Volterra Integral Equations And Fractional Calculus Do

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Haar Wavelets - Ülo Lepik 2014-01-09
This is the first book to present a systematic review of applications of the Haar wavelet method for solving Calculus and Structural Mechanics problems. Haar wavelet-based solutions for a wide range of problems, such as various differential and integral equations, fractional equations, optimal control theory, buckling, bending and vibrations of elastic beams are considered. Numerical examples demonstrating the efficiency and accuracy of the Haar method are provided for all solutions.
Advances in Harmonic Analysis and Operator Theory - Alexandre Almeida 2013-01-31
This volume is dedicated to

Professor Stefan Samko on the occasion of his seventieth birthday. The contributions display the range of his scientific interests in harmonic analysis and operator theory. Particular attention is paid to fractional integrals and derivatives, singular, hypersingular and potential operators in variable exponent spaces, pseudodifferential operators in various modern function and distribution spaces, as well as related applications, to mention but a few. Most contributions were firstly presented in two conferences at Lisbon and Aveiro, Portugal, in June–July 2011.

q-Fractional Calculus and Equations - Mahmoud H. Annaby 2012-08-26

This nine-chapter monograph introduces a rigorous investigation of q-difference operators in standard and fractional settings. It starts with elementary calculus of q-differences and integration of Jackson's type before turning to q-difference equations. The existence and uniqueness theorems are derived using successive approximations, leading to systems of equations with retarded arguments. Regular q-Sturm–Liouville theory is also introduced; Green's function is constructed and the eigenfunction expansion theorem is given. The monograph also discusses some integral equations of Volterra and Abel type, as introductory material for the study of fractional q-calculi. Hence fractional q-calculi of the types Riemann–Liouville; Grünwald–Letnikov; Caputo; Erdélyi–Kober and Weyl are defined analytically. Fractional q-Leibniz rules with applications in q-series are also obtained with rigorous proofs of the formal results of Al-Salam-Verma, which remained unproved for decades. In working towards the investigation of q-fractional difference equations; families of q-Mittag-Leffler functions are defined and their properties are investigated, especially the q-Mellin–Barnes integral and Hankel contour integral representation of the

q-Mittag-Leffler functions under consideration, the distribution, asymptotic and reality of their zeros, establishing q-counterparts of Wiman's results. Fractional q-difference equations are studied; existence and uniqueness theorems are given and classes of Cauchy-type problems are completely solved in terms of families of q-Mittag-Leffler functions. Among many q-analogs of classical results and concepts, q-Laplace, q-Mellin and q2-Fourier transforms are studied and their applications are investigated.

Collocation Methods for Volterra Integral and Related Functional Differential Equations - Hermann Brunner 2004-11-15

Collocation based on piecewise polynomial approximation represents a powerful class of methods for the numerical solution of initial-value problems for functional differential and integral equations arising in a wide spectrum of applications, including biological and physical phenomena. The present book introduces the reader to the general principles underlying these methods and then describes in detail their convergence properties when applied to ordinary differential equations, functional equations with (Volterra type) memory terms, delay equations, and differential-algebraic and integral-algebraic equations. Each chapter starts with a self-contained introduction to the relevant theory of the class of equations under consideration. Numerous exercises and examples are supplied, along with extensive historical and bibliographical notes utilising the vast annotated reference list of over 1300 items. In sum, Hermann Brunner has written a treatise that can serve as an introduction for students, a guide for users, and a comprehensive resource for experts.

The Optimal Homotopy Asymptotic Method - Vasile Marinca 2015-04-02

This book emphasizes in detail the applicability of the Optimal Homotopy Asymptotic Method

to various engineering problems. It is a continuation of the book “Nonlinear Dynamical Systems in Engineering: Some Approximate Approaches”, published at Springer in 2011 and it contains a great amount of practical models from various fields of engineering such as classical and fluid mechanics, thermodynamics, nonlinear oscillations, electrical machines and so on. The main structure of the book consists of 5 chapters. The first chapter is introductory while the second chapter is devoted to a short history of the development of homotopy methods, including the basic ideas of the Optimal Homotopy Asymptotic Method. The last three chapters, from Chapter 3 to Chapter 5, are introducing three distinct alternatives of the Optimal Homotopy Asymptotic Method with illustrative applications to nonlinear dynamical systems. The third chapter deals with the first alternative of our approach with two iterations. Five applications are presented from fluid mechanics and nonlinear oscillations. The Chapter 4 presents the Optimal Homotopy Asymptotic Method with a single iteration and solving the linear equation on the first approximation. Here are treated 32 models from different fields of engineering such as fluid mechanics, thermodynamics, nonlinear damped and undamped oscillations, electrical machines and even from physics and biology. The last chapter is devoted to the Optimal Homotopy Asymptotic Method with a single iteration but without solving the equation in the first approximation.

The Analysis of Fractional Differential Equations - Kai Diethelm 2010-08-18

Fractional calculus was first developed by pure mathematicians in the middle of the 19th century. Some 100 years later, engineers and physicists have found applications for these concepts in their areas. However there has traditionally been little interaction between these two

communities. In particular, typical mathematical works provide extensive findings on aspects with comparatively little significance in applications, and the engineering literature often lacks mathematical detail and precision. This book bridges the gap between the two communities. It concentrates on the class of fractional derivatives most important in applications, the Caputo operators, and provides a self-contained, thorough and mathematically rigorous study of their properties and of the corresponding differential equations. The text is a useful tool for mathematicians and researchers from the applied sciences alike. It can also be used as a basis for teaching graduate courses on fractional differential equations.

Analytical and Numerical Methods for Volterra Equations - Peter Linz 1985-01-01

Presents an aspect of activity in integral equations methods for the solution of Volterra equations for those who need to solve real-world problems. Since there are few known analytical methods leading to closed-form solutions, the emphasis is on numerical techniques. The major points of the analytical methods used to study the properties of the solution are presented in the first part of the book. These techniques are important for gaining insight into the qualitative behavior of the solutions and for designing effective numerical methods. The second part of the book is devoted entirely to numerical methods. The author has chosen the simplest possible setting for the discussion, the space of real functions of real variables. The text is supplemented by examples and exercises.

Numerical Analysis: Historical Developments in the 20th Century - C. Brezinski 2012-12-02

Numerical analysis has witnessed many significant developments in the 20th century. This book brings together 16 papers dealing with historical developments, survey papers and papers on

recent trends in selected areas of numerical analysis, such as: approximation and interpolation, solution of linear systems and eigenvalue problems, iterative methods, quadrature rules, solution of ordinary-, partial- and integral equations. The papers are reprinted from the 7-volume project of the Journal of Computational and Applied Mathematics on '/homepage/sac/cam/na2000/index.htmlNumerical Analysis 2000'. An introductory survey paper deals with the history of the first courses on numerical analysis in several countries and with the landmarks in the development of important algorithms and concepts in the field.

Fuzzy Fractional Differential Operators and Equations - Tofigh Allahviranloo 2020-06-15

This book contains new and useful materials concerning fuzzy fractional differential and integral operators and their relationship. As the title of the book suggests, the fuzzy subject matter is one of the most important tools discussed. Therefore, it begins by providing a brief but important and new description of fuzzy sets and the computational calculus they require. Fuzzy fractals and fractional operators have a broad range of applications in the engineering, medical and economic sciences. Although these operators have been addressed briefly in previous papers, this book represents the first comprehensive collection of all relevant explanations. Most of the real problems in the biological and engineering sciences involve dynamic models, which are defined by fuzzy fractional operators in the form of fuzzy fractional initial value problems. Another important goal of this book is to solve these systems and analyze their solutions both theoretically and numerically. Given the content covered, the book will benefit all researchers and students in the mathematical and computer sciences, but also the engineering sciences.

Factorization, Singular Operators and Related Problems - Stefan Samko 2013-11-11

These proceedings comprise a large part of the papers presented at the In ternational Conference Factorization, Singular Operators and related problems, which was held from January 28 to February 1, 2002, at the University of th Madeira, Funchal, Portugal, to mark Professor Georgii Litvinchuk's 70 birth day. Experts in a variety of fields came to this conference to pay tribute to the great achievements of Professor Georgii Litvinchuk in the development of vari ous areas of operator theory. The main themes of the conference were focussed around the theory of singular type operators and factorization problems, but other topics such as potential theory and fractional calculus, to name but a couple, were also presented. The goal of the conference was to bring together mathematicians from var ious fields within operator theory and function theory in order to highlight recent advances in problems many of which were originally studied by Profes sor Litvinchuk and his scientific school. A second aim was to stimulate in ternational collaboration even further and promote the interaction of different approaches in current research in these areas. The Proceedings will be of great interest to researchers in Operator The ory, Real and Complex Analysis, Functional and Harmonic Analysis, Potential Theory, Fractional Calculus and other areas, as well as to graduate students looking for the latest results.

Abel Integral Equations - Rudolf Gorenflo 2006-11-14

In many fields of application of mathematics, progress is crucially dependent on the good flow of information between (i) theoretical mathematicians looking for applications, (ii) mathematicians working in applications in need of theory, and (iii) scientists and engineers applying mathematical models and

methods. The intention of this book is to stimulate this flow of information. In the first three chapters (accessible to third year students of mathematics and physics and to mathematically interested engineers) applications of Abel integral equations are surveyed broadly including determination of potentials, stereology, seismic travel times, spectroscopy, optical fibres. In subsequent chapters (requiring some background in functional analysis) mapping properties of Abel integral operators and their relation to other integral transforms in various function spaces are investi- gated, questions of existence and uniqueness of solutions of linear and nonlinear Abel integral equations are treated, and for equations of the first kind problems of ill-posedness are discussed. Finally, some numerical methods are described. In the theoretical parts, emphasis is put on the aspects relevant to applications.

Fractional Calculus and its Applications in Physics - Dumitru Baleanu 2019-11-15

Volterra Integral and Functional Equations - G. Gripenberg 1990-03-30

This book looks at the theories of Volterra integral and functional equations.

Advanced Numerical Methods in Applied Sciences - Luigi Brugnano 2019-06-20

The use of scientific computing tools is currently customary for solving problems at several complexity levels in Applied Sciences. The great need for reliable software in the scientific community conveys a continuous stimulus to develop new and better performing numerical methods that are able to grasp the particular features of the problem at hand. This has been the case for many different settings of numerical analysis, and this Special Issue aims at covering some important developments in various areas of application.

Computational Methods In The Fractional Calculus Of Variations - Ricardo Almeida 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.

Fractional Order Analysis - Hemen Dutta 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.

Fractional Calculus - 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.

Advances in Fractional Calculus - J. Sabatier 2007-07-28

In the last two decades, fractional (or non integer) differentiation has played a very important role in various fields such as mechanics, electricity, chemistry, biology, economics, control theory and signal and image processing. For example, in the last three fields, some important considerations such as modelling, curve fitting, filtering, pattern recognition, edge detection, identification, stability, controllability, observability and robustness are now linked to long-range dependence phenomena. Similar progress has been made in other fields listed here. The scope of the book is thus to present the state of the art in the study of fractional systems and the application of fractional differentiation. As this volume covers recent applications of fractional calculus, it will be of interest to engineers, scientists, and applied mathematicians.

Numerical Methods for Fractional Calculus - Changpin Li 2015-05-19

Numerical Methods for Fractional Calculus presents numerical methods for fractional integrals and fractional derivatives, finite difference methods for fractional ordinary differential equations (FODEs) and fractional partial differential equations (FPDEs), and finite element methods for

FPDEs.The book introduces the basic definitions and propertie

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

Theory and Numerical Approximations of Fractional Integrals and Derivatives - Changpin Li 2019-10-31

Due to its ubiquity across a variety of fields in science and engineering, fractional calculus has gained momentum in industry and academia. While a number of books and papers introduce either fractional calculus or numerical approximations, no current literature provides a comprehensive collection of both topics. This monograph introduces fundamental information on fractional calculus, provides a detailed treatment of existing numerical approximations, and presents an inclusive review of fractional calculus in terms of theory and numerical methods and systematically examines almost all existing numerical approximations for fractional integrals and derivatives. The authors consider the relationship between the fractional Laplacian and the Riesz derivative, a key component absent from other related texts, and highlight recent developments, including their own research and results. The core audience spans several fractional communities, including those interested in fractional partial differential equations, the fractional Laplacian, and applied and computational mathematics. Advanced undergraduate and graduate students will find the material suitable as a primary or supplementary resource for their studies.

Fractional Order Processes - Seshu Kumar Damarla 2018-09-03

The book presents efficient numerical methods for simulation and analysis of physical processes exhibiting fractional order (FO) dynamics. The book introduces FO system identification method to

estimate parameters of a mathematical model under consideration from experimental or simulated data. A simple tuning technique, which aims to produce a robust FO PID controller exhibiting iso-damping property during re-parameterization of a plant, is devised in the book. A new numerical method to find an equivalent finite dimensional integer order system for an infinite dimensional FO system is developed in the book. The book also introduces a numerical method to solve FO optimal control problems. Key features Proposes generalized triangular function operational matrices. Shows significant applications of triangular orthogonal functions as well as triangular strip operational matrices in simulation, identification and control of fractional order processes. Provides numerical methods for simulation of physical problems involving different types of weakly singular integral equations, Abel's integral equation, fractional order integro-differential equations, fractional order differential and differential-algebraic equations, and fractional order partial differential equations. Suggests alternative way to do numerical computation of fractional order signals and systems and control. Provides source codes developed in MATLAB for each chapter, allowing the interested reader to take advantage of these codes for broadening and enhancing the scope of the book itself and developing new results.

Mathematical Analysis and Applications - Hari Mohan Srivastava 2019-01-14

This book is a printed edition of the Special Issue "Mathematical Analysis and Applications" that was published in Axioms

Novel Methods for Solving Linear and Nonlinear Integral Equations - Santanu Saha Ray 2018-12-07

This book deals with the numerical solution of integral equations based on approximation of functions and the authors apply wavelet

approximation to the unknown function of integral equations. The book's goal is to categorize the selected methods and assess their accuracy and efficiency.

Topics in Integral and Integro-Differential Equations - Harendra Singh 2021-04-16

This book includes different topics associated with integral and integro-differential equations and their relevance and significance in various scientific areas of study and research. Integral and integro-differential equations are capable of modelling many situations from science and engineering. Readers should find several useful and advanced methods for solving various types of integral and integro-differential equations in this book. The book is useful for graduate students, Ph.D. students, researchers and educators interested in mathematical modelling, applied mathematics, applied sciences, engineering, etc. Key Features • New and advanced methods for solving integral and integro-differential equations • Contains comparison of various methods for accuracy • Demonstrates the applicability of integral and integro-differential equations in other scientific areas • Examines qualitative as well as quantitative properties of solutions of various types of integral and integro-differential equations

Fractional Differential Equations - Anatoly Kochubei 2019-02-19

This multi-volume handbook is the most up-to-date and comprehensive reference work in the field of fractional calculus and its numerous applications. This second volume collects authoritative chapters covering the mathematical theory of fractional calculus, including ordinary and partial differential equations of fractional order, inverse problems, and evolution equations.

Scientific Computing in Chemical Engineering II - Frerich Keil 2012-12-06

The application of modern methods in numerical

mathematics on problems in chemical engineering is essential for designing, analyzing and running chemical processes and even entire plants. Scientific Computing in Chemical Engineering II gives the state of the art from the point of view of numerical mathematicians as well as that of engineers. The present volume as part of a two-volume edition covers topics such as the simulation of reactive flows, reaction engineering, reaction diffusion problems, and molecular properties. The volume is aimed at scientists, practitioners and graduate students in chemical engineering, industrial engineering and numerical mathematics.

Integral Equations, Boundary Value Problems and Related Problems - Xing Li 2013-03-07

In this volume, we report new results about various theories and methods of integral equation, boundary value problems for partial differential equations and functional equations, and integral operators including singular integral equations, applications of boundary value problems and integral equations to mechanics and physics, numerical methods of integral equations and boundary value problems, theories and methods for inverse problems of mathematical physics, Clifford analysis and related problems. Contents:Some Properties of a Kind of Singular Integral Operator for K-Monogenic Function in Clifford Analysis (L P Wang, Z L Xu and Y Y Qiao)Some Results Related with Möbius Transformation in Clifford Analysis (Z X Zhang)The Scattering of SH Wave on the Array of Periodic Cracks in a Piezoelectric Substrate Bonded a Half-Plane of Functionally Graded Materials (J Q Liu, X Li, S Z Dong, X Y Yao and C F Wang)Anti-Plane Problem of Two Collinear Cracks in a Functionally Graded Coating–Substrate Structure (S H Ding and X Li)A Kind of Riemann Boundary Value Problem for Triharmonic Functions in Clifford Analysis

(L F Gu)A New Dynamical Systems Method for Nonlinear Operator Equations (X J Luo, F C Li and S H Yang)A Class of Integral Inequality and Application (W S Wang)An Efficient Spectral Boundary Integral Equation Method for the Simulation of Earthquake Rupture Problems (W S Wang and B W Zhang)High-Frequency Asymptotics for the Modified Helmholtz Equation in a Half-Plane (H M Huang)An Inverse Boundary Value Problem Involving Filtration for Elliptic Systems of Equations (Z L Xu and L Yan)Fixed Point Theorems of Contractive Mappings in Extended Cone Metric Spaces (H P Huang and X Li)Positive Solutions of Singular Third-Order Three-Point Boundary Value Problems (B Q Yan and X Liu)Modified Neumann Integral and Asymptotic Behavior in the Half-Space (Y H Zhang, G T Deng and Z Z Wei)Piecewise Tikhonov Regularization Scheme to Reconstruct Discontinuous Density in Computerized Tomography (J Cheng, Y Jiang, K Lin and J W Yan)About the Quaternionic Jacobian Conjecture (H Liu)Interaction Between Antiplane Circular Inclusion and Circular Hole of Piezoelectric Materials (L H Chang and X Li)Convergence of Numerical Algorithm for Coupled Heat and Mass Transfer in Textile Materials (M B Ge, J X Cheng and D H Xu)Haversian Cortical Bone with a Radial Microcrack (X Wang)Spectra of Unitary Integral Operators on L2(ℝ) with Kernels k(xy) (D W Ma and G Chen)The Numerical Simulation of Long-Period Ground Motion on Basin Effects (Y Q Li and X Li)Complete Plane Strain Problem of a One-Dimensional Hexagonal Quasicrystals with a Doubly-Periodic Set of Cracks (X Li and P P Shi)The Problem About an Elliptic Hole with III Asymmetry Cracks in One-Dimensional Hexagonal Piezoelectric Quasicrystals (H S Huo and X Li)The Second Fundamental Problem of Periodic Plane Elasticity of a One-Dimensional Hexagonal Quasicrystals (J Y Cui, P P Shi

and X Li)The Optimal Convex Combination Bounds for the Centroidal Mean (H Liu and X J Meng)The Method of Fundamental Solution for a Class of Elliptical Partial Differential Equations with Coordinate Transformation and Image Technique (L N Wu and Q Jiang)Various Wavelet Methods for Solving Fractional Fredholm–Volterra Integral Equations (P P Shi, X Li and X Li) Readership: Researchers in analysis and differential equations. Keywords:Integral Equations;Boundary Value ProblemsKey Features:Provides new research progress on these topics

Fractional Calculus for Hydrology, Soil Science and Geomechanics - Ninghu Su 2020-11-02

This book is an unique integrated treatise, on the concepts of fractional calculus as models with applications in hydrology, soil science and geomechanics. The models are primarily fractional partial differential equations (fPDEs), and in limited cases, fractional differential equations (fDEs). It develops and applies relevant fPDEs and fDEs mainly to water flow and solute transport in porous media and overland, and in some cases, to concurrent flow and energy transfer. It is an integrated resource with theory and applications for those interested in hydrology, hydraulics and fluid mechanics. The self-contained book summaries the fundamentals for porous media and essential mathematics with extensive references supporting the development of the model and applications.

Implicit Fractional Differential and Integral Equations - Saïd Abbas 2018-02-05

This book deals with the existence and stability of solutions to initial and boundary value problems for functional differential and integral equations and inclusions involving the Riemann-Liouville, Caputo, and Hadamard fractional derivatives and integrals. A wide variety of topics is covered in a mathematically

rigorous manner making this work a valuable source of information for graduate students and researchers working with problems in fractional calculus. ContentsPreliminary Background Nonlinear Implicit Fractional Differential Equations Impulsive Nonlinear Implicit Fractional Differential Equations Boundary Value Problems for Nonlinear Implicit Fractional Differential Equations Boundary Value Problems for Impulsive NIFDE Integrable Solutions for Implicit Fractional Differential Equations Partial Hadamard Fractional Integral Equations and Inclusions Stability Results for Partial Hadamard Fractional Integral Equations and Inclusions Hadamard–Stieltjes Fractional Integral Equations Ulam Stabilities for Random Hadamard Fractional Integral Equations

Fractional-Order Equations and Inclusions - Michal Fečkan 2017-11-07

This book presents fractional difference, integral, differential, evolution equations and inclusions, and discusses existence and asymptotic behavior of their solutions. Controllability and relaxed control results are obtained. Combining rigorous deduction with abundant examples, it is of interest to nonlinear science researchers using fractional equations as a tool, and physicists, mechanics researchers and engineers studying relevant topics. Contents Fractional Difference Equations Fractional Integral Equations Fractional Differential Equations Fractional Evolution Equations: Continued Fractional Differential Inclusions

Fractional Calculus - Dumitru Baleanu 2012

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.

Fractional Differential Equations - Bangti Jin 2021-07-22

This graduate textbook provides a self-contained introduction to modern mathematical theory on

fractional differential equations. It addresses both ordinary and partial differential equations with a focus on detailed solution theory, especially regularity theory under realistic assumptions on the problem data. The text includes an extensive bibliography, application-driven modeling, extensive exercises, and graphic illustrations throughout to complement its comprehensive presentation of the field. It is recommended for graduate students and researchers in applied and computational mathematics, particularly applied analysis, numerical analysis and inverse problems.

Fractional Differential Equations - Igor Podlubny 1998-10-27

This book is a landmark title in the continuous move from integer to non-integer in mathematics: from integer numbers to real numbers, from factorials to the gamma function, from integer-order models to models of an arbitrary order. For historical reasons, the word 'fractional' is used instead of the word 'arbitrary'. This book is written for readers who are new to the fields of fractional derivatives and fractional-order mathematical models, and feel that they need them for developing more adequate mathematical models. In this book, not only applied scientists, but also pure mathematicians will find fresh motivation for developing new methods and approaches in their fields of research. A reader will find in this book everything necessary for the initial study and immediate application of fractional derivatives fractional differential equations, including several necessary special functions, basic theory of fractional differentiation, uniqueness and existence theorems, analytical numerical methods of solution of fractional differential equations, and many inspiring examples of applications. A unique survey of many applications of fractional calculus Presents basic theory Includes a unified presentation

of selected classical results, which are important for applications Provides many examples Contains a separate chapter of fractional order control systems, which opens new perspectives in control theory The first systematic consideration of Caputo's fractional derivative in comparison with other selected approaches Includes tables of fractional derivatives, which can be used for evaluation of all considered types of fractional derivatives

Ordinary Differential Equations and Integral Equations - C.T.H. Baker 2001-07-04

/homepage/sac/cam/na2000/index.html7-Volume Set now available at special set price ! This volume contains contributions in the area of differential equations and integral equations. Many numerical methods have arisen in response to the need to solve "real-life" problems in applied mathematics, in particular problems that do not have a closed-form solution. Contributions on both initial-value problems and boundary-value problems in ordinary differential equations appear in this volume. Numerical methods for initial-value problems in ordinary differential equations fall naturally into two classes: those which use one starting value at each step (one-step methods) and those which are based on several values of the solution (multistep methods). John Butcher has supplied an expert's perspective of the development of numerical methods for ordinary differential equations in the 20th century. Rob Corless and Lawrence Shampine talk about established technology, namely software for initial-value problems using Runge-Kutta and Rosenbrock methods, with interpolants to fill in the solution between mesh-points, but the 'slant' is new - based on the question, "How should such software integrate into the current generation of Problem Solving Environments?" Natalia Borovykh and Marc Spijker study the problem of establishing upper bounds for

the norm of the nth power of square matrices. The dynamical system viewpoint has been of great benefit to ODE theory and numerical methods. Related is the study of chaotic behaviour. Willy Govaerts discusses the numerical methods for the computation and continuation of equilibria and bifurcation points of equilibria of dynamical systems. Arieh Iserles and Antonella Zanna survey the construction of Runge-Kutta methods which preserve algebraic invariant functions. Valeria Antohe and Ian Gladwell present numerical experiments on solving a Hamiltonian system of Hénon and Heiles with a symplectic and a nonsymplectic method with a variety of precisions and initial conditions. Stiff differential equations first became recognized as special during the 1950s. In 1963 two seminal publications laid to the foundations for later development: Dahlquist's paper on A-stable multistep methods and Butcher's first paper on implicit Runge-Kutta methods. Ernst Hairer and Gerhard Wanner deliver a survey which retraces the discovery of the order stars as well as the principal achievements obtained by that theory. Guido Vanden Berghe, Hans De Meyer, Marnix Van Daele and Tanja Van Hecke construct exponentially fitted Runge-Kutta methods with s stages. Differential-algebraic equations arise in control, in modelling of mechanical systems and in many other fields. Jeff Cash describes a fairly recent class of formulae for the numerical solution of initial-value problems for stiff and differential-algebraic systems. Shengtai Li and Linda Petzold describe methods and software for sensitivity analysis of solutions of DAE initial-value problems. Again in the area of differential-algebraic systems, Neil Biehn, John Betts, Stephen Campbell and William Huffman present current work on mesh adaptation for DAE two-point boundary-value problems. Contrasting approaches to the question of how good an approximation is as a solution

of a given equation involve (i) attempting to estimate the actual error (i.e., the difference between the true and the approximate solutions) and (ii) attempting to estimate the defect - the amount by which the approximation fails to satisfy the given equation and any side-conditions. The paper by Wayne Enright on defect control relates to carefully analyzed techniques that have been proposed both for ordinary differential equations and for delay differential equations in which an attempt is made to control an estimate of the size of the defect. Many phenomena incorporate noise, and the numerical solution of stochastic differential equations has developed as a relatively new item of study in the area. Keven Burrage, Pamela Burrage and Taketomo Mitsui review the way numerical methods for solving stochastic differential equations (SDE's) are constructed. One of the more recent areas to attract scrutiny has been the area of differential equations with after-effect (retarded, delay, or neutral delay differential equations) and in this volume we include a number of papers on evolutionary problems in this area. The paper of Genna Bocharov and Fathalla Rihan conveys the importance in mathematical biology of models using retarded differential equations. The contribution by Christopher Baker is intended to convey much of the background necessary for the application of numerical methods and includes some original results on stability and on the solution of approximating equations. Alfredo Bellen, Nicola Guglielmi and Marino Zennaro contribute to the analysis of stability of numerical solutions of nonlinear neutral differential equations. Koen Engelborghs, Tatyana Luzyanina, Dirk Roose, Neville Ford and Volker Wulf consider the numerics of bifurcation in delay differential equations. Evelyn Buckwar contributes a paper indicating the construction and analysis of a numerical strategy for stochastic delay differential

equations (SDDEs). This volume contains contributions on both Volterra and Fredholm-type integral equations. Christopher Baker responded to a late challenge to craft a review of the theory of the basic numerics of Volterra integral and integro-differential equations. Simon Shaw and John Whiteman discuss Galerkin methods for a type of Volterra integral equation that arises in modelling viscoelasticity. A subclass of boundary-value problems for ordinary differential equation comprises eigenvalue problems such as Sturm-Liouville problems (SLP) and Schrödinger equations. Liviu Ixaru describes the advances made over the last three decades in the field of piecewise perturbation methods for the numerical solution of Sturm-Liouville problems in general and systems of Schrödinger equations in particular. Alan Andrew surveys the asymptotic correction method for regular Sturm-Liouville problems. Leon Greenberg and Marco Marletta survey methods for higher-order Sturm-Liouville problems. R. Moore in the 1960s first showed the feasibility of validated solutions of differential equations, that is, of computing guaranteed enclosures of solutions. Boundary integral equations. Numerical solution of integral equations associated with boundary-value problems has experienced continuing interest. Peter Junghanns and Bernd Silbermann present a selection of modern results concerning the numerical analysis of one-dimensional Cauchy singular integral equations, in particular the stability of operator sequences associated with different projection methods. Johannes Elschner and Ivan Graham summarize the most important results achieved in the last years about the numerical solution of one-dimensional integral equations of Mellin type of means of projection methods and, in particular, by collocation methods. A survey of results on quadrature methods for solving boundary

integral equations is presented by Andreas Rathsfeld. Wolfgang Hackbusch and Boris Khoromski present a novel approach for a very efficient treatment of integral operators. Ernst Stephan examines multilevel methods for the h-, p- and hp- versions of the boundary element method, including pre-conditioning techniques. George Hsiao, Olaf Steinbach and Wolfgang Wendland analyze various boundary element methods employed in local discretization schemes.

Volterra Integral Equations - Hermann Brunner 2017-01-20

See publisher description :

The Analysis of Fractional Differential Equations - Kai Diethelm 2010-09-03

Fractional calculus was first developed by pure mathematicians in the middle of the 19th century. Some 100 years later, engineers and physicists have found applications for these concepts in their areas. However there has traditionally been little interaction between these two communities. In particular, typical mathematical works provide extensive findings on aspects with comparatively little significance in applications, and the engineering literature often lacks mathematical detail and precision. This book bridges the gap between the two communities. It concentrates on the class of fractional derivatives most important in applications, the Caputo operators, and provides a self-contained, thorough and mathematically rigorous study of their properties and of the corresponding differential equations. The text is a useful tool for mathematicians and researchers from the applied sciences alike. It can also be used as a basis for teaching graduate courses on fractional differential equations.

Operators of Fractional Calculus and Their Applications - Hari Mohan Srivastava (Ed.) 2019-01-16

This book is a printed edition of the Special Issue "Operators of Fractional Calculus and Their Applications" that was published in Mathematics

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; and methods 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 particular branches, 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

Principles of Differential and Integral Equations - C. Corduneanu 2008-05-09

In summary, the author has provided an elegant introduction to important topics in the theory of ordinary differential equations and integral equations. -- Mathematical Reviews This book is intended for a one-semester course in differential and integral equations for advanced undergraduates or beginning graduate students,

with a view toward preparing the reader for graduate-level courses on more advanced topics. There is some emphasis on existence, uniqueness, and the qualitative behavior of solutions. Students from applied mathematics, physics, and engineering will find much of value in this book. The first five chapters cover ordinary differential equations. Chapter 5 contains a good treatment of the stability of ODEs. The next four chapters cover integral equations, including applications to second-order differential equations. Chapter 7 is a concise introduction to the important Fredholm theory of linear integral equations. The final chapter is a well-selected collection of fascinating miscellaneous facts about differential and integral equations. The prerequisites are a good course in advanced calculus, some preparation in linear algebra, and a reasonable acquaintance with elementary complex analysis. There are exercises throughout the text, with the more advanced of them providing good challenges to the student.