing how they can help in the study of differential equations.

Dynamical Systems with Applications using Mathematica® Stephen Lynch, 2007-09-20. This book provides an introduction to the theory of dynamical systems with the aid of the Mathematica computer algebra system. It is written for both senior undergraduates and graduate students. The first part of the book deals with continuous systems using ordinary differential equations. Chapters 1-10. The second part is devoted to the study of discrete dynamical systems. Chapters 11-15 and Chapters 16 and 17 deal with both continuous and discrete systems. It should be pointed out that dynamical systems theory is not limited to these topics but also compasses partial differential equations, integral and integro-differential equations, stochastic systems, and time delay systems, for instance. References 1-4 given at the end of the Preface provide more information for the interested reader. The author has gone for breadth of coverage rather

than ne detail and theorems with proofs are kept at a minimum The material is not clouded by functional analytic and group theoretical de nitions and so is intelligible to readers with a general mathematical background Some of the topics covered are scarcely covered el where Most of the material in Chapters 9 10 14 16 and 17 is at a postgraduate level and has been influenced by the author s own research interests There is more theory in these chapters than in the rest of the book since it is not easily accessed anywhere else It has been found that these chapters are especially useful as reference material for senior undergraduate project work The theory in other chapters of the book is dealt with more comprehensively in other texts some of which may be found in the references section of the corresponding chapter

Graphics with Mathematica Chonatz Getz, Janet Margaret Helmstedt, 2004-09-29 In this book we generate graphic images using the software Mathematica thus providing a gentle and enjoyable introduction to this rather technical software and its graphic capabilities The programs we use for generating these graphics are easily adaptable to many variations These graphic images are enhanced by introducing a variety of different coloring techniques Detailed instructions are given for the construction of some interesting 2D and 3D fractals using iterated functions systems as well as the construction of many different types of Julia sets and parameter sets such as the Mandelbrot set The mathematics underlying the theory of Iterated function systems and Julia sets is given an intuitive explanation and references are provided for more detailed study Brilliant Graphic images Interesting Introduction to Mathematica for Beginners Easy constructions A variety of Coloring Techniques Programs Easily Adaptable to Many Variations Constructions useful for Dynamics and Fractals Courses

An Introduction to Dynamical Systems and Chaos G.C. Layek, 2015-12-01 The book discusses continuous and discrete systems in systematic and sequential approaches for all aspects of nonlinear dynamics The unique feature of the book is its mathematical theories on flow bifurcations oscillatory solutions symmetry analysis of nonlinear systems and chaos theory The logically structured content and sequential orientation provide readers with a global overview of the topic A systematic mathematical approach has been adopted and a number of examples worked out in detail and exercises have been included Chapters 1 8 are devoted to continuous systems beginning with one dimensional flows Symmetry is an inherent character of nonlinear systems and the Lie invariance principle and its algorithm for finding symmetries of a system are discussed in Chap 8 Chapters 9 13 focus on discrete systems chaos and fractals Conjugacy relationship among maps and its properties are described with proofs Chaos theory and its connection with fractals Hamiltonian flows and symmetries of nonlinear systems are among the main focuses of this book Over the past few decades there has been an unprecedented interest and advances in nonlinear systems chaos theory and fractals which is reflected in undergraduate and postgraduate curricula around the world The book is useful for courses in dynamical systems and chaos nonlinear dynamics etc for advanced undergraduate and postgraduate students in mathematics physics and engineering

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