

Discrete Fractional Calculus Applications In Control And Image Processing Series In Computer Vision

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Theoretical Developments and Applications of Non-Integer Order Systems - Stefan Domek 2015-08-20

This volume is devoted to presentation of new results of research on systems of non-integer order, called also fractional systems. Their analysis and practical implementation have been the object of spontaneous development for a few last decades. The fractional order models can depict a physical plant better than the classical integer order ones. This covers different research fields such as insulator properties, visco-elastic materials, electrodynamic, electrothermal, electrochemical, economic processes modelling etc. On the other hand fractional controllers often outperform their integer order counterparts. This volume contains new ideas and examples of implementation, theoretical and pure practical aspects of using a non-integer order calculus. It is divided into four parts covering: mathematical fundamentals, modeling and approximations, controllability, observability and stability problems and practical applications of fractional control systems. The first part expands the base of tools and methods of the mathematical basis for non-integer order calculus. Part two focuses on new methods and developments in process modeling and fractional derivatives approximations. In the third part a bunch of papers which raise problems of controllability, observability and stability of non-integer order systems is provided. Part four is devoted to presentation of different fractional order control applications. This book was created thanks to many experts in the field of fractional calculus: authors, anonymous referees whose comments allowed us to improve the final form of the papers and active and inspiring discussion of the participants of RRNR'2015, the 7th Conference on Non-Integer Order Calculus and Its Applications that was organized by the Faculty of Electrical Engineering, West Pomeranian University of Technology, Szczecin, Poland.

Fractional Order Systems - Riccardo Caponetto 2010

This book aims to propose implementations and applications of Fractional Order Systems (FOS). It is well known that FOS can be applied in control applications and systems modeling, and their effectiveness has been proven in many theoretical works and simulation routines. A further and mandatory step for FOS real world utilization is their hardware implementation and applications on real systems modeling. With this viewpoint, introductory chapters on FOS are included, on the definition of stability region of Fractional Order PID Controller and Chaotic FOS, followed by the practical implementation based on Microcontroller, Field Programmable Gate Array, Field Programmable Analog Array and Switched Capacitor. Another section is dedicated to FO modeling of Ionic Polymeric Metal Composite

(IPMC). This new material may have applications in robotics, aerospace and biomedicine.

Advances in Modelling and Control of Non-integer-Order Systems - Krzysztof J. Latawiec 2014-08-16

This volume presents selected aspects of non-integer, or fractional order systems, whose analysis, synthesis and applications have increasingly become a real challenge for various research communities, ranging from science to engineering. The spectrum of applications of the fractional order calculus has incredibly expanded, in fact it would be hard to find a science/engineering-related subject area where the fractional calculus had not been incorporated. The content of the fractional calculus is ranged from pure mathematics to engineering implementations and so is the content of this volume. The volume is subdivided into six parts, reflecting particular aspects of the fractional order calculus. The first part contains a single invited paper on a new formulation of fractional-order descriptor observers for fractional-order descriptor continuous LTI systems. The second part provides new elements to the mathematical theory of fractional-order systems. In the third part of this volume, a bunch of new results in approximation, modeling and simulations of fractional-order systems is given. The fourth part presents new solutions to some problems in controllability and control of non-integer order systems, in particular fractional PID-like control. The fifth part analyzes the stability of non-integer order systems and some new results are offered in this important respect, in particular for discrete-time systems. The final, sixth part of this volume presents a spectrum of applications of the noninteger order calculus, ranging from bi-fractional filtering, in particular of electromyographic signals, through the thermal diffusion and advection diffusion processes to the SIEMENS platform implementation. This volume's papers were all subjected to stimulating comments and discussions from the active audience of the RRNR'2014, the 6th Conference on Non-integer Order Calculus and Its Applications that was organized by the Department of Electrical, Control and Computer Engineering, Opole University of Technology, Opole, Poland.

Fractional Calculus in Medical and Health Science - Devendra Kumar 2020-07-09

This book covers applications of fractional calculus used for medical and health science. It offers a collection of research articles built into chapters on classical and modern dynamical systems formulated by fractional differential equations describing human diseases and how to control them. The mathematical results included in the book will be helpful to mathematicians and doctors by enabling them to explain real-life problems accurately. The book will also offer

case studies of real-life situations with an emphasis on describing the mathematical results and showing how to apply the results to medical and health science, and at the same time highlighting modeling strategies. The book will be useful to graduate level students, educators and researchers interested in mathematics and medical science.

Advanced, Contemporary Control - Andrzej Bartoszewicz 2020-06-24

This book presents the proceedings of the 20th Polish Control Conference. A triennial event that was first held in 1958, the conference successfully combines its long tradition with a modern approach to shed light on problems in control engineering, automation, robotics and a wide range of applications in these disciplines. The book presents new theoretical results concerning the steering of dynamical systems, as well as industrial case studies and worked solutions to real-world problems in contemporary engineering. It particularly focuses on the modelling, identification, analysis and design of automation systems; however, it also addresses the evaluation of their performance, efficiency and reliability. Other topics include fault-tolerant control in robotics, automated manufacturing, mechatronics and industrial systems. Moreover, it discusses data processing and transfer issues, covering a variety of methodologies, including model predictive, robust and adaptive techniques, as well as algebraic and geometric methods, and fractional order calculus approaches. The book also examines essential application areas, such as transportation and autonomous intelligent vehicle systems, robotic arms, mobile manipulators, cyber-physical systems, electric drives and both surface and underwater marine vessels. Lastly, it explores biological and medical applications of the control-theory-inspired methods.

Positive Systems - Filippo Cacace 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.

Basic Theory - Anatoly Kochubei 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.

Selected Problems of Fractional Systems Theory - Tadeusz Kaczorek 2011-05-10

This monograph covers some selected problems of positive fractional 1D and 2D linear systems. It is an extended and modified English version of its preceding Polish edition published by Technical University of Bialystok in 2009. This book is based on the lectures delivered by the author to the Ph.D. students of the Faculty of Electrical Engineering of Bialystok University of Technology and of

Warsaw University of Technology and on invited lectures in several foreign universities in the last three years.

Fractional Calculus - Praveen Agarwal 2019-11-23

This book collects papers presented at the International Conference on Fractional Differentiation and its Applications (ICFDA), held at the University of Jordan, Amman, Jordan, on 16–18 July 2018. Organized into 13 chapters, the book discusses the latest trends in various fields of theoretical and applied fractional calculus. Besides an essential mathematical interest, its overall goal is a general improvement of the physical world models for the purpose of computer simulation, analysis, design and control in practical applications. It showcases the development of fractional calculus as an acceptable tool for a large number of diverse scientific communities due to more adequate modeling in various fields of mechanics, electricity, chemistry, biology, medicine, economics, control theory, as well as signal and image processing. The book will be a valuable resource for graduate students and researchers of mathematics and engineering.

Descriptor Systems of Integer and Fractional Orders - Tadeusz Kaczorek 2021-04-13

This book covers some selected problems of the descriptor integer and fractional order positive continuous-time and discrete-time systems. The book consists of 3 chapters, 4 appendices and the list of references. Chapter 1 is devoted to descriptor integer order continuous-time and discrete-time linear systems. In Chapter 2, descriptor fractional order continuous-time and discrete-time linear systems are considered. Chapter 3 is devoted to the stability of descriptor continuous-time and discrete-time systems of integer and fractional orders. In Appendix A, extensions of the Cayley–Hamilton theorem for descriptor linear systems are given. Some methods for computation of the Drazin inverse are presented in Appendix B. In Appendix C, some basic definitions and theorems on Laplace transforms and Z-transforms are given. Some properties of the nilpotent matrices are given in Appendix D.

Automation 2021: Recent Achievements in Automation, Robotics and Measurement Techniques - Roman Szewczyk 2021-04-29

This book contains 38 papers authored by both scientists and practitioners focused on an interdisciplinary approach to the development of cyber-physical systems. Recently our civilization has been facing one of the most severe challenges in modern history. The COVID-19 pandemic devastated the global economy and significantly disrupted numerous areas of economic activity. Only radical increase of efficiency and versatility of industrial production, with further limitation of human involvement, paralleled by the decrease of environmental burden, will enable us to cope with such challenges. We hope that the presented book provides input to the solution of at least some problems brought about by this challenge. This approach relies on the development of measuring techniques, robotic and mechatronic systems, industrial automation, numerical modeling and simulation as well as application of artificial intelligence techniques required by the transformation leading to Industry 4.0.

Stabilization and Control of Fractional Order Systems: A Sliding Mode Approach - Bijan Bandyopadhyay 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.

Fractional Order Systems - Ahmed G. Radwan 2021-10-13

Fractional Order Systems: An Overview of Mathematics, Design, and Applications for Engineers introduces applications from a design perspective, helping readers plan and design their own applications. The book includes the different techniques employed to design fractional-order systems/devices comprehensively and straightforwardly. Furthermore, mathematics is available in the literature on how to solve fractional-order calculus for system applications. This book introduces the mathematics that has been employed explicitly for fractional-order systems. It will prove an excellent material for students and scholars who want to quickly understand the field of fractional-order systems and contribute to its different domains and applications. Fractional-order systems are believed to play an essential role in our day-to-day activities. Therefore, several researchers around the globe endeavor to work in the different domains of fractional-order systems. The efforts include developing the mathematics to solve fractional-order calculus/systems and to achieve the feasible designs for various applications of fractional-order systems. Presents a simple and comprehensive understanding of the field of fractional-order systems Offers practical knowledge on the design of fractional-order systems for different applications Exposes users to possible new applications for fractional-order systems

Automation 2020: Towards Industry of the Future - Roman Szewczyk 2020-02-27

This book presents the scientific outcomes of the International Conference AUTOMATION 2020, held on March 18–20, 2020 in Warsaw, Poland. The next 30 years will see radical innovations in production processes, transportation management and social life. The changes brought about by the transformation to zero-emission industry require advances in many fields, but especially in industrial automation, robotics and measurement techniques associated with the cyber-physical systems employing artificial intelligence that will be key to reducing costs and enabling European society to maintain its quality of live. In this context, the book features the latest research toward further developing these fields of engineering, and also offers solutions and guidelines that are useful for both researchers and engineers addressing problems associated with the world of ongoing radical changes.

Automatic Control, Robotics, and Information Processing - Piotr Kulczycki 2020-09-03

This book presents a wide and comprehensive range of issues and problems in various fields of science and engineering, from both theoretical and applied perspectives. The desire to develop more effective and efficient tools and techniques for dealing with complex processes and systems has been a natural inspiration for the emergence of numerous fields of science and technology, in particular control and automation and, more recently, robotics. The contributions gathered here concern the development of methods and algorithms to determine best practices regarding broadly perceived decisions or controls. From an engineering

standpoint, many of them focus on how to automate a specific process or complex system. From a tools-based perspective, several contributions address the development of analytic and algorithmic methods and techniques, devices and systems that make it possible to develop and subsequently implement the automation and robotization of crucial areas of human activity. All topics discussed are illustrated with sample applications.

Artificial Intelligence and Soft Computing - Leszek Rutkowski 2017-06-01

The two-volume set LNAI 10245 and LNAI 10246 constitutes the refereed proceedings of the 16th International Conference on Artificial Intelligence and Soft Computing, ICAISC 2017, held in Zakopane, Poland in June 2017. The 133 revised full papers presented were carefully reviewed and selected from 274 submissions. The papers included in the first volume are organized in the following five parts: neural networks and their applications; fuzzy systems and their applications; evolutionary algorithms and their applications; computer vision, image and speech analysis; and bioinformatics, biometrics and medical applications.

Fractional Calculus in Analysis, Dynamics, and Optimal Control - Jacky Cresson 2014-01-01

This book is devoted to applications of fractional calculus in classical fields of mathematics like analysis, dynamics, partial differential equations and optimal control. The first chapter deals with the notion of local fractional derivatives and its applications to the study of regularity and geometry of curves. The second chapter develops the notion of fractional embedding and fractional asymmetric calculus of variations in order to find fractional Lagrangian variational structures for classical dissipative partial differential equations. In continuation of this chapter, a fractional analogue of the classical Pontryagin maximum principle is proved for discrete and continuous fractional optimal control problems. The fourth chapter gives a first mathematical model that allows a rigorous connection to be made between the dynamics of chaotic Hamiltonian systems and fractional dynamics, mixing the previous approaches of G Zaslavsky and R Hilfer. Finally, numerical methods to deal with fractional optimal control problems are discussed and implemented. All the chapters are self-contained and complete proofs are given.

Theory and Applications of Non-integer Order Systems - Artur Babiarz 2016-09-15

This book collects papers from the 8th Conference on Non-Integer Order Calculus and Its Applications that have been held on September 20-21, 2016 in Zakopane, Poland. The preceding two conferences were held in Szczecin, Poland in 2015, and in Opole, Poland, in 2014. This conference provides a platform for academic exchange on the theory and application of fractional calculus between domestic and international universities, research institutes, corporate experts and scholars. The Proceedings of the 8th Conference on Non-Integer Order Calculus and Its Applications 2016 brings together rigorously reviewed contributions from leading international experts. The included papers cover novel various important aspects of mathematical foundations of fractional calculus, modeling and control of fractional systems as well as controllability, detectability, observability and stability problems for this systems.

Automation 2017 - Roman Szewczyk 2017-02-28

This book consists of papers presented at Automation 2017, an international conference held in Warsaw from March 15 to 17, 2017. It discusses research findings associated with the concepts behind INDUSTRY 4.0, with a focus on offering a better understanding of and promoting participation in the Fourth Industrial Revolution. Each chapter presents a detailed analysis of a specific

technical problem, in most cases followed by a numerical analysis, simulation and description of the results of implementing the solution in a real-world context. The theoretical results, practical solutions and guidelines presented are valuable for both researchers working in the area of engineering sciences and practitioners looking for solutions to industrial problems.

New Trends in Nonlinear Dynamics - Walter Lacarbonara 2020-01-27

This third of three volumes from the inaugural NODYCON, held at the University of Rome, in February of 2019, presents papers devoted to New Trends in Nonlinear Dynamics. The collection features both well-established streams of research as well as novel areas and emerging fields of investigation. Topics in Volume III include NEMS/MEMS and nanomaterials: multi-sensors, actuators exploiting nonlinear working principles; adaptive, multifunctional, and meta material structures; nanocomposite structures (e.g., carbon nanotube/polymer composites, composites with functionalized nanoparticles); 0D,1D,2D,3D nanostructures; biomechanics applications, DNA modeling, walking dynamics, heart dynamics, neurodynamics, capsule robots, jellyfish-like robots, nanorobots; cryptography based on chaotic maps; ecosystem dynamics, social media dynamics (user behavior dynamics in multi-messages social hotspots, prediction models), financial engineering, complexity in engineering; and network dynamics (multi-agent systems, leader-follower dynamics, swarm dynamics, biological networks dynamics).

Advances in the Theory and Applications of Non-integer Order Systems - Wojciech Mitkowski 2013-06-03

This volume presents various aspects of non-integer order systems, also known as fractional systems, which have recently attracted an increasing attention in the scientific community of systems science, applied mathematics, control theory. Non-integer systems have become relevant for many fields of science and technology exemplified by the modeling of signal transmission, electric noise, dielectric polarization, heat transfer, electrochemical reactions, thermal processes, acoustics, etc. The content is divided into six parts, every of which considers one of the currently relevant problems. In the first part the Realization problem is discussed, with a special focus on positive systems. The second part considers stability of certain classes of non-integer order systems with and without delays. The third part is focused on such important aspects as controllability, observability and optimization especially in discrete time. The fourth part is focused on distributed systems where non-integer calculus leads to new and interesting results. The next part considers problems of solutions and approximations of non-integer order equations and systems. The final and most extensive part is devoted to applications. Problems from mechatronics, biomedical engineering, robotics and others are all analyzed and solved with tools from fractional systems. This volume came to fruition thanks to high level of talks and interesting discussions at RRNR 2013 - 5th Conference on Non-integer Order Calculus and its Applications that took place at AGH University of Science and Technology in Kraków, Poland, which was organized by the Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering.

Fractional Signals and Systems - Manuel Duarte Ortigueira 2020-03-09

The book illustrates the theoretical results of fractional derivatives via applications in signals and systems, covering continuous and discrete derivatives, and the corresponding linear systems. Both time and frequency analysis are presented. Some advanced topics are included like derivatives of stochastic processes. It is an essential reference for researchers in mathematics, physics, and engineering.

Fractional Modeling and Controller Design of Robotic Manipulators - Abhaya Pal Singh 2020-10-15

This book at hand is an appropriate addition to the field of fractional calculus applied to control systems. If an engineer or a researcher wishes to delve into fractional-order systems, then this book has many collections of such systems to work upon, and this book also tells the reader about how one can convert an integer-order system into an appropriate fractional-order one through an efficient and simple algorithm. If the reader further wants to explore the controller design for the fractional-order systems, then for them, this book provides a variety of controller design strategies. The use of fractional-order derivatives and integrals in control theory leads to better results than integer-order approaches and hence provides solid motivation for further development of control theory. Fractional-order models are more useful than the integer-order models when accuracy is of paramount importance. Real-time experimental validation of controller design strategies for the fractional-order plants is available. This book is beneficial to the academic institutes for postgraduate and advanced research-level that need a specific textbook on fractional control and its applications in robotic manipulators. The book is also a valuable teaching and learning resource for undergraduate and postgraduate students.

Applications in Control - Ivo Petráš 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 sixth volume collects authoritative chapters covering several applications of fractional calculus in control theory, including fractional controllers, design methods and toolboxes, and a large number of engineering applications of control.

Mathematical Economics - Vasily E. Tarasov 2020-06-03

This book is devoted to the application of fractional calculus in economics to describe processes with memory and non-locality. Fractional calculus is a branch of mathematics that studies the properties of differential and integral operators that are characterized by real or complex orders. Fractional calculus methods are powerful tools for describing the processes and systems with memory and nonlocality. Recently, fractional integro-differential equations have been used to describe a wide class of economical processes with power law memory and spatial nonlocality. Generalizations of basic economic concepts and notions the economic processes with memory were proposed. New mathematical models with continuous time are proposed to describe economic dynamics with long memory. This book is a collection of articles reflecting the latest mathematical and conceptual developments in mathematical economics with memory and non-locality based on applications of fractional calculus.

Fractional Discrete Chaos: Theories, Methods and Applications - Adel Ouannas 2023-03-27

In the nineteenth-century, fractional calculus had its origin in extending differentiation and integration operators from the integer-order case to the fractional-order case. Discrete fractional calculus has recently become an important research topic, useful in various science and engineering applications. The first definition of the fractional-order discrete-time/difference operator was introduced in 1974 by Diaz and Osler, where such operator was derived by discretizing the fractional-order continuous-time operator. Successfully, several types of fractional-order difference operators have then been proposed and introduced through further generalizing numerous classical operators, motivating several researchers to publish extensively on a new class of systems, viz the

nonlinear fractional-order discrete-time systems (or simply, the fractional-order maps), and their chaotic behaviors. This discovery of chaos in such maps, has led to novel control methods for effectively stabilizing their chaotic dynamics. The aims of this book are as follows:

Fractional Order Systems and Applications in Engineering - Dumitru Baleanu 2022-12-01

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

Automation 2018 - Roman Szewczyk 2018-03-07

This book consists of papers presented at Automation 2018, an international conference held in Warsaw from March 21 to 23, 2018. It discusses the radical technological changes occurring due to the INDUSTRY 4.0, with a focus on offering a better understanding of the Fourth Industrial Revolution. Each chapter presents a detailed analysis of interdisciplinary knowledge, numerical modeling and simulation as well as the application of cyber-physical systems, where information technology and physical devices create synergic systems leading to unprecedented efficiency. The theoretical results, practical solutions and guidelines presented are valuable for both researchers working in the area of engineering sciences and practitioners looking for solutions to industrial problems.

Automation 2022 - Roman Szewczyk 2022

This book presents the unique result of discussion among interdisciplinary specialists facing recent industrial and economic challenges. It contains papers authored by both scientists and practitioners focused on an interdisciplinary approach to developing measuring techniques, robotic and mechatronic systems, industrial automation, numerical modelling and simulation, and application of artificial intelligence techniques required by the transformation leading to Industry 4.0. We strongly believe that the solutions and guidelines presented in this book will be useful to both researchers and engineers facing problems

associated with developing cyber-physical systems for global development. *New Trends in Nanotechnology and Fractional Calculus Applications* - Dumitru Baleanu 2010-03-14

In recent years fractional calculus has played an important role in various fields such as mechanics, electricity, chemistry, biology, economics, modeling, identification, control theory and signal processing. The scope of this book is to present the state of the art in the study of fractional systems and the application of fractional differentiation. Furthermore, the manufacture of nanowires is important for the design of nanosensors and the development of high-yield thin films is vital in procuring clean solar energy. This wide range of applications is of interest to engineers, physicists and mathematicians.

Automation 2019 - Roman Szewczyk 2019-02-15

This book consists of papers presented at AUTOMATION2019, an international conference held in Warsaw from March 27 to 29, 2019. It discusses the radical technological changes occurring due to the INDUSTRY 4.0. To follow these changes, both scientists and engineers have to face the challenge of interdisciplinary approach directed at the development of cyber-physical systems. This approach encompasses interdisciplinary theoretical knowledge, numerical modelling and simulation as well as application of artificial intelligence techniques. Both software and physical devices are composed into systems that will increase production efficiency and resource savings. The theoretical results, practical solutions and guidelines presented are valuable for both researchers working in the area of engineering sciences and practitioners looking for solutions to industrial problems.

Fractal Control and Its Applications - Shu Tang Liu 2020-07-11

The book focuses on fractal control and applications in various fields. Fractal phenomena occur in nonlinear models, and since the behaviors depicted by fractals need to be controlled in practical applications, an understanding of fractal control is necessary. This book introduces readers to Julia set fractals and Mandelbrot set fractals in a range of models, such as physical systems, biological systems and SIRS models, and discusses controllers designed to control these fractals. Further, it demonstrates how the fractal dimension can be calculated in order to describe the complexity of various systems. Offering a comprehensive and systematic overview of the practical issues in fractal control, this book is a valuable resource for readers interested in practical solutions in fractal control. It will also appeal to researchers, engineers, and graduate students in fields of fractal control and applications, as well as chaos control and applications.

Discrete Fractional Calculus - Piotr Ostalczyk 2015-11-26

The main subject of the monograph is the fractional calculus in the discrete version. The volume is divided into three main parts. Part one contains a theoretical introduction to the classical and fractional-order discrete calculus where the fundamental role is played by the backward difference and sum. In the second part, selected applications of the discrete fractional calculus in the discrete system control theory are presented. In the discrete system identification, analysis and synthesis, one can consider integer or fractional models based on the fractional-order difference equations. The third part of the book is devoted to digital image processing. Contents: Discrete-Variable Real Functions The n-th Order Backward Difference/Sum of the Discrete-Variable Function Fractional-Order Backward Differ-Sum The F0BD-S Graphical Interpretation The F0BD/S Selected Properties The F0 Dynamic System Description Linear F0 System

AnalysisThe Linear FO Discrete-Time Fundamental ElementsFO Discrete-Time System StructuresFractional Discrete-Time PID ControllerFOS Approximation ProblemsFractional PotentialFO Image Filtering and Edge DetectionAppendix A: Selected Linear Algebra Formulae and Discrete-Variable Special Functions Readership: Researchers, academics, professionals and graduate students in pattern recognition/image analysis, robotics and automated systems, systems engineering and mathematical modeling. Keywords:Fractional Calculus;Fractional-Order Backward-Difference;Fractional-Order Linear Difference Equation;Discrete-System;State-Space Equations

Advanced Mathematical Methods - Francesco Mainardi 2020-02-05

The many technical and computational problems that appear to be constantly emerging in various branches of physics and engineering beg for a more detailed understanding of the fundamental mathematics that serves as the cornerstone of our way of understanding natural phenomena. The purpose of this Special Issue was to establish a brief collection of carefully selected articles authored by promising young scientists and the world's leading experts in pure and applied mathematics, highlighting the state-of-the-art of the various research lines focusing on the study of analytical and numerical mathematical methods for pure and applied sciences.

Boundary Value Problems for Second-Order Finite Difference Equations and Systems - Johnny Henderson 2023-01-30

This is an indispensable reference for those mathematicians that conduct research activity in applications of fixed-point theory to boundary value problems for nonlinear functional equations. Coverage includes second-order finite difference equations and systems of difference equations subject to multi-point boundary conditions, various methods to study the existence of positive solutions for difference equations, and Green functions.

Applications in Control - Ivo Petráš 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 sixth volume collects authoritative chapters covering several applications of fractional calculus in control theory, including fractional controllers, design methods and toolboxes, and a large number of engineering applications of control.

Discrete Fractional Calculus - Christopher Goodrich 2016-02-09

This text provides the first comprehensive treatment of the discrete fractional calculus. Experienced researchers will find the text useful as a reference for discrete fractional calculus and topics of current interest. Students who are interested in learning about discrete fractional calculus will find this text to provide a useful starting point. Several exercises are offered at the end of each chapter and select answers have been provided at the end of the book. The presentation of the content is designed to give ample flexibility for potential use in a myriad of courses and for independent study. The novel approach taken by the authors includes a simultaneous treatment of the fractional- and integer-order difference calculus (on a variety of time scales, including both the usual forward and backwards difference operators). The reader will acquire a solid foundation in the classical topics of the discrete calculus while being introduced to exciting recent developments, bringing them to the frontiers of the subject. Most chapters may be covered or omitted, depending upon the background of the student. For example, the text may be used as a primary reference in an introductory course for difference equations which also includes discrete fractional calculus. Chapters 1–2 provide a basic introduction to the delta calculus including fractional

calculus on the set of integers. For courses where students already have background in elementary real analysis, Chapters 1–2 may be covered quickly and readers may then skip to Chapters 6–7 which present some basic results in fractional boundary value problems (FBVPs). Chapters 6–7 in conjunction with some of the current literature listed in the Bibliography can provide a basis for a seminar in the current theory of FBVPs. For a two-semester course, Chapters 1–5 may be covered in depth, providing a very thorough introduction to both the discrete fractional calculus as well as the integer-order calculus.

Advances in Non-Integer Order Calculus and Its Applications - Agnieszka B. Malinowska 2019-04-17

This book provides an overview of some recent findings in the theory and applications of non-integer order systems. Discussing topics ranging from the mathematical foundations to technical applications of continuous-time and discrete-time fractional calculus, it includes 22 original research papers and is subdivided into four parts: • Mathematical Foundations • Approximation, Modeling and Simulations • Fractional Systems Analysis and Control • Applications The papers were selected from those presented at the 10th International Conference of Non-integer Order Calculus and its Applications, which was held at the Bialystok University of Technology, Poland, September 20–21, 2018. Thanks to the broad spectrum of topics covered, the book is suitable for researchers from applied mathematics and engineering. It is also a valuable resource for graduate students, as well as for scholars looking for new mathematical tools.

Fractional Dynamical Systems - Piotr Kulczycki 2022

This book presents a wide and comprehensive spectrum of issues and problems related to fractional-order dynamical systems. It is meant to be a full-fledge, comprehensive presentation of many aspects related to the broadly perceived fractional-order dynamical systems which constitute an extension of the traditional integer-order-type descriptions. This implies far-reaching consequences, both analytic and algorithmic, because--in general--properties of the traditional integer-order systems cannot be directly extended by a straightforward generalization to fractional-order systems, modeled by fractional-order differential equations involving derivatives of a non-integer order. This can be useful for describing and analyzing, for instance, anomalies in the behavior of various systems, chaotic behavior, etc. The book contains both analytic contributions with state-of-the-art and theoretical foundations, algorithmic implementation of tools and techniques, and--finally--some examples of relevant and successful practical applications.

Non-Integer Order Calculus and its Applications - Piotr Ostalczyk 2018-03-22

This book focuses on fractional calculus, presenting novel advances in both the theory and applications of non-integer order systems. At the end of the twentieth century it was predicted that it would be the calculus of the twenty-first century, and that prophecy is confirmed year after year. Now this mathematical tool is successfully used in a variety of research areas, like engineering (e.g. electrical, mechanical, chemical), dynamical systems modeling, analysis and synthesis (e.g. technical, biological, economical) as well as in multidisciplinary areas (e.g. biochemistry, electrochemistry).As well as the mathematical foundations the book concentrates on the technical applications of continuous-time and discrete-time fractional calculus, investigating the identification, analysis and control of electrical circuits and dynamical systems. It also presents the latest results.Although some scientific centers and scientists are skeptical and actively criticize the applicability of fractional calculus, it is worth breaking

through the scientific and technological walls. Because the “fractional community” is growing rapidly there is a pressing need for the exchange of scientific results. The book includes papers presented at the 9th International Conference on Non-integer Order Calculus and Its Applications and is divided into three parts:

• Mathematical foundations
• Fractional systems analysis and synthesis
• System modeling
Seven papers discuss the mathematical foundations, twelve papers address fractional order analysis and synthesis and three focus on dynamical system modeling by the fractional order differential and difference equations. It is a useful resource for fractional calculus scientific community.