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# ROBUST CONTROL OF NONLINEAR UNCERTAIN SYSTEMS

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Zhihua Qu

WILEY SERIES IN NONLINEAR SCIENCE

# Robust Control Of Nonlinear Uncertain Systems

**Hongjiu Yang, Yuanqing Xia, Peng  
Shi, Ling Zhao**



## **Robust Control Of Nonlinear Uncertain Systems:**

**Robust Control of Nonlinear Uncertain Systems** Zhihua Qu, 1998-04-29 This timely work presents the definitive treatment of stability analysis and robust control design for nonlinear uncertain systems While other books on the subject deal with robust control in linear systems this is the first book to tackle robust control design for such nonlinear entities as power systems robotics and more It combines examples proofs and applications clearly showing how to build high performance and better control into systems that are too complex to be modeled accurately A unique feature of this book is its Lyapunov based approach to control design which is the only universal approach for nonlinear systems The Lyapunov direct method is used here to develop all design procedures to correlate leading techniques in the field to the structural properties of uncertain systems and to compare robust and nonrobust types of controls such as adaptive control learning control and optimal control The subject is introduced with a self contained treatment of the nonlinear stability theory originally proposed by Lyapunov and LaSalle Emphasizing the basics the introductory chapters incorporate three types of solutions stability concepts and various theorems The main body of the text offers a comprehensive treatment for current design methods including state space robust control designs properties of various robust controllers input output control and discrete robust control designs In **Robust Control of Nonlinear Uncertain Systems** author Zhihua Qu presents the complete set of control design procedures for nonlinear uncertain systems including backward recursive design forward recursive design recursive interlacing design feedback linearization nonlinear optimal control and sub optimal control Also featured here is the breakthrough recursive interlacing design that facilitates robust control for uncertain systems with all cascaded feedback and feedforward dynamics Throughout Professor Qu presents the pros and cons of specific methods rationales for choosing particular design parameters and tips on questions of stability performance and systems structure For engineers and graduate students in mechanical electrical and aerospace engineering **Robust Control of Nonlinear Uncertain Systems** imparts the technical know how for effective design explores key theoretical issues in control and provides insight into future trends in the field

**Robust Control Designs for Nonlinear Uncertain Systems** Joseph Kaloust, 1995 The analysis and design of robust controllers are developed using Lyapunov's direct method Five different controllers are proposed designed and simulated for a certain class of nonlinear systems

**Development of Robust Control Based on Sliding Mode for Nonlinear Uncertain Systems** Xinming Yan, 2016 This work deals with the development of control laws for nonlinear uncertain systems based on sliding mode theory The standard sliding mode control approaches are state feedback ones in which the sliding variable and its time derivatives are required This first objective of this thesis is to propose high order sliding mode control laws with a reduced use of sliding variable time derivatives The contributions are made for the second and third order sliding mode control The second objective is to combine the proposed control laws with a gain adaptation mechanism The use of adaptive gain law allows to simplify the tuning process to reduce the convergence time and to improve

the accuracy Finally the applicability of the proposed approaches is shown on IRCCyN pneumatic benchmark Applications are also made on 3DOF flying system      **Robust Control** Andrzej Bartoszewicz, 2011-04-11 The main objective of this monograph is to present a broad range of well worked out recent theoretical and application studies in the field of robust control system analysis and design The contributions presented here include but are not limited to robust PID H infinity sliding mode fault tolerant fuzzy and QFT based control systems They advance the current progress in the field and motivate and encourage new ideas and solutions in the robust control area      **Nonlinear Dynamical Systems and Control** Wassim M. Haddad, VijaySekhar Chellaboina, 2011-09-19 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

**Robust Control Design Using  $H_\infty$  Methods** Ian R. Petersen, Valery A. Ugrinovskii, Andrey V. Savkin, 2012-12-06 This is a unified collection of important recent results for the design of robust controllers for uncertain systems primarily based on  $H_2$  control theory or its stochastic counterpart risk sensitive control theory Two practical applications are used to illustrate the methods throughout      **New Results on Practical Stability for Linear and Nonlinear Uncertain Systems** Laura Celentano, 2012

*Perspectives in Robust Control* S.O.Reza Moheimani, 2001-03-30 This book is based on a workshop entitled Robust Control workshop 2000 The workshop was held in Newcastle Australia from the 6th to the 8th December 2000 Chapters of the book are written by some of the leading researchers in the field of Robust Control They cover a variety of topics all related to Robust Control and analysis of uncertain systems      **Robust Control of Nonlinear Time-varying**

**Mismatched Uncertain Systems** Wei Hua Wang, 1998      **Adaptive Control of Dynamic Systems with Uncertainty and Quantization** Jing Zhou, Lantao Xing, Changyun Wen, 2021-12-15 This book presents a series of innovative technologies and research results on adaptive control of dynamic systems with quantization uncertainty and nonlinearity including the

theoretical success and practical development such as the approaches for stability analysis the compensation of quantization the treatment of subsystem interactions and the improvement of system tracking and transient performance Novel solutions by adopting backstepping design tools to a number of hotspots and challenging problems in the area of adaptive control are provided In the first three chapters the general design procedures and stability analysis of backstepping controllers and the basic descriptions and properties of quantizers are introduced as preliminary knowledge for this book In the remainder of this book adaptive control schemes are introduced to compensate for the effects of input quantization state quantization both input and state output quantization for uncertain nonlinear systems and are applied to helicopter systems and DC Microgrid Discussion remarks are provided in each chapter highlighting new approaches and contributions to emphasize the novelty of the presented design and analysis methods Simulation results are also given in each chapter to show the effectiveness of these methods This book is helpful to learn and understand the fundamental backstepping schemes for state feedback control and output feedback control It can be used as a reference book or a textbook on adaptive quantized control for students with some background in feedback control systems Researchers graduate students and engineers in the fields of control information and communication electrical engineering mechanical engineering computer science and others will benefit from this book

Probabilistic and Randomized Methods for Design under Uncertainty Giuseppe Calafiore, Fabrizio

Dabbene, 2006-03-06 In many engineering design and optimization problems the presence of uncertainty in the data is a critical issue There are different ways to describe this uncertainty and to devise designs that are partly insensitive or robust to it This book examines uncertain systems in control engineering and general decision or optimization problems for which data is uncertain Written by leading researchers in optimization and robust control it highlights the interactions between these two fields Part I describes theory and solution methods for probability constrained and stochastic optimization problems Part II focuses on numerical methods for solving randomly perturbed convex programs and semi infinite optimization problems by probabilistic techniques Part III details the theory and applications of randomized techniques to the analysis and design of robust control systems It will interest researchers academics and postgraduates in control engineering and operations research as well as professionals working in operations research

**Deterministic Learning Theory for**

**Identification, Recognition, and Control** Cong Wang, David J. Hill, 2018-10-03 Deterministic Learning Theory for Identification Recognition and Control presents a unified conceptual framework for knowledge acquisition representation and knowledge utilization in uncertain dynamic environments It provides systematic design approaches for identification recognition and control of linear uncertain systems Unlike many books currently available that focus on statistical principles this book stresses learning through closed loop neural control effective representation and recognition of temporal patterns in a deterministic way A Deterministic View of Learning in Dynamic Environments The authors begin with an introduction to the concepts of deterministic learning theory followed by a discussion of the persistent excitation property of RBF networks

They describe the elements of deterministic learning and address dynamical pattern recognition and pattern based control processes The results are applicable to areas such as detection and isolation of oscillation faults ECG EEG pattern recognition robot learning and control and security analysis and control of power systems A New Model of Information Processing This book elucidates a learning theory which is developed using concepts and tools from the discipline of systems and control Fundamental knowledge about system dynamics is obtained from dynamical processes and is then utilized to achieve rapid recognition of dynamical patterns and pattern based closed loop control via the so called internal and dynamical matching of system dynamics This actually represents a new model of information processing i e a model of dynamical parallel distributed processing DPDP Neural Information Processing Derong Liu, Shengli Xie, Yuanqing Li, Dongbin Zhao, El-Sayed M. El-Alfy, 2017-11-07 The six volume set LNCS 10634 LNCS 10635 LNCS 10636 LNCS 10637 LNCS 10638 and LNCS 10639 constitutes the proceedings of the 24rd International Conference on Neural Information Processing ICONIP 2017 held in Guangzhou China in November 2017 The 563 full papers presented were carefully reviewed and selected from 856 submissions The 6 volumes are organized in topical sections on Machine Learning Reinforcement Learning Big Data Analysis Deep Learning Brain Computer Interface Computational Finance Computer Vision Neurodynamics Sensory Perception and Decision Making Computational Intelligence Neural Data Analysis Biomedical Engineering Emotion and Bayesian Networks Data Mining Time Series Analysis Social Networks Bioinformatics Information Security and Social Cognition Robotics and Control Pattern Recognition Neuromorphic Hardware and Speech Processing

**Adaptive Control Systems** Gang Feng, Rogelio Lozano, 1999-05-10 Adaptive control is no longer just an important theoretical field of study but is also providing solutions to real world problems Adaptive techniques will transform the world of control The leading world practitioners of adaptive control have contributed to this handbook which is the most important work yet in this field Not only are techniques described in theory but detailed control algorithms are given making this a practical cookbook of adaptive control for both control professionals and practising engineers The book presents the most advanced techniques and algorithms of adaptive control These include various robust techniques performance enhancement techniques techniques with less a priori knowledge nonlinear adaptive control techniques and intelligent adaptive techniques Each technique described has been developed to provide a practical solution to a real life problem This volume will therefore not only advance the field of adaptive control as an area of study but will also show how the potential of this technology can be realised and offer significant benefits Practical cookbook of adaptive control Contains important research *European Control Conference 1993*, 1993-06-28 Proceedings of the European Control Conference 1993 Groningen Netherlands June 28 July 1 1993 **Applied Mechanics Reviews**, 1992 *Sliding Mode Control Methodology in the Applications of Industrial Power Systems* Jianxing Liu, Yabin Gao, Yunfei Yin, Jiahui Wang, Wensheng Luo, Guanghui Sun, 2019-10-23 This book presents recent advanced techniques in sliding mode control and observer design for industrial power systems focusing on their

applications in polymer electrolyte membrane fuel cells and power converters Readers will find not only valuable new fault detection and isolation techniques based on sliding mode control and observers but also a number of robust control and estimation methodologies combined with fuzzy neural networks and extended state observer methods The book also provides necessary experimental and simulation examples for proton exchange membrane fuel cell systems and power converter systems Given its scope it offers a valuable resource for undergraduate and graduate students academics scientists and engineers who are working in the field

Analysis and Synthesis of Delta Operator Systems Hongjiu Yang, Yuanqing Xia, Peng Shi, Ling Zhao, 2012-04-23 This book is devoted to analysis and design on delta operator systems When sampling is fast a dynamical system will become difficult to control which can be seen in wide real world applications Delta operator approach is very effective to deal with fast sampling systems Moreover it is easy to observe and analyze the control effect with different sampling periods in delta operator systems The framework of this book has been carefully constructed for delta operator systems to handle sliding mode control time delays filter design finite frequency and networked control These problems indeed are especially important and significant in automation and control systems design Through the clear framework of the book readers can easily go through the learning process on delta operator systems via a precise and comfortable learning sequence Following this enjoyable trail readers will come out knowing how to use delta operator approach to deal with control problems under fast sampling case This book should be a good reference for academics post graduates scientists and engineers working in the field of control science and control engineering

Stability Analysis of Markovian Jump Systems Yu Kang, Yun-Bo Zhao, Ping Zhao, 2017-09-08 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

**Control Systems Theory with Engineering Applications** Sergey E. Lyshevski, 2012-12-06 Dynamics systems living organisms electromechanical and industrial systems chemical and technological processes market and ecology and so forth can be considered and analyzed using information and systems theories For example adaptive human behavior can be studied using automatic feedback control As an illustrative example the driver controls a car changing the speed and steering wheels using incoming information such as traffic and road conditions This book focuses on the most important and manageable topics in applied multivariable control with application to a wide class of electromechanical dynamic systems A large spectrum of systems familiar to electrical mechanical and

aerospace students engineers and scholars are thoroughly studied to build the bridge between theory and practice as well as to illustrate the practical application of control theory through illustrative examples It is the author's goal to write a book that can be used to teach undergraduate and graduate classes in automatic control and nonlinear control at electrical mechanical and aerospace engineering departments The book is also addressed to engineers and scholars and the examples considered allow one to implement the theory in a great variety of industrial systems The main purpose of this book is to help the reader grasp the nature and significance of multivariable control



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