Stability Analysis Of Nonlinear Systems With Linear

Many problems in decision making, monitoring, fault detection, and control require the knowledge of state variables and time-varying parameters that are not directly measured by sensors. In such situations, observers, or estimators, can be employed that use the measured input and output signals along with a dynamic model of the system in order to estimate the unknown states or parameters. An essential requirement in designing an observer is to guarantee the convergence of the estimates to the true values or at least to a small neighborhood around the true values. However, for nonlinear, large-scale, or time-varying systems, the design and tuning of an observer is generally complicated and involves large computational costs. This book provides a range of methods and tools to design observers for nonlinear systems represented by a special type of a dynamic nonlinear model -- the Takagi--Sugeno (TS) fuzzy model. The TS model is a convex combination of affine linear models, which facilitates its stability analysis and observer design by using effective algorithms based on Lyapunov functions and linear matrix inequalities. Takagi--Sugeno models are known to be universal approximators and, in addition, a broad class of nonlinear systems can be exactly represented as a TS system. Three particular structures of large-scale TS models are considered: cascaded systems, distributed systems, and systems affected by unknown disturbances. The reader will find in-depth theoretic analysis accompanied by illustrative examples and simulations of real-world systems. Stability analysis of TS fuzzy systems is addressed in detail. The intended audience are graduate students and researchers both from academia and industry. For newcomers to the field, the book provides a concise introduction dynamic TS fuzzy models along with two methods to construct TS models for a given nonlinear system

This text provides a rigorous mathematical analysis of the behavior of nonlinear control systems under a variety of situations.

Systems with time delays have a broad range of applications not only in control systems but also in many other disciplines such as mathematical biology, financial economics, etc. The time delays cause more complex behaviours of the systems. It requires more sophisticated analysis due to the infinite dimensional structure of the space spaces. In this thesis we investigate stability properties associated with output functions of delay systems. Our primary target is the equivalent Lyapunov characterization of input-tooutput stability (ios). A main approach used in this work is the Lyapunov Krasovskii functional method. The Lyapunov characterization of the so called output-Lagrange stability is technically the backbone of this work, as it induces a Lyapunov description for all the other output stability properties, in particular for ios. In the study, we consider two types of output functions. The first type is defined in between Banach spaces, whereas the second type is defined between Euclidean spaces. The Lyapunov characterization for the first type of output maps provides equivalence between the stability properties and the existence of the Lyapunov-Krasovskii functionals. On the other hand, as a special case of the first type, the second type output renders flexible Lyapunov descriptions that are more efficient in applications. In the special case when the output variables represent the complete collection of the state variables, our Lyapunov work lead to Lyapunov characterizations of iss, complementing the current iss theory with some novel results. We also aim at understanding how output stability are affected by the initial data and the external signals. Since the output variables are in general not a full collection of the state variables, the overshoots and decay properties may be affected in different ways by the initial data of either the state variables or just only the output variables. Accordingly, there are different ways of defining notions on output stability, making them mathematically precisely. After presenting the definitions, we explore the connections of these notions. Understanding the relation among the notions is not only mathematically necessary, it also provides guidelines in system control and design.

Cooperative Control of Nonlinear Networked Systems is concerned with the distributed cooperative control of multiple networked nonlinear systems in the presence of unknown non-parametric uncertainties and non-vanishing disturbances under certain communication conditions. It covers stability analysis tools and distributed control methods for analyzing and synthesizing nonlinear networked systems. The book presents various solutions to cooperative control problems of multiple networked nonlinear systems on graphs. The book includes various examples with segments of MATLAB® codes for readers to verify, validate, and replicate the results. The authors present a series of new control results for nonlinear networked systems subject to both non-parametric and non-vanishing uncertainties, including the cooperative uniformly ultimately bounded (CUUB) result, finite-time stability result, and finite-time cooperative uniformly ultimately bounded (FT-CUUB) result. With some mathematical tools, such as algebraic graph theory and certain aspects of matrix analysis theory introduced by the authors, the readers can obtain a deeper understanding of the roles of matrix operators as mathematical machinery for cooperative control design for multi-agent systems. Cooperative Control of Nonlinear Networked Systems is a valuable source of information for researchers and engineers in cooperative adaptive control, as its technical contents are presented with examples in full analytical and numerical detail, and graphically illustrated for easy-to-understand results. Scientists in research institutes and academics in universities working on nonlinear systems, adaptive control and distributed control will find the book of interest, as it contains multi-disciplinary problems and covers different areas of research.

The book investigates stability theory in terms of two different measure, exhibiting the advantage of employing families of Lyapunov functions and treats the theory of a variety of inequalities, clearly bringing out the underlying theme. It also demonstrates manifestations of the general Lyapunov method, showing how this technique can be adapted to various apparently diverse nonlinear problems. Furthermore it discusses the application of theoretical results to several different models chosen from real world phenomena, furnishing data that is particularly relevant for practitioners. Stability Analysis of Nonlinear Systems is an invaluable single-sourse reference for industrial and applied mathematicians, statisticians, engineers, researchers in the applied sciences, and graduate students studying differential equations.

Recently, the subject of nonlinear control systems analysis has grown rapidly and this book provides a simple and self-contained presentation of their stability and feedback stabilization which enables the reader to learn and understand major techniques used in mathematical control theory. In particular: the important techniques of proving global stability properties are presented closely linked with corresponding methods of nonlinear feedback stabilization; a general framework of methods for proving stability is given, thus allowing the study of a wide class of nonlinear systems, including finite-dimensional systems described by ordinary differential equations, discrete-time systems, systems with delays and sampled-data systems; approaches to the proof of classical global stability properties are extended to non-classical global stability properties such as non-uniform-in-time stability and input-to-output stability; and new tools for stability analysis and control design of a wide class of nonlinear systems are introduced. The presentational emphasis of Stability and Stabilization of Nonlinear Systems is theoretical but the theory's importance for concrete control problems is highlighted with a chapter specifically dedicated to applications and with numerous illustrative examples. Researchers working on nonlinear control theory will find this monograph of interest while graduate students of systems and control can also gain much insight and assistance from the methods and proofs detailed in this book.

This book focuses on the stability analysis of Markovian jump systems (MJSs) with various settings and discusses its applications in several different areas. It also presents general definitions of the necessary concepts and an overview of the recent developments in MJSs. Further, it addresses the general robust problem of Markovian jump linear systems (MJLSs), the asynchronous stability of a class of nonlinear systems, the robust adaptive control scheme for a class of nonlinear uncertain MJSs, the practical stability of MJSs and its applications as a modelling tool for networked control systems, Markovian-based control for wheeled mobile manipulators and the jump-linear-quadratic (JLQ) problem of a class of continuous-time MJLSs. It is a valuable resource for researchers and graduate students in the field of control theory and engineering.

Singular systems which are also referred to as descriptor systems, semi-state systems, differential- algebraic systems or generalized state-space systems have attracted much attention because of their extensive applications in the Leontief dynamic model, electrical and mechanical models, etc. This monograph presented up-to-date research developments and references on stability analysis and design of nonlinear singular systems. It investigated the problems of practical stability, strongly absolute stability, input-state stability and observer design for nonlinear singular systems and the problems of absolute stability and multi-objective control for nonlinear singularly perturbed systems by using Lyapunov stability theory, comparison principle, S-procedure and linear matrix inequality (LMI), etc. Practical stability, being quite different from stability in the sense of Lyapunov, is a significant performance specification from an engineering point of view. The basic concepts and results on practical stability for standard state-space systems were generalized to singular systems. For Lur’e type descriptor systems (LDS) which were the feedback interconnection of a descriptor system with a static nonlinearity, strongly absolute stability was defined and Circle criterion and Popov criterion were derived. The notion of input-state stability (ISS) for nonlinear singular systems was defined based on the concept of ISS for standard state-space systems and the characteristics of singular systems. LMI-based sufficient conditions for ISS of Lur’e singular systems were proposed. Furthermore, observer design for nonlinear singular systems was studied and some observer design methods were proposed by the obtained stability results and convex optimization algorithms. Finally, absolute stability and multi-objective control of nonlinear singularly perturbed systems were considered. By Lyapunov functions, absolute stability criteria of Lur’e singularly perturbed systems were proposed and multi-objective control of T-S fuzzy singularly perturbed systems was achieved. Compared with the existing results, the obtained methods do not depend on the decomposition of the original system and can produce a determinate upper bound for the singular perturbation parameter.

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This report investigates an optimal quadratic Liapunov function generating algorithm for estimating domain of equilibrium attraction of nonlinear star tracker attitude control systems for OAO stability.

This book focuses on several key aspects of nonlinear systems including dynamic modeling, state estimation, and stability analysis. It is intended to provide a wide range of readers in applied mathematics and various engineering disciplines an excellent survey of recent studies of nonlinear systems. With its thirteen chapters, the book brings together important contributions from renowned international researchers to provide an excellent survey of recent studies of nonlinear systems. The first section consists of eight chapters that focus on nonlinear dynamic modeling and analysis techniques, while the next section is composed of five chapters that center on state estimation methods and stability analysis for nonlinear systems.

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This book details the analysis of continuous- and discrete-time dynamical systems described by differential and difference equations respectively. Differential geometry provides the tools for this, such as first-integrals or orbital symmetries, together with normal forms of vector fields and of maps. A crucial point of the analysis is linearization by state immersion. The theory is developed for general nonlinear systems and specialized for the class of Hamiltonian systems. By using the strong geometric structure of Hamiltonian systems, the results proposed are stated in a different, less complex and more easily comprehensible manner. They are applied to physically motivated systems, to demonstrate how much insight into known properties is gained using these techniques. Various control systems applications of the techniques are characterized including: computation of the flow of nonlinear systems; computation of semi-invariants; computation of Lyapunov functions for stability analysis and observer design.

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

One service mathematics has rendered the 'Et moi, '", si j'avait su comment en revenir, je n'y serais point all".' human race. It has put common sense back where it belongs, on the topmost shelf next Jules Verne to the dusty canister labelled 'discarded non sense'. The series is divergent; therefore we may be able to do something with it. Eric T. Bell O. Heaviside Mathematics is a tool for thought. A highly necessary tool in a world where both feedback and non linearities abound. Similarly, all kinds of parts of mathematics serve as tools for other parts and for other sciences. Applying a simple rewriting rule to the quote on the right above one finds such statements as: 'One service topology has rendered mathematical physics . .'; 'One service logic has rendered com puter science . .'; 'One service category theory has rendered mathematics . .'. All arguably true. And all statements obtainable this way form part of the raison d'etre of this series.

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.

This straightforward text makes the complicated but powerful methods of non-linear control accessible to process engineers. Not only does it cover the necessary mathematics, but it consistently refers to the widely-known finite-dimensional linear time-invariant continuous case as a basis for extension to the nonlinear situation.

The equations used to describe dynamic properties of physical systems are often nonlinear, and it is rarely possible to find their solutions. Although numerical solutions are impractical and graphical techniques are not useful for many types of systems, there are different theorems and methods that are useful regarding qualitative properties of nonlinear systems and their solutions—system stability being the most crucial property. Without stability, a system will not have value. Nonlinear Systems Stability Analysis: Lyapunov-Based Approach introduces advanced tools for stability analysis of nonlinear systems. It presents the most recent progress in stability analysis and provides a complete review of the dynamic systems stability analysis methods using Lyapunov approaches. The author discusses standard stability techniques, highlighting their shortcomings, and also describes recent developments in stability analysis that can improve applicability of the standard methods. The text covers mostly new topics such as stability of homogonous nonlinear systems and higher order Lyapunov functions derivatives for stability analysis. It also addresses special classes of nonlinear systems including time-delayed and fuzzy systems. Presenting new methods, this book provides a nearly complete set of methods for constructing Lyapunov functions in both autonomous and nonautonomous systems, touching on new topics that open up novel research possibilities. Gathering a body of research into one volume, this text offers information to help engineers design stable systems using practice-oriented methods and can be used for graduate courses in a range of engineering disciplines.