Intelligent Systems, Control and Automation:
Science and Engineering

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Fractional Order Differentiation and Robust Control Design

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Fractional Order Differentiation And Robust Control Design Crone H Infinity And Motion Control Intelligent Systems Control And Automation Science And Engineering

Bijnan Bandyopadhyay,Shyam Kamal

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Fractional Order Differentiation and Robust Control Design Jocelyn Sabatier,Patrick Lanusse,Pierre Melchior,Alain Oustaloup,2015-05-06 This book provides an overview of the research done and results obtained during the last ten years in the fields of fractional systems control fractional PI and PID control robust and CRONE control and fractional path planning and path tracking Coverage features theoretical results applications and exercises The book will be useful for post graduate students who are looking to learn more on fractional systems and control In addition it will also appeal to researchers from other fields interested in increasing their knowledge in this area *Positive Systems* Filippo Cacace,Lorenzo Farina,Roberto Setola,Alfredo Germani,2017-04-01 This book presents high quality original contributions on positive systems including topics such as monotone dynamical systems in mathematical biology and game theory mathematical developments for networked systems in biology chemistry and the social sciences linear and nonlinear positive operators dynamical analysis observation and control of positive distributed parameter systems stochastic realization theory biological systems with positive variables and positive controls iterated function systems nonnegative dynamic processes and dimensioning problems for collaborative systems The book comprises a selection of the best papers presented at the POSTA 2016 the 5th International Symposium on Positive Systems which was held in Rome Italy in September 2016 This conference series represents a targeted response to the growing need for research that reports on and critically discusses a wide range of topics concerning the theory and applications of positive systems Implicit Fractional Differential and Integral Equations Saïd Abbas,Mouffak Benchohra,John R. Graef,Johnny Henderson,2018-02-05 This book deals with the existence and stability of solutions to initial and boundary value problems for functional differential and integral equations and inclusions involving the Riemann Liouville Caputo and Hadamard fractional derivatives and integrals A wide variety of topics is covered in a mathematically rigorous manner making this work a valuable source of information for graduate students and researchers working with problems in fractional calculus Contents Preliminary Background Nonlinear Implicit Fractional Differential Equations Impulsive Nonlinear Implicit Fractional Differential Equations Boundary Value Problems for Nonlinear Implicit Fractional Differential Equations Boundary Value Problems for Impulsive NIFDE Integrable Solutions for Implicit Fractional Differential Equations Partial Hadamard Fractional Integral Equations and Inclusions Stability Results for Partial Hadamard Fractional Integral Equations and Inclusions Hadamard Stieltjes Fractional Integral Equations Ulam Stabilities for Random Hadamard Fractional Integral Equations **Basic Theory** Anatoly Kochubei,Yuri Luchko,2019-02-19 This multi volume handbook is the most up to date and comprehensive reference work in the field of fractional calculus and its numerous applications This first volume collects authoritative chapters covering the mathematical theory of fractional calculus including fractional order operators integral transforms and equations special functions calculus of variations and

probabilistic and other aspects *Fractional Order Systems—Control Theory and Applications* Omar Naifar,Abdellatif Ben Makhlouf,2021-08-30 This book aims to bring together the latest innovative knowledge analysis and synthesis of fractional control problems of nonlinear systems as well as some related applications Fractional order systems FOS are dynamical systems that can be modelled by a fractional differential equation carried with a non integer derivative In the last few decades the growth of science and engineering systems has considerably stimulated the employment of fractional calculus in many subjects of control theory for example in stability stabilization controllability observability observer design and fault estimation The application of control theory in FOS is an important issue in many engineering applications So to accurately describe these systems the fractional order differential equations have been introduced **Fractional Order Systems and Applications in Engineering** Dumitru Baleanu,Valentina Emilia Balas,Praveen Agarwal,2022-11-17 Fractional Order Systems and Applications in Engineering presents the use of fractional calculus calculus of non integer order in the description and modelling of systems and in a range of control design and practical applications The book covers the fundamentals of fractional calculus together with some analytical and numerical techniques and provides MATLAB codes for the simulation of fractional order control FOC systems The use of fractional calculus can improve and generalize well established control methods and strategies Many different FOC schemes are presented for control and dynamic systems problems These extend to the challenging control engineering design problems of robust and nonlinear control Practical material relating to a wide variety of applications including among others mechatronics civil engineering irrigation and water management and biological systems is also provided All the control schemes and applications are presented with either system simulation results or real experimental results or both Fractional Order Systems and Applications in Engineering introduces readers to the essentials of FOC and imbues them with a basic understanding of FOC concepts and methods With this knowledge readers can extend their use of FOC in other industrial system applications thereby expanding their range of disciplines by exploiting this versatile new set of control techniques Provides the most recent and up to date developments on the Fractional order Systems and their analyzing process Integrates recent advancements of modeling of real phenomena on Fractional order Systems via different different mathematical equations with demonstrated applications in numerous seemingly diverse and widespread fields of science and engineering Provides readers with illustrative examples of how to use the presented theories of Fractional order Systems in specific cases with associated MATLAB code **Intelligent Fractional Order Systems and Control** Indranil Pan,Saptarshi Das,2012-08-23 Fractional order calculus is finding increasing interest in the control system community Hardware realizations of fractional order controllers have sparked off a renewed zeal into the investigations of control system design in the light of fractional calculus As such many notions of integer order LTI systems are being modified and extended to incorporate these new concepts Computational Intelligence CI techniques have been applied to engineering problems to find solutions to many hitherto intractable conundrums and is a

useful tool for dealing with problems of higher computational complexity This book borders on the interface between CI techniques and fractional calculus and looks at ways in which fractional order control systems may be designed or enhanced using CI based paradigms To the best of the author s knowledge this is the first book of its kind exclusively dedicated to the application of computational intelligence techniques in fractional order systems and control The book tries to assimilate various existing concepts in this nascent field of fractional order intelligent control and is aimed at researchers and post graduate students working in this field *Advanced Synchronization Control and Bifurcation of Chaotic Fractional-Order Systems* Boulkroune, Abdesselem,Ladaci, Samir,2018-05-11 In the recent years fractional order systems have been studied by many researchers in the engineering field It was found that many systems can be described more accurately by fractional differential equations than by integer order models Advanced Synchronization Control and Bifurcation of Chaotic Fractional Order Systems is a scholarly publication that explores new developments related to novel chaotic fractional order systems control schemes and their applications Featuring coverage on a wide range of topics including chaos synchronization nonlinear control and cryptography this publication is geared toward engineers IT professionals researchers and upper level graduate students seeking current research on chaotic fractional order systems and their applications in engineering and computer science **Stabilization and Control of Fractional Order Systems: A Sliding Mode Approach** Bijnan Bandyopadhyay,Shyam Kamal,2014-07-22 In the last two decades fractional differential equations have been used more frequently in physics signal processing fluid mechanics viscoelasticity mathematical biology electro chemistry and many others It opens a new and more realistic way to capture memory dependent phenomena and irregularities inside the systems by using more sophisticated mathematical analysis This monograph is based on the authors work on stabilization and control design for continuous and discrete fractional order systems The initial two chapters and some parts of the third chapter are written in tutorial fashion presenting all the basic concepts of fractional order system and a brief overview of sliding mode control of fractional order systems The other parts contain deal with robust finite time stability of fractional order systems integral sliding mode control of fractional order systems co operative control of multi agent systems modeled as fractional differential equation robust stabilization of discrete fractional order systems high performance control using soft variable structure control and contraction analysis by integer and fractional order infinitesimal variations **Advances in Robust Fractional Control** Fabrizio Padula,Antonio Visioli,2014-09-19 This monograph presents design methodologies for robust fractional control systems It shows the reader how to take advantage of the superior flexibility of fractional control systems compared with integer order systems in achieving more challenging control requirements There is a high degree of current interest in fractional systems and fractional control arising from both academia and industry and readers from both milieux are catered to in the text Different design approaches having in common a trade off between robustness and performance of the control system are considered explicitly The text generalizes methodologies techniques and theoretical results that have

been successfully applied in classical integer control to the fractional case The first part of Advances in Robust Fractional Control is the more industrially oriented It focuses on the design of fractional controllers for integer processes In particular it considers fractional order proportional integral derivative controllers because integer order PID regulators are undoubtedly the controllers most frequently adopted in industry The second part of the book deals with a more general approach to fractional control systems extending techniques such as H infinity optimal control and optimal input output inversion based control originally devised for classical integer order control Advances in Robust Fractional Control will be a useful reference for the large number of academic researchers in fractional control for their industrial counterparts and for graduate students who want to learn more about this subject **Robust Adaptive Control for Fractional-Order Systems with Disturbance and Saturation** Mou Chen,Shuyi Shao,Peng Shi,2017-10-20 A treatise on investigating tracking control and synchronization control of fractional order nonlinear systems with system uncertainties external disturbance and input saturation Robust Adaptive Control for Fractional Order Systems with Disturbance and Saturation provides the reader with a good understanding on how to achieve tracking control and synchronization control of fractional order nonlinear systems with system uncertainties external disturbance and input saturation Although some texts have touched upon control of fractional order systems the issues of input saturation and disturbances have rarely been considered together This book offers chapter coverage of fractional calculus and fractional order systems fractional order PID controller and fractional order disturbance observer design of fractional order controllers for nonlinear chaotic systems and some applications sliding mode control for fractional order nonlinear systems based on disturbance observer disturbance observer based neural control for an uncertain fractional order rotational mechanical system adaptive neural tracking control for uncertain fractional order chaotic systems subject to input saturation and disturbance stabilization control of continuous time fractional positive systems based on disturbance observer sliding mode synchronization control for fractional order chaotic systems with disturbance and more Based on the approximation ability of the neural network NN the adaptive neural control schemes are reported for uncertain fractional order nonlinear systems Covers the disturbance estimation techniques that have been developed to alleviate the restriction faced by traditional feedforward control and reject the effect of external disturbances for uncertain fractional order nonlinear systems By combining the NN with the disturbance observer the disturbance observer based adaptive neural control schemes have been studied for uncertain fractional order nonlinear systems with unknown disturbances Considers together the issue of input saturation and the disturbance for the control of fractional order nonlinear systems in the present of system uncertainty external disturbance and input saturation Robust Adaptive Control for Fractional Order Systems with Disturbance and Saturation can be used as a reference for the academic research on fractional order nonlinear systems or used in Ph D study of control theory and engineering **Fractional Order Motion Controls** ,2012-11-07 Covering fractional order theory simulation and experiments this book explains how fractional order

modelling and fractional order controller design compares favourably with traditional velocity and position control systems The authors systematically compare the two approaches using applied fractional calculus Stability theory in fractional order controllers design is also analysed Presents material suitable for a variety of real world applications including hard disk drives vehicular controls robot control and micropositioners in DNA microarray analysis Includes extensive experimental results from both lab bench level tests and industrial level mass production ready implementations Covers detailed derivations and numerical simulations for each case Discusses feasible design specifications ideal for practicing engineers The book also covers key topics including fractional order disturbance cancellation and adaptive learning control studies for external disturbances optimization approaches for nonlinear system control and design schemes with backlash and friction Illustrations and experimental validations are included for each of the proposed control schemes to enable readers to develop a clear understanding of the approaches covered and move on to apply them in real world scenarios **Fractional Order Systems** Ahmad Taher Azar,Ahmed G. Radwan,Sundarapandian Vaidyanathan,2018-08-16 Fractional Order Systems Optimization Control Circuit Realizations and Applications consists of 21 contributed chapters by subject experts Chapters offer practical solutions and novel methods for recent research problems in the multidisciplinary applications of fractional order systems such as FPGA circuits memristors control algorithms photovoltaic systems robot manipulators oscillators etc This book is ideal for researchers working in the modeling and applications of both continuous time and discrete time dynamics and chaotic systems Researchers from academia and industry who are working in research areas such as control engineering electrical engineering mechanical engineering computer science and information technology will find the book most informative Discusses multi disciplinary applications with new fundamentals modeling analysis design realization and experimental results Includes new circuits and systems based on the new nonlinear elements Covers most of the linear and nonlinear fractional order theorems that will solve many scientific issues for researchers Closes the gap between theoretical approaches and real world applications Provides MATLAB and Simulink code for many of the applications in the book

Fractional Order Control and Synchronization of Chaotic Systems Ahmad Taher Azar,Sundarapandian Vaidyanathan,Adel Ouannas,2017-02-27 The book reports on the latest advances in and applications of fractional order control and synchronization of chaotic systems explaining the concepts involved in a clear matter of fact style It consists of 30 original contributions written by eminent scientists and active researchers in the field that address theories methods and applications in a number of research areas related to fractional order control and synchronization of chaotic systems such as fractional chaotic systems hyperchaotic systems complex systems fractional order discrete chaotic systems chaos control chaos synchronization jerk circuits fractional chaotic systems with hidden attractors neural network fuzzy logic controllers behavioral modeling robust and adaptive control sliding mode control different types of synchronization circuit realization of chaotic systems etc In addition to providing readers extensive information on chaos fundamentals fractional calculus

fractional differential equations fractional control and stability the book also discusses key applications of fractional order chaotic systems as well as multidisciplinary solutions developed via control modeling As such it offers the perfect reference guide for graduate students researchers and practitioners in the areas of fractional order control systems and fractional order chaotic systems **Fractional-order Systems and Controls** Concepción A. Monje,YangQuan Chen,Blas M. Vinagre,Dingyu Xue,Vicente Feliu-Batlle,2010-09-28 Fractional order Systems and Controls details the use of fractional calculus in the description and modeling of systems and in a range of control design and practical applications It is largely self contained covering the fundamentals of fractional calculus together with some analytical and numerical techniques and providing MATLAB codes for the simulation of fractional order control FOC systems Many different FOC schemes are presented for control and dynamic systems problems Practical material relating to a wide variety of applications is also provided All the control schemes and applications are presented in the monograph with either system simulation results or real experimental results or both Fractional order Systems and Controls provides readers with a basic understanding of FOC concepts and methods so they can extend their use of FOC in other industrial system applications thereby expanding their range of disciplines by exploiting this versatile new set of control techniques Mathematical Techniques of Fractional Order Systems Ahmad Taher Azar,Ahmed G. Radwan,Sundarapandian Vaidyanathan,2018-06-11 Mathematical Techniques of Fractional Order Systems illustrates advances in linear and nonlinear fractional order systems relating to many interdisciplinary applications including biomedical control circuits electromagnetics and security The book covers the mathematical background and literature survey of fractional order calculus and generalized fractional order circuit theorems from different perspectives in design analysis and realizations nonlinear fractional order circuits and systems the fractional order memristive circuits and systems in design analysis emulators simulation and experimental results It is primarily meant for researchers from academia and industry and for those working in areas such as control engineering electrical engineering computer science and information technology This book is ideal for researchers working in the area of both continuous time and discrete time dynamics and chaotic systems Discusses multidisciplinary applications with new fundamentals modeling analysis design realization and experimental results Includes circuits and systems based on new nonlinear elements Covers most of the linear and nonlinear fractional order theorems that will solve many scientific issues for researchers Closes the gap between theoretical approaches and real world applications Provides MATLAB and Simulink code for many applications in the book *Fractional-Order Singular Systems* Qing-Hao Zhang,Jun-Guo Lu,YangQuan Chen,2025-03-03 This book explores robust control strategies to manage the inherent uncertainties and maintain the admissibility and performance of fractional order singular systems It covers essential topics such as system admissibility robust stabilization H control positive real control fault detection delay systems and provides a comprehensive framework for both the theoretical analysis and practical implementation of robust control methods **Fractional-Order Control**

Systems Dingyü Xue,2017-07-10 This book explains the essentials of fractional calculus and demonstrates its application in control system modeling analysis and design It presents original research to find high precision solutions to fractional order differentiations and differential equations Numerical algorithms and their implementations are proposed to analyze multivariable fractional order control systems Through high quality MATLAB programs it provides engineers and applied mathematicians with theoretical and numerical tools to design control systems Contents Introduction to fractional calculus and fractional order control Mathematical prerequisites Definitions and computation algorithms of fractional order derivatives and Integrals Solutions of linear fractional order differential equations Approximation of fractional order operators Modelling and analysis of multivariable fractional order transfer function Matrices State space modelling and analysis of linear fractional order Systems Numerical solutions of nonlinear fractional order differential Equations Design of fractional order PID controllers Frequency domain controller design for multivariable fractional order Systems Inverse Laplace transforms involving fractional and irrational Operations FOTF Toolbox functions and models Benchmark problems for the assessment of fractional order differential equation algorithms *Fractional Order Systems-Control Theory and Applications* Omar Naifar,Abdellatif Ben Makhlouf,2022 This book aims to bring together the latest innovative knowledge analysis and synthesis of fractional control problems of nonlinear systems as well as some related applications Fractional order systems FOS are dynamical systems that can be modelled by a fractional differential equation carried with a non integer derivative In the last few decades the growth of science and engineering systems has considerably stimulated the employment of fractional calculus in many subjects of control theory for example in stability stabilization controllability observability observer design and fault estimation The application of control theory in FOS is an important issue in many engineering applications So to accurately describe these systems the fractional order differential equations have been introduced **Sliding Mode Control of Fractional-order Systems** Hamid Reza Karimi,Xin Meng,Baoping Jiang,2025-05-01 In the fields of dynamical systems and control theory a fractional order system is a dynamical system that can be modeled by a fractional differential equation containing derivatives of non integer order In control systems sliding mode control SMC is a nonlinear control method that alters the dynamics of a nonlinear system by applying a discontinuous control signal or more rigorously a set valued control signal that forces the system to slide along a cross section of the system s normal behavior Sliding Mode Control of Fractional order Systems discusses the design of several types of fractional order systems Sliding mode control strategy allows the exploration of the problems of projection synchronization control finite time stability asymptotic stability and formation control of fractional order systems which make up the shortages in the analysis and design of fractional order systems The book focuses on several types of fractional order control systems combined with the sliding mode control SMC and event triggered control the problems of projection synchronization control finite time stability asymptotic stability and formation control for those systems are explored which makes up the shortages in the

analysis and design of fractional order systems Provides a comprehensive and clear explanation of recent developments in sliding mode control of fractional order systems Unifies existing and emerging concepts concerning sliding mode control of fractional order systems Provides a series of the latest results in including but not limited to projective synchronization control exponential consensus control formation control and fractional order event triggered control

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