



Series on Complexity, Nonlinearity and Chaos – Vol. 3

FRACTIONAL CALCULUS

Models and Numerical Methods

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Fractional Calculus Models And Numerical Methods Series On Complexity Nonlinearity And Chaos

Dumitru Baleanu, Jordan Hristov



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Fractional Calculus: Models And Numerical Methods (Second Edition) Juan J Trujillo, Enrico Scalas, Kai Diethelm, Dumitru Baleanu, 2016-09-15 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

Fractional Calculus Dumitru Baleanu, 2012 This title 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

Fractional Calculus: Models And Numerical Methods Dumitru Baleanu, Kai Diethelm, Enrico Scalas, Juan J Trujillo, 2012-01-27 The subject of fractional calculus and its applications that is convolution type pseudo differential operators including integrals and derivatives of any arbitrary real or complex order has gained considerable popularity and importance during the past three decades or so mainly due to its applications in diverse fields of science and engineering These operators have been used to model problems with anomalous dynamics however they also are an effective tool as filters and controllers and they can be applied to write complicated functions in terms of fractional integrals or derivatives of elementary functions and so on 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 was written with a trade off in mind 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 Numerical code is also provided

Discontinuity and Complexity in Nonlinear Physical Systems J. A. Tenreiro Machado, Dumitru Baleanu, Albert C J Luo, 2013-12-04 Discontinuity in Nonlinear Physical Systems explores recent developments in experimental research in this broad field organized in four distinct sections Part I introduces the reader to the fractional dynamics and Lie group analysis for nonlinear partial differential equations Part II covers chaos and complexity in nonlinear Hamiltonian systems important to understand the resonance interactions in nonlinear dynamical systems such as Tsunami waves and wildfire propagations as well as Lev flights in chaotic trajectories dynamical system synchronization and DNA information complexity analysis Part III examines chaos and periodic motions in discontinuous dynamical systems extensively present in a range of systems including piecewise linear systems vibro impact systems and drilling systems in engineering And in Part IV engineering and financial nonlinearity are discussed The mechanism of shock wave with saddle node bifurcation and rotating disk stability will be presented and the financial nonlinear models will be discussed

Fractional Calculus: Theory and Applications Francesco Mainardi, 2018-09-20 This book is a printed edition of the Special Issue Fractional Calculus Theory and Applications that was published in Mathematics 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

Fractional Dynamics in Natural Phenomena and Advanced Technologies Dumitru Baleanu, Jordan Hristov, 2024-01-29 This book addresses different applied problems in order to demonstrate the feasibility of fractional calculus use irrespective of the type of memory kernels used to model varieties of natural phenomena and new processes emerging in advanced technologies In this context the book's focus is on modelling adequate results and interpretations rather than theorems and proofs The book includes a total of 12 chapters representing various aspects of applied fractional modelling and covering important issues in modern technologies to provide a better understanding of applications of fractional calculus in applied modelling The book will be a versatile source of information for undergraduate and graduate students and for scientists involved in modelling of nonlinear and

hereditary phenomena **Models and Theories in Social Systems** Cristina Flaut, Šárka Hošková-Mayerová, Daniel Flaut, 2018-10-12 This book concisely presents a broad range of models and theories on social systems Because of the huge spectrum of topics involving social systems various issues related to Mathematics Statistics Teaching Social Science and Economics are discussed In an effort to introduce the subject to a wider audience this volume part of the series Studies in Systems Decision and Control equally addresses the needs of mathematicians statisticians sociologists and philosophers The studies examined here are divided into four parts The first part Perusing the Minds Behind Scientific Discoveries traces the winding path of Syamal K Sen and Ravi P Agarwal s scholarship throughout history and most importantly the thought processes that allowed each of them to master their subject The second part covers Theories in Social Systems and the third discusses Models in Social Systems while the fourth and final part is dedicated to Mathematical Methods in the Social Sciences Given its breadth of coverage the book will offer inquisitive readers a valuable point of departure for exploring these rich vast and ever expanding fields of knowledge **Fractional Calculus in Medical and Health Science** Devendra Kumar, Jagdev Singh, 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 *Analysis, Approximation, Optimization: Computation and Applications* Marija P. Stanić, Miloljub Albijanić, Dragan Djurčić, Miodrag M. Spalević, 2025-07-14 This contributed volume is dedicated to Academician Gradimir V Milovanovi on his 75th birthday and contains recent results in the fields of approximation theory numerical analysis mathematical analysis optimization theory and various applications of an interdisciplinary character Most of these results were presented in person during an International Conference Analysis Approximations and Applications AAA2023 organized by the Faculty of Science University of Kragujevac in Vrnja ka Banja Serbia June 21 24 2023 This book is intended for researchers and students of mathematics and other computational and applied sciences This book provides surveys of state of the art results in the fields of Extremal Problems Optimization and Calculus of Variations Orthogonal Systems and Quadrature Formulas Differential and Integral Equations Integral Transforms and Operation Calculus Analytic Number Theory and Special Functions Real and Complex Functions Sequences Series Approximations and Expansions Functional Analysis Operator Theory Fixed Point Theory and Iterative Processes as well as in Miscellaneous Applications **Complex Systems and Networks** Jinhu Lü, Xinghuo Yu, Guanrong Chen, Wenwu Yu, 2015-08-14 This elementary book provides some state of the art research results on broad

disciplinary sciences on complex networks It presents an in depth study with detailed description of dynamics controls and applications of complex networks The contents of this book can be summarized as follows First the dynamics of complex networks for example the cluster dynamic analysis by using kernel spectral methods community detection algorithms in bipartite networks epidemiological modeling with demographics and epidemic spreading on multi layer networks are studied Second the controls of complex networks are investigated including topics like distributed finite time cooperative control of multi agent systems by applying homogenous degree and Lyapunov methods composite finite time containment control for disturbed second order multi agent systems fractional order observer design of multi agent systems chaos control and anticontrol of complex systems via Parrondos game and many more Third the applications of complex networks provide some applicable carriers which show the importance of theories developed in complex networks In particular a general model for studying time evolution of transition networks deflection routing in complex networks recommender systems for social networks analysis and mining strategy selection in networked evolutionary games integration and methods in computational biology are discussed in detail

Recent Trends in Wave Mechanics and Vibrations Zuzana Dimitrovová, Paritosh Biswas, Rodrigo Gonçalves, Tiago Silva, 2022-10-06 This volume gathers select proceedings of the 10th International Conference on Wave Mechanics and Vibrations WMVC held in Lisbon Portugal on July 4 6 2022 It covers recent developments and cutting edge methods in wave mechanics and vibrations applied to a wide range of engineering problems It presents analytical and computational studies in structural mechanics seismology and earthquake engineering mechanical engineering aeronautics robotics and nuclear engineering among others The volume will be of interest for students researchers and professionals interested in the wide ranging applications of wave mechanics and vibrations

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

Advances in Mathematical Analysis and its Applications Bipan Hazarika, Santanu Acharjee, H M Srivastava, 2022-12-12 Advances in Mathematical Analysis and its Applications is designed as a reference text and explores several important aspects of recent developments in the interdisciplinary applications of mathematical analysis MA and highlights how MA is now being employed in many areas of scientific research It discusses theory and problems in real and complex analysis functional analysis approximation theory operator theory analytic inequalities the Radon transform nonlinear analysis and various applications of interdisciplinary research some topics are also devoted to specific applications such as the three body problem finite element analysis in fluid mechanics algorithms for difference of monotone operators a vibrational approach to a financial problem and more Features The book encompasses several contemporary topics in the field of mathematical analysis their applications and relevancies in

other areas of research and study It offers an understanding of research problems by presenting the necessary developments in reasonable details The book also discusses applications and uses of operator theory fixed point theory inequalities bi univalent functions functional equations and scalar objective programming and presents various associated problems and ways to solve such problems Contains applications on wavelets analysis and COVID 19 to show that mathematical analysis has interdisciplinary as well as real life applications The book is aimed primarily at advanced undergraduates and postgraduate students studying mathematical analysis and mathematics in general Researchers will also find this book useful

Algorithms as a Basis of Modern Applied Mathematics Šárka Hošková-Mayerová, Cristina Flaut, Fabrizio Maturo, 2021-01-13 This book offers a self contained guide to advanced algorithms and their applications in various fields of science Gathering contributions by authoritative researchers in the field of mathematics statistics and computer science it aims at offering a comprehensive and up to date view of algorithms including the theory behind them as well as practical considerations current limitations and solutions It covers applications in energy management decision making computer networks materials science mechanics and process optimization It offers an integrated and timely guide to important algorithms and represents a valuable reference resource for graduate students and researchers in various fields of applied mathematics statistics and engineering

Applications in Physics, Part A Vasily E. Tarasov, 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 fourth volume collects authoritative chapters covering several applications of fractional calculus in physics including classical and continuum mechanics

Automatic Control, Robotics, and Information Processing Piotr Kulczycki, Józef Korbicz, Janusz Kacprzyk, 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

Asymptotic Expansions and Summability Pascal Remy, 2024-07-01 This book provides a comprehensive exploration of the theory of summability of formal power series with analytic coefficients at the origin of \mathbb{C}_n aiming to apply it to formal solutions of partial differential equations PDEs It offers three characterizations of summability and discusses their applications to PDEs which play a pivotal role in understanding physical chemical biological and

ecological phenomena Determining exact solutions and analyzing properties such as dynamic and asymptotic behavior are major challenges in this field The book compares various summability approaches and presents simple applications to PDEs introducing theoretical tools such as Nagumo norms Newton polygon and combinatorial methods Additionally it presents moment PDEs offering a broad class of functional equations including classical fractional and q difference equations With detailed examples and references the book caters to readers familiar with the topics seeking proofs or deeper understanding as well as newcomers looking for comprehensive tools to grasp the subject matter Whether readers are seeking precise references or aiming to deepen their knowledge this book provides the necessary tools to understand the complexities of summability theory and its applications to PDEs

Recent Trends in Formal and Analytic Solutions of Diff. Equations

Galina Filipuk,Alberto Lastra,Sławomir Michalik,2023-02-09 This volume contains the proceedings of the conference on Formal and Analytic Solutions of Diff Equations held from June 28 July 2 2021 and hosted by University of Alcal Alcal de Henares Spain The manuscripts cover recent advances in the study of formal and analytic solutions of different kinds of equations such as ordinary differential equations difference equations q difference equations partial differential equations moment differential equations etc Also discussed are related topics such as summability of formal solutions and the asymptotic study of their solutions The volume is intended not only for researchers in this field of knowledge but also for students who aim to acquire new techniques and learn recent results

Asymptotic Integration And Stability: For Ordinary. Functional And Discrete Differential Equations Of Fractional Order Dumitru Baleanu,Octavian G Mustafa,2015-01-15 This volume presents several important and recent contributions to the emerging field of fractional differential equations in a self contained manner It deals with new results on existence uniqueness and multiplicity smoothness asymptotic development and stability of solutions The new topics in the field of fractional calculus include also the Mittag Leffler and Razumikhin stability stability of a class of discrete fractional non autonomous systems asymptotic integration with a priori given coefficients intervals of disconjugacy non oscillation existence of L_p solutions for various linear and nonlinear fractional differential equations

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