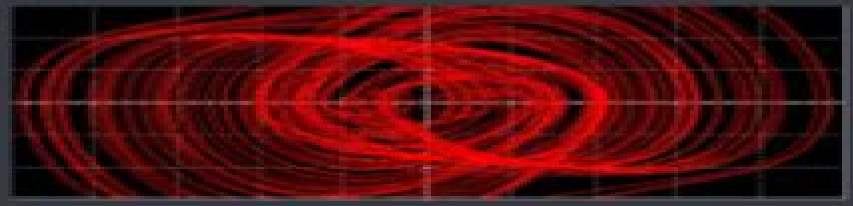
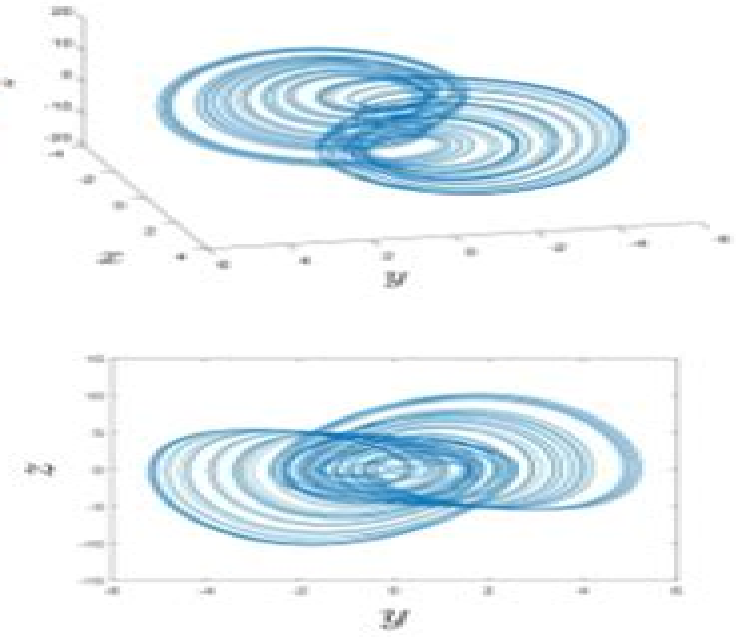
FRACTIONAL CALCULUS: NEW APPLICATIONS IN UNDERSTANDING NONLINEAR PHENOMENA





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New Methods Problems Fractional Calculus

Jesus Martin-Vaquero,Feliz Minhós,Juan L. G. Guirao,Bruce Alan Wade

New Methods Problems Fractional Calculus:

New Methods and Problems in Fractional Calculus MILICI Constantin,Draganescu Gheorghe,2015-12-09 The aim of this book is to present a series of problems not yet investigated in the field of fractional differential equations There are presented also a series of examples in the field of symbolic computation written in Maple and Mathematica It is introduced a new definition of the fractional derivative in terms of translation operator We introduced a new method based on decomposition method and Laplace transform is presented in our previous LAP book We studied also the fractional differential equations with the aid small parameter method We used also the power series method In the Chapter 5 it was established some predictor corrector methods for fractional differential equations of type Adams Moulton Adams Bashforth and Adams Bashforth Moulton We investigated also the fractional integral equations It was generalized the Galerkin and Ritz methods to the case of fractional differential equations This book is addressed to a large category of readers working in the field of fundamental and applied mathematics theoretical physics and experimental methods in physics and engineering

Functional Fractional Calculus Shantanu Das,2011-06-01 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

Advanced Research on Electronic Commerce, Web Application, and Communication Gang Shen,Xiong Huang,2011-03-31 The two volume set CCIS 143 and CCIS 144 constitutes the refereed proceedings of the International Conference on Electronic Commerce Web Application and Communication ECWAC 2011 held in Guangzhou China in April 2011 The 148 revised full papers presented in both volumes were carefully reviewed and selected from a large number of submissions Providing a forum for engineers scientists researchers in electronic commerce Web application and communication fields the conference will put special focus also on aspects such as e business e learning and e security intelligent information applications database and system security image and video signal processing pattern recognition information science industrial automation process control user machine systems security integrity and protection as well as mobile and multimedia communications **Mathematical Approaches to Challenges in Biology and Biomedicine** Martin Golubitsky,Stefano Boccaletti,Carla M.A. Pinto,2026-01-01 This book collects selected peer reviewed works presented at the International Conference on Mathematical Analysis and Applications in Science and Engineering ICMASC which took place at the University of Porto Portugal in hybrid mode on June 20 22 2024 This book covers advancements in mathematical analysis and modeling with an emphasis on mathematical biology It addresses topics such as partial and ordinary differential equations integer and fractional order equations linear algebra numerical analysis operations research discrete mathematics optimization control probability and computational mathematics to name a few Applications range from tumor and tissue properties infection spatial models cancer immunotherapy and others The conference was dedicated to Professor J A Tenreiro Machado who unexpectedly passed away in October 2021 Prof Tenreiro was a Professor at the Polytechnic Institute of Porto where he served as the Dean of the Institute Additionally he held a visiting position at the Lodz Institute of Technology Poland for many years Prof Tenreiro Machado authored 1 160 publications including 11 books IUTAM Symposium on Dynamics Modeling and Interaction Control in Virtual and Real Environments Gábor Stépán,László L. Kovács,András Tóth,2011-07-01 This volume contains the invited papers presented at the IUTAM Symposium on Multibody Dynamics and Interaction Control in Virtual and Real Environments held in Budapest Hungary June 7 11 2010 The symposium aimed to bring together specialists in the fields of multibody system modeling contact collision mechanics and

control of mechanical systems The offered topics included modeling aspects mechanical and mathematical models the question of neglections and simplifications reduction of large systems interaction with environment like air water and obstacles contact of all types control concepts control stability and optimization Discussions between experts in these fields made it possible to exchange ideas about the recent advances in multibody system modeling and interaction control as well as about the possible future trends The presentations of recent scientific results may facilitate the interaction between scientific areas like system control engineering and mechanical engineering Papers on dynamics modeling and interaction control were selected to cover the main areas mathematical modeling dynamic analysis friction modeling solid and thermomechanical aspects and applications A significant outcome of the meeting was the opening towards applications that are of key importance to the future of nonlinear dynamics **Computational Methods In The Fractional Calculus Of Variations** Ricardo Almeida,Shakoor Pooseh,Delfim F M Torres,2015-03-19 This book fills a gap in the literature by introducing numerical techniques to solve problems of fractional calculus of variations FCV In most cases finding the analytic solution to such problems is extremely difficult or even impossible and numerical methods need to be used The authors are well known researchers in the area of FCV and the book contains some of their recent results serving as a companion volume to Introduction to the Fractional Calculus of Variations by A B Malinowska and D F M Torres where analytical methods are presented to solve FCV problems After some preliminaries on the subject different techniques are presented in detail with numerous examples to help the reader to better understand the methods The techniques presented may be used not only to deal with FCV problems but also in other contexts of fractional calculus such as fractional differential equations and fractional optimal control It is suitable as an advanced book for graduate students in mathematics physics and engineering as well as for researchers interested in fractional calculus Analytical and Numerical Methods for Differential Equations and Applications Jesus Martin-Vaquero,Feliz Minhós,Juan L. G. Guirao,Bruce Alan Wade,2021-10-29 Fractional Calculus and its Applications in Physics Dumitru Baleanu,Devendra Kumar,2019-11-15 **Fractional Order Analysis** Hemen Dutta,Ahmet Ocak Akdemir,Abdon Atangana,2020-08-06 A guide to the new research in the field of fractional order analysis Fractional Order Analysis contains the most recent research findings in fractional order analysis and its applications The authors noted experts on the topic offer an examination of the theory methods applications and the modern tools and techniques in the field of fractional order analysis The information tools and applications presented can help develop mathematical methods and models with better accuracy Comprehensive in scope the book covers a range of topics including new fractional operators fractional derivatives fractional differential equations inequalities for different fractional derivatives and fractional integrals fractional modeling related to transmission of Malaria and dynamics of Zika virus with various fractional derivatives and more Designed to be an accessible text several useful relevant and connected topics can be found in one place which is crucial for an understanding of the research problems of an applied nature This book Contains recent

development in fractional calculus Offers a balance of theory methods and applications Puts the focus on fractional analysis and its interdisciplinary applications such as fractional models for biological models Helps make research more relevant to real life applications Written for researchers professionals and practitioners Fractional Order Analysis offers a comprehensive resource to fractional analysis and its many applications as well as information on the newest research

Basic Theory Anatoly Kochubei,Yuri Luchko,2019-02-19 This multi volume handbook is the most up to date and comprehensive reference work in the field of fractional calculus and its numerous applications This first volume collects authoritative chapters covering the mathematical theory of fractional calculus including fractional order operators integral transforms and equations special functions calculus of variations and probabilistic and other aspects **Fractional Dynamics and Control** Dumitru Baleanu,José António Tenreiro Machado,Albert C. J. Luo,2011-11-19 Fractional Dynamics and Control provides a comprehensive overview of recent advances in the areas of nonlinear dynamics vibration and control with analytical numerical and experimental results This book provides an overview of recent discoveries in fractional control delves into fractional variational principles and differential equations and applies advanced techniques in fractional calculus to solving complicated mathematical and physical problems Finally this book also discusses the role that fractional order modeling can play in complex systems for engineering and science **Theoretical Developments and Applications of Non-Integer Order Systems** Stefan Domek,Paweł Dworak,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 *Numerical Methods for Fractional*

Differentiation Kolade M. Owolabi,Abdon Atangana,2019-10-14 This book discusses numerical methods for solving partial differential and integral equations as well as ordinary differential and integral equations involving fractional differential and integral operators Differential and integral operators presented in the book include those with exponential decay law known as Caputo Fabrizio differential and integral operators those with power law known as Riemann Liouville fractional operators and those for the generalized Mittag Leffler function known as the Atangana Baleanu fractional operators The book reviews existing numerical schemes associated with fractional operators including those with power law while also highlighting new trends in numerical schemes for recently introduced differential and integral operators In addition the initial chapters address useful properties of each differential and integral fractional operator Methods discussed in the book are subsequently used to solved problems arising in many fields of science technology and engineering including epidemiology chaos solitons fractals diffusion groundwater and fluid mechanics Given its scope the book offers a valuable resource for graduate students of mathematics and engineering and researchers in virtually all fields of science technology and engineering as well as an excellent addition to libraries **Fractional Calculus** Roy Abi Zeid Daou,2014 The first volume of this two volume book presents history the mathematical modeling and the applications of fractional order systems and contains mathematical and theoretical studies and research related to this domain This volume is made up of 11 chapters The first chapter presents an analysis of the Caputo derivative and the pseudo state representation with the infinite state approach The second chapter studies the stability of a class of fractional Cauchy problems The third chapter shows how to solve fractional order differential equations and fractional order partial differential equations using modern matrix algebraic approaches Following this chapter chapter four proposes another analytical method to solve differential equations with local fractional derivative operators Concerning chapter five it presents the extended Borel transform and its related fractional analysis After presenting the analytical resolution methods for fractional calculus chapter six shows the essentials of fractional calculus on discrete settings The initialization of such systems is shown in chapter seven In fact this chapter presents a generalized application of the Hankel operator for initialization of fractional order systems The last four chapters show some new studies and applications of non integer calculus In fact chapter eight presents the fractional reaction transport equations and evanescent continuous time random walks Chapter nine shows a novel approach in the exponential integrators for fractional differential equations Chapter ten presents the non fragile tuning of fractional order PD controllers for integrating time delay systems At the end chapter eleven proposes a discrete finite dimensional approximation of linear infinite dimensional systems To sum up this volume presents a mathematical and theoretical study of fractional calculus along with a stability study and some applications This volume ends up with some new techniques and methods applied in fractional calculus This volume will be followed up by a second volume that focuses on the applications of fractional calculus in several engineering domains **The Fractional Calculus Theory and Applications of Differentiation and**

Integration to Arbitrary Order ,1974-09-05 In this book we study theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems A number of computing techniques are considered such as methods of operator approximation with any given accuracy operator interpolation techniques including a non Lagrange interpolation methods of system representation subject to constraints associated with concepts of causality memory and stationarity methods of system representation with an accuracy that is the best within a given class of models methods of covariance matrix estimation methods for low rank matrix approximations hybrid methods based on a combination of iterative procedures and best operator approximation andmethods for information compression and filtering under condition that a filter model should satisfy restrictions associated with causality and different types of memory As a result the book represents a blend of new methods in general computational analysis and specific but also generic techniques for study of systems theory ant its particularbranches such as optimal filtering and information compression Best operator approximation Non Lagrange interpolation Generic Karhunen Loeve transform Generalised low rank matrix approximation Optimal data compression Optimal nonlinear filtering **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 Science in China ,2006-02 *Fractional Calculus and Fractional Differential Equations* Varsha Daftardar-Gejji,2019-08-10 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 **Computational Science and its Applications** A. H. Siddiqi,R. C. Singh,G. D. Veerappa Gowda,2020-10-20 Computational science is a rapidly growing multidisciplinary field concerned with the design implementation and use of mathematical models to analyze and solve real world problems It is an area of science that spans many disciplines and which involves the development of models and allows the use of computers to perform simulations or numerical analysis to understand problems that are computational and theoretical Computational Science and its Applications provides an opportunity for readers to develop abilities to pose and solve problems that combine insights from one or more disciplines from the natural sciences with mathematical tools and computational skills This requires a unique combination of applied and theoretical knowledge and skills The topics covered in this edited book are applications of wavelet and fractals modeling by partial differential equations on flat structure as well as on graphs and networks computational linguistics prediction of natural calamities and diseases like epilepsy seizure heart attack stroke biometrics modeling through inverse problems interdisciplinary topics of physics mathematics and medical science and modeling of terrorist attacks and human behavior The focus of this book is not to educate computer specialists but to provide readers with a solid understanding of basic science as well as an integrated knowledge on how to use essential methods from computational science Features Modeling of complex systems Cognitive computing systems for real world problems Presentation of inverse problems in medical science and their numerical solutions Challenging research problems in many areas of computational science This book could be used as a reference book for researchers working in theoretical research as well as those who are doing modeling and simulation in such disciplines as physics biology geoscience and mathematics and those who have a background in computational science **Introduction To The Fractional Calculus Of Variations** Delfim F M Torres,Agnieszka Barbara Malinowska,2012-09-14 This invaluable book provides a broad introduction to the

fascinating and beautiful subject of Fractional Calculus of Variations FCV In 1996 FVC evolved in order to better describe non conservative systems in mechanics The inclusion of non conservatism is extremely important from the point of view of applications Forces that do not store energy are always present in real systems They remove energy from the systems and as a consequence Noether s conservation laws cease to be valid However it is still possible to obtain the validity of Noether s principle using FCV The new theory provides a more realistic approach to physics allowing us to consider non conservative systems in a natural way The authors prove the necessary Euler Lagrange conditions and corresponding Noether theorems for several types of fractional variational problems with and without constraints using Lagrangian and Hamiltonian formalisms Sufficient optimality conditions are also obtained under convexity and Leitmann s direct method is discussed within the framework of FCV The book is self contained and unified in presentation It may be used as an advanced textbook by graduate students and ambitious undergraduates in mathematics and mechanics It provides an opportunity for an introduction to FCV for experienced researchers The explanations in the book are detailed in order to capture the interest of the curious reader and the book provides the necessary background material required to go further into the subject and explore the rich research literature a

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