Dynamical Systems Stability Theory And Applications Lecture Notes In Mathematics

The communication of knowledge on nonlinear dynamical systems, between the mathematicians working on the analytic approach and the scientists working mostly on the applications and numerical simulations has been less than ideal. This volume hopes to bridge the gap between books written on the subject by mathematicians and those written by scientists. The second objective of this volume is to draw attention to the need for cross-fertilization of knowledge between the physical and biological scientists. The third aim is to provide the reader with a personal guide on the study of global nonlinear dynamical systems.
Stability Theory of Dynamical SystemsSpringer Science & Business Media
This self-contained book provides systematic instructive analysis of uncertain systems of the following types: ordinary differential equations, impulsive equations, equations on time scales, singularly perturbed differential equations, and set differential equations. Each chapter contains new conditions of stability of unperturbed motion of the abo
Reprint of classic reference work. Over 400 books have been published in the series Classics in Mathematics, many remain standard references for their subject. All books in this series are reissued in a new, inexpensive softcover edition to make them easily accessible to younger generations of students and researchers. "... The book has many good points: clear organization, historical notes and references at the end of every chapter, and an excellent bibliography. The text is well-written, at a level appropriate for the intended audience, and it represents a very good introduction to the basic theory of dynamical systems."
Modern complex large-scale dynamical systems exist in virtually every aspect of science and engineering, and are associated with a wide variety of physical, technological, environmental, and social phenomena, including aerospace, power, communications, and network systems, to name just a few. This book develops a general stability analysis and control design framework for nonlinear large-scale interconnected dynamical systems, and presents the most complete treatment on vector Lyapunov function methods, vector dissipativity theory, and decentralized control architectures. Large-scale dynamical systems are strongly interconnected and consist of interacting subsystems exchanging matter, energy, or information with the environment. The sheer size, or dimensionality, of these systems necessitates decentralized analysis and control system synthesis methods for their analysis and design. Written in a theorem-proof format with examples to illustrate new concepts, this book addresses continuous-time, discrete-time, and hybrid large-scale systems. It develops finite-time stability and finite-time decentralized stabilization, thermodynamic modeling, maximum entropy control, and energy-based decentralized control. This book will interest applied mathematicians, dynamical systems theorists, control theorists, and

engineers, and anyone seeking a fundamental and comprehensive understanding of large-scale interconnected dynamical systems and control.
The thesis investigates stable, asymptotically stable and unstable dynamical systems from a topological point of view with direct application and interpretation to systems of differential equations. Knowledge of topology is not a prerequisite. Specifically, such concepts as Poisson and Liapunov stability as well as parallelizable and dispersive systems are investigated. (Author).
An introduction to nonlinear differential equations which equips undergraduate students with the know-how to appreciate stability theory and bifurcation.
This monograph is a first in the world to present three approaches for stability analysis of solutions of dynamic equations. The first approach is based on the application of dynamic integral inequalities and the fundamental matrix of solutions of linear approximation of dynamic equations. The second is based on the generalization of the direct Lyapunovs method for equations on time scales, using scalar, vector and matrix-valued auxiliary functions. The third approach is the application of auxiliary functions (scalar, vector, or matrix-valued ones) in combination with differential dynamic inequalities. This is an alternative comparison method, developed for time continuous and time discrete systems.In recent decades, automatic control theory in the study of air- and spacecraft dynamics and in other areas of modern applied mathematics has encountered problems in the analysis of the behavior of solutions of time continuous-discrete linear and/or nonlinear equations of perturbed motion. In the book “Men of Mathematics,” 1937, E.T.Bell wrote: “A major task of mathematics today is to harmonize the continuous and the discrete, to include them in one comprehensive mathematics, and to eliminate obscurity from both.”Mathematical analysis on time scales accomplishes exactly this. This research has potential applications in such areas as theoretical and applied mechanics, neurodynamics, mathematical biology and finance among others.
Filling a gap in the literature, this volume offers the first comprehensive analysis of all the major types of system models. Throughout the text, there are many examples and applications to important classes of systems in areas such as power and energy, feedback control, artificial neural networks, digital signal processing and control, manufacturing, computer networks, and socio-economics. Replete with exercises and requiring basic knowledge of linear algebra, analysis, and differential equations, the work may be used as a textbook for graduate courses in stability theory of dynamical systems. The book may also serve as a self-study reference for graduate students, researchers, and practitioners in a huge variety of fields.
The second edition of this textbook provides a single source for the analysis of system models represented by continuous-time and discrete-time, finite-dimensional and infinite-dimensional, and continuous and discontinuous dynamical systems. For these system models, it presents results which comprise the classical Lyapunov stability theory involving monotonic Lyapunov functions, as well as corresponding contemporary stability results involving non-monotonic Lyapunov functions. Specific examples from several diverse areas are given to demonstrate the applicability of the developed theory to many important classes of systems, including digital control systems, nonlinear regulator systems, pulse-width-modulated feedback control systems, and artificial neural networks. The authors cover the following four general topics: - Representation

and modeling of dynamical systems of the types described above - Presentation of Lyapunov and Lagrange stability theory for dynamical systems defined on general metric spaces involving monotonic and non-monotonic Lyapunov functions - Specialization of this stability theory to finite-dimensional dynamical systems - Specialization of this stability theory to infinite-dimensional dynamical systems Replete with examples and requiring only a basic knowledge of linear algebra, analysis, and differential equations, this book can be used as a textbook for graduate courses in stability theory of dynamical systems. It may also serve as a self-study reference for graduate students, researchers, and practitioners in applied mathematics, engineering, computer science, economics, and the physical and life sciences. Review of the First Edition: “The authors have done an excellent job maintaining the rigor of the presentation, and in providing standalone statements for diverse types of systems. [This] is a very interesting book which complements the existing literature. [It] is clearly written, and difficult concepts are illustrated by means of good examples.” - Alessandro Astolfi, IEEE Control Systems Magazine, February 2009

Suitable for advanced undergraduates and graduate students, this text introduces the stability theory and asymptotic behavior of solutions of linear and nonlinear differential equations. 1953 edition.

There have been great advances in theory of stability in recent decades due to the requirements of control theory and flight mechanics, for example. We need only mention the theory of A. M. Lyapunov. A number of specialists have given a very mathematical and abstract description of the Lyapunov stability theory which resulted in a 'stability theory of motion' applicable to the kinetics of rigid bodies and systems. The stability theory of elastomechanics was developed independently. However, there have been a number of important developments in recent years, also with respect to this theory, dealing with the following problems: The concept of the 'follower forces', non-conservative loads, respectively, has been introduced in aeroelasticity. A number of prob lems in elastic kinetics that involve pulsating loads or periodically varying parameters has led to new stability questions. So-called 'kinetic' methods have become necessary in elastomechnics in order to determine the stability bound aries. An evaluation of the stability criteria of elastostatics, which have been assumed to be generally valid, has shown that they can only be applied to a limited number of problems under special assumptions. The transition from stability to instability is a kinetic process in elastomechanics. Therefore, the most general and most certain method of determining stability is the kinetic stability criterion even if in special cases the classical stability criteria of elastostatics may remain valid. This will be discussed in detail in Section 2. 3.

Hybrid dynamical systems exhibit continuous and instantaneous changes, having features of continuous-time and discrete-time dynamical systems. Filled with a wealth of examples to illustrate concepts, this book presents a complete theory of robust asymptotic stability for hybrid dynamical systems that is applicable to the design of hybrid control algorithms--algorithms that feature logic, timers, or combinations of digital and analog components. With the tools of modern mathematical analysis, Hybrid Dynamical Systems unifies and generalizes earlier developments in continuous-time and discrete-time nonlinear systems. It presents hybrid system versions of the necessary and sufficient Lyapunov conditions for asymptotic stability, invariance principles, and approximation techniques, and examines the robustness of asymptotic stability, motivated by the goal of designing robust hybrid control algorithms. This self-contained and classroom-tested book requires standard background in mathematical analysis and differential equations or nonlinear systems. It will interest graduate students in engineering as well as students and researchers in control, computer science, and mathematics.

Several distinctive aspects make Dynamical Systems unique, including: treating the subject from a mathematical perspective with the proofs of most of the results included providing a careful review of background materials introducing ideas through examples and at a level accessible to a beginning graduate student

Using the behavioural approach to mathematical modelling, this book views a system as a dynamical relation between manifest and latent variables. The emphasis is on dynamical systems that are represented by systems of linear constant coefficients. The first part analyses the structure of the set of trajectories generated by such dynamical systems, and derives the conditions for two systems of differential equations to be equivalent in the sense that they define the same behaviour. In addition the memory structure of the system is analysed through state space models. The second part of the book is devoted to a number of important system properties, notably controllability, observability, and stability. In the third part, control problems are considered, in particular stabilisation and pole placement questions. Suitable for advanced undergraduate or beginning graduate students in mathematics and engineering, this text contains numerous exercises, including simulation problems, and examples, notably of mechanical systems and electrical circuits.

An introduction to aspects of the theory of dynamial systems based on extensions of Liapunov's direct method. The main ideas and structure for the theory are presented for difference equations and for the analogous theory for ordinary differential equations and retarded functional differential equations. The latest results on invariance properties for non-autonomous time-varying systems processes are presented for difference and differential equations.

This book unifies the dynamical systems and functional analysis approaches to the linear and nonlinear stability of waves. It synthesizes fundamental ideas of the past 20+ years of research, carefully balancing theory and application. The book isolates and methodically develops key ideas by working through illustrative examples that are subsequently synthesized into general principles. Many of the seminal examples of stability theory, including orbital stability of the KdV solitary wave, and asymptotic stability of viscous shocks for scalar conservation laws, are treated in a textbook fashion for the first time. It presents spectral theory from a dynamical systems and functional analytic point of view, including essential and absolute spectra, and develops general nonlinear stability results for dissipative and Hamiltonian systems. The structure of the linear eigenvalue problem for Hamiltonian systems is carefully developed, including the Krein signature and related stability indices. The Evans function for the detection of point spectra is carefully developed through a series of frameworks of increasing complexity. Applications of the Evans function to the Orientation index, edge bifurcations, and large domain limits are developed through illustrative examples. The book is intended for first or second year graduate students in mathematics, or those with equivalent mathematical maturity. It is highly illustrated and there are many exercises scattered throughout the text that highlight and emphasize the key concepts. Upon completion of the book, the reader will be in an excellent position to understand and contribute to current research in nonlinear stability.

This comprehensive book provides the first unified framework for stability and dissipativity analysis and control design for nonnegative and compartmental dynamical systems, which play a key role in a wide range of fields, including engineering, thermal sciences, biology, ecology, economics, genetics, chemistry, medicine, and sociology. Using the highest standards of exposition and rigor, the authors explain these systems and advance the state of the art in their analysis and active control design. Nonnegative and Compartmental Dynamical Systems presents the most complete treatment available of system solution properties, Lyapunov stability analysis, dissipativity theory, and optimal and adaptive control for these systems, addressing continuous-time, discrete-time, and hybrid nonnegative system theory. This book is an indispensable resource for applied mathematicians, dynamical systems theorists, control theorists, and engineers, as well as for researchers and graduate students who want to understand the behavior of nonnegative and compartmental dynamical systems that arise in areas such as biomedicine, demographics, epidemiology, pharmacology, telecommunications, transportation, thermodynamics, networks, heat transfer, and power systems.

There are plenty of challenging and interesting problems open for investigation in the field of switched systems. Stability issues help to generate many complex nonlinear dynamic behaviors within switched systems. The authors present a thorough investigation of stability effects on three broad classes of switching mechanism: arbitrary switching where stability represents robustness to unpredictable and undesirable perturbation, constrained switching, including random (within a known stochastic distribution), dwell-time (with a known minimum duration for each subsystem) and autonomously-generated (with a pre-assigned mechanism) switching; and designed switching in which a measurable and freely-assigned switching mechanism contributes to stability by acting as a control input. For each of these classes this book propounds: detailed stability analysis and/or design, related robustness and performance issues, connections to other control problems and many motivating and illustrative examples.

Since their inception, the Perspectives in Logic and Lecture Notes in Logic series have published seminal works by leading logicians. Many of the original books in the series have been unavailable for years, but they are now in print once again. Stability theory was introduced and matured in the 1960s and 1970s. Today stability theory influences and is influenced by number theory, algebraic group theory, Riemann surfaces, and representation theory of modules. There is little model theory today that does not involve the methods of stability theory. In this volume, the fourth publication in the Perspectives in Logic series, Steven Buechler bridges the gap between a first-year graduate logic course and research papers in stability theory. The book prepares the student for research in any of today's branches of stability theory, and gives an introduction to classification theory with an exposition of Morley's Categoricity Theorem.

This book develops a general analysis and synthesis framework for impulsive and hybrid dynamical systems. Such a framework is imperative for modern complex engineering systems that involve interacting continuous-time and discrete-time dynamics with multiple modes of operation that place stringent demands on controller design and require implementation of increasing complexity--whether advanced high-performance tactical fighter aircraft and space vehicles, variable-cycle gas turbine engines, or air and ground transportation systems. Impulsive and Hybrid Dynamical Systems goes beyond similar treatments by developing invariant set stability theorems, partial stability, Lagrange stability, boundedness, ultimate boundedness, dissipativity theory, vector dissipativity theory, energy-based hybrid control, optimal control, disturbance rejection control, and robust control for nonlinear impulsive and hybrid dynamical systems. A major contribution to mathematical system theory and control system theory, this book is written from a system-theoretic point of view with the highest standards of exposition and rigor. It is intended for graduate students, researchers, and practitioners of engineering and applied mathematics as well as computer scientists, physicists, and other scientists who seek a fundamental understanding of the rich dynamical behavior of impulsive and hybrid dynamical systems.

The 11th International Workshop on Dynamics and Control brought together scientists and engineers from diverse fields and gave them a venue to develop a greater understanding of this discipline and how it relates to many areas in science, engineering, economics, and biology. The event gave researchers an opportunity to investigate ideas and techniq

"Illuminates the most important results of the Lyapunov and Lagrange stability theory for a general class of dynamical systems by developing topics in a metric space independantly of equations, inequalities, or inclusions. Applies the general theory to specific classes of equations. Presents new and expanded material on the stability analysis of hybrid dynamical systems and dynamical systems with discontinuous dynamics."

There has been much excitement over the emergence of new mathematical techniques for the analysis and control of nonlinear systems. In addition, great technological advances have bolstered the impact of analytic advances and produced many new problems and applications which are nonlinear in an essential way. This book lays out in a concise mathematical framework the tools and methods of analysis which underlie this diversity of applications.

Nonlinear Dynamical Systems and Control presents and develops an extensive treatment of stability analysis and control design of nonlinear dynamical systems, with an emphasis on Lyapunov-based methods. Dynamical system theory lies at the heart of mathematical sciences and engineering. The application of dynamical systems has crossed interdisciplinary boundaries from chemistry to biochemistry to chemical kinetics, from medicine to biology to population genetics, from economics to sociology to psychology, and from physics to mechanics to engineering. The increasingly complex nature of engineering systems requiring feedback control to obtain a desired system behavior also gives rise to dynamical systems. Wassim Haddad and VijaySekhar Chellaboina provide an exhaustive treatment of nonlinear systems theory and control using the highest standards of exposition and rigor. This graduate-level textbook goes well beyond standard treatments by developing Lyapunov stability theory, partial stability, boundedness, input-to-state stability, input-output stability, finite-time stability, semistability, stability of sets and periodic orbits, and stability theorems via vector Lyapunov functions. A complete and thorough treatment of dissipativity theory, absolute stability theory, stability of feedback systems, optimal control, disturbance rejection control, and robust control for nonlinear dynamical systems is also given. This book is an indispensable resource for applied mathematicians, dynamical systems theorists, control theorists, and engineers.

The main purpose of developing stability theory is to examine dynamic responses of a system to disturbances as the time approaches infinity. It has been and still is the object of intense investigations due to its intrinsic interest and its relevance to all practical systems in engineering, finance, natural science and social science. This monograph provides some state-of-the-art expositions of major advances in fundamental stability theories and methods for dynamic systems of ODE and DDE types and in limit cycle, normal form and Hopf bifurcation control of nonlinear dynamic systems. Presents comprehensive theory and methodology of stability analysis Can be used as textbook for graduate students in applied mathematics, mechanics, control theory, theoretical physics, mathematical biology, information theory, scientific computation Serves as a comprehensive handbook of stability theory for practicing aerospace, control, mechanical, structural, naval and civil engineers

This authoritative treatment covers theory, optimal estimation and a range of practical applications. The first book on the subject, and written by leading researchers, this clear and rigorous work presents a comprehensive theory for both the stability boundary and the stability regions of a range of nonlinear dynamical systems including continuous, discrete, complex, two-time-scale and non-hyperbolic systems, illustrated with numerical examples. The authors also propose new concepts of quasi-stability region and of relevant stability regions and their complete characterisations. Optimal schemes for estimating stability regions of general nonlinear dynamical systems are also covered, and finally the authors describe and explain how the theory is applied in applications including direct methods for power system transient stability analysis, nonlinear optimisation for finding a set of high-quality optimal solutions, stabilisation of nonlinear systems, ecosystem dynamics, and immunisation problems.