Fractional Processes And Fractional Order Signal Processing Techniques And Applications Signals And Communication Technology

This book gives a practical overview of Fractional Calculus as it relates to Signal Processing
The book focusses on applications of triangular orthogonal function in fractional calculus with numerical methods for solving fractional order integral equations, integro-differential equations, and fractional order algebraic equations. Devised numerical methods are used in solving problems in different areas of engineering and sciences.
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.
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 FunctionsThe n-th Order Backward Difference/Sum of the Discrete-Variable FunctionFractional-Order Backward Differ-SumThe FOBD-S Graphical

InterpretationThe FOBD/S Selected PropertiesThe FO Dynamic System DescriptionLinear FO 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

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, introductive 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.

This book addresses the topic of fractional-order modeling of nuclear reactors. Approaching neutron transport in the reactor core as anomalous diffusion, specifically subdiffusion, it starts with the development of fractional-order neutron telegraph equations. Using a systematic approach, the book then examines the development and analysis of various fractional-order models representing nuclear reactor dynamics, ultimately leading to the fractional-order linear and nonlinear control-oriented models. The book utilizes the mathematical tool of fractional calculus, the calculus of derivatives and integrals with arbitrary non-integer orders (real or complex), which has recently been found to provide a more compact and realistic representation to the dynamics of diverse physical systems. Including extensive simulation results and discussing important issues related to the fractional-order modeling of nuclear reactors, the book offers a valuable resource for students and researchers working in the areas of fractional-order modeling and control and nuclear reactor modeling.

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.

This book presents a concise and insightful view of the knowledge on fractional-order electrical circuits, which belongs to the subject of Electric Engineering and involves mathematics of fractional calculus. It offers an overview of fractional calculus and then describes and analyzes the basic theories and properties of fractional-order elements and fractional-order electrical circuit composed of fractional-order elements. Therein, the fundamental theorems, time-domain analysis, steady-state analysis, complex frequency domain analysis and state variable analysis of fractional-order electrical circuit are included. The fractional-order two-port networks and generalized fractional-order linear electrical circuits are also mentioned. Therefore, this book provides readers with enough background and understanding to go deeper into the topic of fractional-order electrical circuit, so that it is useful as a textbook for courses related to fractional-order elements, fractional-order electrical circuits, etc. This book is intended for students without an extensive mathematical background and is suitable for advanced undergraduate and graduate students, engineers and researchers who focus on the fractional-order elements, electrical circuits and systems.

The first derivative of a particle coordinate means its velocity, the second means its acceleration, but what does a fractional order derivative mean? Where does it come from, how does it work, where does it lead to? The two-volume book written on high didactic level answers these questions. Fractional Derivatives for Physicists and Engineers— The first volume contains a clear introduction into such a modern branch of analysis as the fractional calculus. The second develops a wide panorama of applications of the fractional calculus to various physical problems. This book recovers new perspectives in front of the reader dealing with turbulence and semiconductors, plasma and thermodynamics, mechanics and quantum optics, nanophysics and astrophysics. The book is addressed to students, engineers and physicists, specialists in theory of probability and statistics, in mathematical modeling and numerical simulations, to everybody who doesn't wish to stay apart from the new mathematical methods becoming more and more popular. Prof. Vladimir V. UCHAIKIN is a known Russian scientist and pedagogue, a Honored Worker of Russian High School, a member of the Russian Academy of Natural Sciences. He is the author of about three hundreds articles and more than a dozen books (mostly in Russian) in Cosmic ray physics, Mathematical physics, Levy stable statistics, Monte Carlo methods with applications to anomalous processes in complex systems of various levels: from quantum dots to the Milky Way galaxy. Fractional Processes and Fractional-Order Signal ProcessingTechniques and ApplicationsSpringer Science & Business Media

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.

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.

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.

This book presents a detailed study on fractional-order, set-point, weighted PID control strategies and the development of curve-fitting-based approximation techniques for fractional-order parameters. Furthermore, in all the cases, it includes the Scilab-based commands and functions for easy implementation and better understanding, and to appeal to a wide range of readers working with the software. The presented Scilab-based toolbox is the first toolbox for fractional-order systems developed in open-source software. The toolboxes allow time and frequency domains as well as stability analysis of the fractional-order systems and controllers. The book also provides real-time examples of the control of process plants using the developed fractional-order based PID control strategies and the approximation techniques. The book is of interest to readers in the areas of fractional-order controllers, approximation techniques, process modeling, control, and optimization, both in industry and academia. In industry, the book is particularly valuable in the areas of research and development (R&D) as well as areas where PID controllers suffice – and it should be noted that around 80% of low-level controllers in industry are PID based. The book is also useful where conventional PIDs are constrained, such as in industries where long-term delay and non-linearity are present. Here it can be used for the design of controllers for real-time processes. The book is also a valuable teaching and learning resource for undergraduate and postgraduate students.

When a new extraordinary and outstanding theory is stated, it has to face criticism and skeptism, because it is beyond the usual concept. The fractional calculus though not new, was not discussed or developed for a long time, particularly for lack of its application to real life problems. It is extraordinary because it does not deal with 'ordinary' differential calculus. It is outstanding because it can now be applied to situations where existing theories fail to give satisfactory results. In this book not only mathematical abstractions are discussed in a lucid manner, with physical mathematical and geometrical explanations, but also several practical applications are given particularly for system identification, description and then efficient controls. The normal physical laws like, transport theory, electrodynamics, equation of motions, elasticity, viscosity, and several others of are based on 'ordinary' calculus. In this book these physical laws are generalized in fractional calculus contexts; taking, heterogeneity effect in transport background, the space having traps or islands, irregular distribution of charges, non-ideal spring with mass connected to a pointless-mass ball, material behaving with viscous as well as elastic properties, system relaxation with and without memory, physics of random delay in computer network; and several others; mapping the reality of nature closely. The concept of fractional and complex order differentiation and integration are elaborated mathematically, physically and geometrically with examples. The practical utility of local fractional differentiation for enhancing the character of singularity at phase transition or characterizing the irregularity measure of response function is deliberated. Practical results of viscoelastic experiments, fractional order controls experiments, design of fractional controller and practical circuit synthesis for fractional order elements are elaborated in this book. The book also maps theory of classical integer order differential equations to fractional calculus contexts, and deals in details with conflicting and demanding initialization issues, required in classical techniques. The book presents a modern approach to solve the 'solvable' system of fractional and other differential equations, linear, non-linear; without perturbation or transformations, but by applying physical principle of action-and-opposite-reaction, giving 'approximately exact' series solutions. Historically, Sir Isaac Newton and Gottfried Wihelm Leibniz independently discovered calculus in the middle of the 17th century. In recognition to this remarkable discovery, J.von Neumann remarked, "...the calculus was the first achievement of modern mathematics and it is difficult to overestimate its importance. I think it defines more equivocally than anything else the inception of modern mathematical analysis which is logical development, still constitute the greatest technical advance in exact thinking." This XXI century has thus started to 'think-exactly' for advancement in science & technology by growing application of fractional calculus, and this century has started speaking the language which nature understands the best.

This book describes the design and realization of analog fractional-order circuits, which are suitable for on-chip implementation, capable of low-voltage operation and electronic adjustment of their characteristics. The authors provide a brief introduction to fractional-order calculus, followed by design issues for fractional-order circuits of various orders and types. The benefits of this approach are demonstrated with current-mode and voltage-mode filter designs. Electronically tunable emulators of fractional-order capacitors and inductors are presented, where the behavior of the corresponding chips fabricated using the AMS 0.35um CMOS process has been experimentally verified. Applications of fractional-order circuits are demonstrated, including a pre-processing stage suitable for the implementation of the Pan-Tompkins algorithm for detecting the QRS complexes of an electrocardiogram (ECG), a fully tunable implementation of the Cole-Cole model used for the modeling of biological tissues, and a simple, non-impedance based measuring technique for super-capacitors.

This book is about algebraic and differential methods, as well as fractional calculus, applied to diagnose and reject faults in nonlinear systems, which are of integer or fractional order. This represents an extension of a very important and widely studied problem in control theory, namely fault diagnosis and rejection (using differential algebraic approaches), to systems presenting fractional dynamics, i.e. systems whose dynamics are represented by derivatives and integrals of non-integer order. The authors offer a thorough overview devoted to fault diagnosis and fault-tolerant control applied to fractional-order and integer-order dynamical systems, and they introduce new methodologies for control and observation described by fractional and integer models, together with successful simulations and real-time applications. The basic concepts and tools of mathematics required to understand the methodologies proposed are all clearly introduced and explained. Consequently, the book is useful as supplementary reading in courses of applied mathematics and nonlinear control theory. This book is meant for engineers, mathematicians, physicists and, in general, to researchers and postgraduate students in diverse areas who have a minimum knowledge of calculus. It also contains advanced topics for researchers and professionals interested in the area of states and faults estimation.

This book will give readers the possibility of finding very important mathematical tools for working with fractional models and solving fractional differential equations, such as a generalization of Stirling numbers in the framework of fractional calculus and a set of efficient numerical methods. Moreover, we will introduce some applied topics, in particular fractional variational methods which are used in physics, engineering or economics. We will also discuss the relationship between semi-Markov continuous-time random walks and the space-time fractional diffusion equation, which generalizes the usual theory relating random walks to the diffusion equation. These methods can be applied in finance, to model tick-by-tick (log)-price fluctuations, in insurance theory, to study ruin, as well as in macroeconomics as prototypical growth models. All these topics are complementary to what is dealt with in existing books on fractional calculus and its applications. This book will keep in mind the trade-off between full mathematical rigor and the needs of readers coming from different applied areas of science and engineering. In particular, the numerical methods listed in the book are presented in a readily accessible way that immediately allows the readers to implement them on a computer in a programming language of their choice. The second edition of the book has been expanded and now includes a discussion of additional, newly developed numerical methods for fractional calculus and a chapter on the application of fractional calculus for modeling processes in the life sciences.

This book focuses on two specific areas related to fractional order systems – the realization of physical devices characterized by non-integer order impedance, usually called fractional-order elements (FOEs); and the characterization of vegetable tissues via electrical impedance spectroscopy (EIS) – and provides readers with new tools for designing new types of integrated circuits. The majority of the book addresses FOEs. The interest in these topics is related to the need to produce “analogue” electronic devices characterized by non-integer order impedance, and to the characterization of natural phenomena, which are systems with memory or aftereffects and for which the fractional-order calculus tool is the ideal choice for analysis. FOEs represent the building blocks for designing and realizing analogue integrated electronic circuits, which the authors believe hold the potential for a wealth of mass-market applications. The freedom to choose either an integer- or non-integer-order analogue integrator/derivator is a new one for electronic circuit designers. The book shows how specific non-integer-order impedance elements can be created using materials with specific structural properties. EIS measures the electrical impedance of a specimen across a given range of frequencies, producing a spectrum that represents the variation of the impedance versus frequency – a technique that has the advantage of avoiding aggressive examinations. Biological tissues are complex systems characterized by dynamic processes that occur at different lengths and time scales; this book proposes a model for vegetable tissues that describes the behavior of such materials by considering the interactions among various relaxing phenomena and memory effects.

The book tries to briefly introduce the diverse literatures in the field of fractional order signal processing which is becoming an emerging topic among an interdisciplinary community of researchers. This book is aimed at postgraduate and beginning level research scholars who would like to work in the field of Fractional Order Signal processing (FOSP). The readers should have preliminary knowledge about basic signal processing techniques. Prerequisite knowledge of fractional calculus is not essential and is exposited at relevant places in connection to the appropriate signal processing topics. Basic signal processing techniques like filtering, estimation, system identification, etc. in the light of fractional order calculus are presented along with relevant application areas. The readers can easily extend these concepts to varied disciplines like image or speech processing, pattern recognition, time series forecasting, financial data analysis and modeling, traffic modeling in communication channels, optics, biomedical signal processing, electrochemical applications and many more. Adequate references are provided in each category so that the researchers can delve deeper into each area and broaden their horizon of understanding. Available MATLAB tools to simulate FOSP theories are also introduced so that the readers can apply the theoretical concepts right-away and gain practical insight in the specific domain.

This book unites two fast-developing forms of control—vision-based control and fractional-order control—and applies them in mechatronic systems. Image-Based and Fractional-Order Control for Mechatronic Systems is presented in two parts covering the theory and applications of the subject matter. The theoretical material presents the concepts of visual servoing and image-based feature extraction for feedback loops and fractional-order control. It discusses a range of systems from the classic monocular camera to new RGB-D sensors. The applications part of the book first discusses practical issues with the implementation of fractional-order control, comparing them with more traditional integer-order PID systems. The authors then introduce real-life examples such as a manipulator robot and a Stewart platform and results generated from such systems. MATLAB® functions and source codes are included wherever relevant to help readers develop simulations based on the theoretical ideas and practical examples in the text. Suggestions for the use of other pertinent open-source software are also indicated with the places where such may be obtained. With its combination of theoretical ideas and practical examples, Image-Based and Fractional-Order Control for Mechatronic Systems will be of interest to academic researchers looking to develop the fields of vision-based and fractional-order control and to engineers who are looking for developments that will help them provide closer control of their plants than can be achieved with integer-order PID. Advances in Industrial Control reports and encourages the transfer of technology in control engineering. The rapid development of control technology has an impact on all areas of the control discipline. The series offers an opportunity for researchers to present an extended exposition of new work in all aspects of industrial control.

This book reports on an outstanding research devoted to modeling and control of dynamic systems using fractional-order calculus. It describes the development of model-based control design methods for systems described by fractional dynamic models. More than 300 years had passed since Newton and Leibniz developed a set of mathematical tools we now know as calculus. Ever since then the idea of non-integer derivatives and integrals, universally referred to as fractional calculus, has been of interest to many researchers. However, due to various issues, the usage of fractional-order models in real-life applications was limited. Advances in modern computer science made it possible to apply efficient numerical methods to the computation of fractional derivatives and integrals. This book describes novel methods developed by the author for fractional modeling and control, together with their successful application in real-world process control scenarios.

This book is a printed edition of the Special Issue "Special Functions: Fractional Calculus and the Pathway for Entropy Dedicated to Professor Dr. A.M. Mathai on the occasion of his 80th Birthday" that was published in Axioms

This book is focused on fractional order systems. Historically, fractional calculus has been recognized since the inception of regular calculus, with the first written reference dated in September 1695 in a letter from Leibniz to L’Hospital. Nowadays, fractional calculus has a wide area of applications in areas such as physics, chemistry, bioengineering, chaos theory, control systems engineering, and many others. In all those applications, we deal with fractional order systems in general. Moreover, fractional calculus plays an important role even in complex systems and therefore allows us to develop better descriptions of real-world phenomena. On that basis, fractional order systems are ubiquitous, as the whole real world around us is fractional. Due to this reason, it is urgent to consider almost all systems as fractional order systems. This Special Issue explores applications of such systems to control, synchronization, and various mathematical models, as for instance, MRI, long memory process, diffusion.

This monograph provides an accessible introduction to the regional analysis of fractional diffusion processes. It begins with background coverage of fractional calculus, functional analysis, distributed parameter systems and relevant basic control theory. New research problems are then defined in terms of their actuation and sensing policies within the regional analysis framework. The results presented provide insight into the control-theoretic analysis of fractional-order systems for use in real-life applications such as hard-disk drives, sleep stage identification and classification, and unmanned aerial vehicle control. The results can also be extended to complex fractional-order distributed-parameter systems and various open questions with potential for further investigation are discussed. For instance, the problem of fractional order distributed-parameter systems with mobile actuators/sensors, optimal parameter identification, optimal locations/trajectory of actuators/sensors and regional actuation/sensing configurations are of great interest. The book’s use of illustrations and consistent examples throughout helps readers to understand the significance of the proposed fractional models and methodologies and to enhance their comprehension. The applications treated in the book run the gamut from environmental science to national security. Academics and graduate students working with cyber-physical and distributed systems or interested in the applications of fractional calculus will find this book to be an instructive source of state-of-the-art results and inspiration for further research.

In this book, a novel approach using equations with derivatives of fractional orders is applied to describe anomalous transport and relaxation in disordered semiconductors, dielectrics and quantum dot systems. A relationship between the self-similarity of transport, the Levy stable limiting distributions and the kinetic equations with fractional derivatives is established. It is shown that unlike the well-known Scher-Montroll and Arkhipov-Rudenko models, which are in a sense alternatives to the normal transport model, fractional differential equations provide a unified mathematical framework for describing normal and dispersive transport. The fractional differential formalism allows the equations of bipolar transport to be written down and transport in distributed dispersion systems to be described.

Fractional Calculus and Fractional Processes with Applications to Financial Economics presents the theory and application of fractional calculus and fractional processes to financial data. Fractional calculus dates back to 1695 when Gottfried Wilhelm Leibniz first suggested the possibility of fractional derivatives. Research on fractional calculus started in full earnest in the second half of the twentieth century. The fractional paradigm applies not only to calculus, but also to stochastic processes, used in many applications in financial economics such as modelling volatility, interest rates, and modelling high-frequency data. The key features of fractional processes that make them interesting are long-range memory, path-dependence, non-Markovian properties, self-similarity, fractal paths, and anomalous diffusion behaviour. In this book, the authors discuss how fractional calculus and fractional processes are used in financial modelling and finance economic theory. It provides a practical guide that can be useful for students, researchers, and quantitative asset and risk managers interested in applying fractional calculus and fractional processes to asset pricing, financial time-series analysis, stochastic volatility modelling, and portfolio optimization. Provides the necessary background for the book's content as applied to financial economics Analyzes the application of fractional calculus and fractional processes from deterministic and stochastic perspectives

The book systematically presents the theories of pseudo-differential operators with symbols singular in dual variables, fractional order derivatives, distributed and variable order fractional derivatives, random walk approximants, and applications of these theories to various initial and multi-point boundary value problems for pseudo-differential equations. Fractional Fokker-Planck-Kolmogorov equations associated with a large class of stochastic processes are presented. A complex version of the theory of pseudo-differential operators with meromorphic symbols based on the recently introduced complex Fourier transform is developed and applied for initial and boundary value problems for systems of complex differential and pseudo-differential equations.

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.

This book provides a broad overview of the latest developments in fractional calculus and fractional differential equations (FDEs) with an aim to motivate the readers to venture into these areas. It also presents original research describing the fractional operators of variable order, fractional-order delay differential equations, chaos and related phenomena in detail. Selected results on the stability of solutions of nonlinear dynamical systems of the non-commensurate fractional order have also been included. Furthermore, artificial neural network and fractional differential equations are elaborated on; and new transform methods (for example, Sumudu methods) and how they can be employed to solve fractional partial differential equations are discussed. The book covers the latest research on a variety of topics, including: comparison of various numerical methods for solving FDEs, the Adomian decomposition method and its applications to fractional versions of the classical Poisson processes, variable-order fractional operators, fractional variational principles, fractional delay differential equations, fractional-order dynamical systems and stability analysis, inequalities and comparison theorems in FDEs, artificial neural network approximation for fractional operators, and new transform methods for solving partial FDEs. Given its scope and level of detail, the book will be an invaluable asset for researchers working in these areas.

This volume provides the latest developments in the field of fractional dynamics, which covers fractional (anomalous) transport phenomena, fractional statistical mechanics, fractional quantum mechanics and fractional quantum field theory. The contributors are selected based on their active and important contributions to their respective topics. This volume is the first of its kind that covers such a comprehensive range of topics in fractional dynamics. It will point out to advanced undergraduate and graduate students, and young researchers the possible directions of research in this subject. In addition to those who intend to work in this field and those already in the field, this volume will also be useful for researchers not directly involved in the field, but want to know the current status and trends of development in this subject. This latter group includes theoretical chemists, mathematical biologists and engineers.

Fractional processes are widely found in science, technology and engineering systems. In Fractional Processes and Fractional-order Signal Processing, some complex random signals, characterized by the presence of a heavy-tailed distribution or non-negligible dependence between distant observations (local and long memory), are introduced and examined from the ‘fractional’ perspective using simulation, fractional-order modeling and filtering and realization of fractional-order systems. These fractional-order signal processing (FOSP) techniques are based on fractional calculus, the fractional Fourier transform and fractional lower-order moments. Fractional Processes and Fractional-order Signal Processing: presents fractional processes of fixed, variable and distributed order studied as the output of fractional-order differential systems; introduces FOSP techniques and the fractional signals and fractional systems point of view; details real-world-application examples of FOSP techniques to demonstrate their utility; and provides important background material on Mittag–Leffler functions, the use of numerical inverse Laplace transform algorithms and supporting MATLAB® codes together with a helpful survey of relevant webpages. Readers will be able to use the techniques presented to re-examine their signals and signal-processing methods. This text offers an extended toolbox for complex signals from diverse fields in science and engineering. It will give academic researchers and practitioners a novel insight into the complex random signals characterized by fractional properties, and some powerful tools to analyze those signals.

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.

"Fractional-Order Nonlinear Systems: Modeling, Analysis and Simulation" presents a study of fractional-order chaotic systems accompanied by Matlab programs for simulating their state space trajectories, which are shown in the illustrations in the book. Description of the chaotic systems is clearly presented and their analysis and numerical solution are done in an easy-to-follow manner. Simulink models for the selected fractional-order systems are also presented. The readers will understand the fundamentals of the fractional calculus, how real dynamical systems can be described using fractional derivatives and fractional differential equations, how such equations can be solved, and how to simulate and explore chaotic systems of fractional order. The book addresses to mathematicians, physicists, engineers, and other scientists interested in chaos phenomena or in fractional-order systems. It can be used in courses on dynamical systems, control theory, and applied mathematics at graduate or postgraduate level. Ivo Petráš is an Associate Professor of automatic control and the Director of the Institute of Control and Informatization of Production Processes, Faculty of BERG, Technical University of Košice, Slovak Republic. His main research interests include control systems, industrial automation, and applied mathematics.

This book illustrates the application of fractional calculus in crowd dynamics via modeling and control groups of pedestrians. Decision-making processes, conservation laws of mass/momentum, and micro-macro models are employed to describe system dynamics while cooperative movements in micro scale, and fractional diffusion in macro scale are studied to control the group of pedestrians. Obtained work is included in the Intelligent Evacuation Systems that is used for modeling and to control crowds of pedestrians. With practical issues considered, this book is of interests to mathematicians, physicists, and engineers.

??? Topics in Fractional Differential Equations is devoted to the existence and uniqueness of solutions for various classes of Darboux problems for hyperbolic differential equations or inclusions involving the Caputo fractional derivative. ??Fractional calculus generalizes the integrals and derivatives to non-integer orders. During the last decade, fractional calculus was found to play a fundamental role in the modeling of a considerable number of phenomena; in particular the modeling of memory-dependent and complex media such as porous media. It has emerged as an important tool for the study of dynamical systems where classical methods reveal strong limitations. Some equations present delays which may be finite, infinite, or state-dependent. Others are subject to an impulsive effect. The above problems are studied using the fixed point approach, the method of upper and lower solution, and the Kuratowski measure of noncompactness.

This book is addressed to a wide audience of specialists such as mathematicians, engineers, biologists, and physicists. ?