Differential Equation Analysis Biomedical Engineering

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Differential Equation Analysis Biomedical Engineering ***2023-10-30***

OSBORN KAISER

Dictionary of Analysis, Calculus, and Differential Equations Elsevier
Mathematical models stated as systems of partial differential equations (PDEs) are broadly used in biology, chemistry, physics and medicine (physiology). These models describe the spatial and temporial variations of the problem system dependent variables, such as temperature, chemical and biochemical concentrations and cell densities, as a function of space and time (spatiotemporal distributions). For a complete PDE model, initial conditions (ICs) specifying how the problem system starts and boundary conditions (BCs) specifying how the system is defined at its spatial boundaries, must also be included for a well-posed PDE model. In this book, PDE models are considered for which the physical boundaries move with time. For example, as a tumor grows, its boundary moves outward. In atherosclerosis, the plaque formation on the arterial wall moves inward, thereby restricting blood flow with serious consequences such as stroke and myocardial infarction (heart attack). These two examples are considered as applications of the reported moving boundary PDE (MBPDE) numerical method (algorithm). The method is programmed in a set of documented routines coded in R, a quality, open-source scientific programming system. The routines are provided as a download so that the reader/analyst/researcher can use MFPDE models without having to first study numerical methods and computer programming.
Partial Differential Equation Applications with R Wiley
Presents numerical methods and computer code in Matlab for the solution of ODEs and PDEs with detailed line-by-line discussion. Method of Lines Analysis with Matlab John Wiley & Sons
This monograph presents teaching material in the field of differential equations while addressing applications and topics in electrical and biomedical engineering primarily. The book contains problems with varying levels of difficulty, including Matlab simulations. The target audience comprises advanced undergraduate and graduate students as well as lecturers, but the book may also be beneficial for practicing engineers alike.
Ordinary Differential Equations for Engineers CRC Press
Partial Differential Equations: Topics in Fourier Analysis explains how to use the Fourier transform and heuristic methods to obtain significant insight into the solutions of standard PDE models. It shows how this powerful approach is valuable in getting plausible answers that can then be justified by modern analysis. Using Fourier analysis, the text constructs explicit formulas for solving PDEs governed by canonical operators related to the Laplacian on the Euclidean space. After presenting background material, it focuses on: Second-order equations governed by the Laplacian on Rn The Hermite operator and corresponding equation The sub-Laplacian on the Heisenberg group Designed for a one-semester course, this text provides a bridge between the standard PDE course for undergraduate students in science and engineering and the PDE course for graduate students in mathematics who are pursuing a research career in analysis. Through its coverage of fundamental examples of PDEs, the book prepares students for studying more advanced topics such as pseudo-differential operators. It also helps them appreciate PDEs as beautiful structures in analysis, rather than a bunch of isolated ad-hoc techniques.
Moving Boundary PDE Analysis Princeton University Press
The trajectory of fractional calculus has undergone several periods of intensive development, both in pure and applied sciences. During the last few decades fractional calculus has also been associated with the power law effects and its various applications. It is a natural to ask if fractional calculus, as a nonlocal calculus, can produce new results within the well-established field of Lie symmetries and their applications. In Lie Symmetry Analysis of Fractional Differential Equations the authors try to answer this vital question by analyzing different aspects of fractional Lie symmetries and related conservation laws. Finding the exact solutions of a given fractional partial differential equation is not an easy task, but is one that the authors seek to grapple with here. The book also includes generalization of Lie symmetries for fractional integro differential equations. Features Provides a solid basis for understanding fractional calculus, before going on to explore in detail Lie Symmetries and their applications Useful for PhD and postdoc graduates, as well as for all mathematicians and applied researchers who use the powerful concept of Lie symmetries Filled with various examples to aid understanding of the topics
Variational Methods and Qualitative Analysis CRC Press
The intent of this book is to present a methodology for the formulation and computer implementation of mathematical models based on time delay ordinary differential equations (DODEs) and partial differential equations (DPDEs) in biomedical science and engineering (BMSE). The book applies DODE/DPDE models to biological/physiological systems through a series of examples. The first chapter has four example DODE applications that illustrate various properties of delayed systems. This discussion is then extended in the second chapter to an introductory DPDE model with the model solution presented as spatiotemporal numerical and 2D and 3D graphical (plotted) output. Subsequent chapters pertain to a series of DPDEBMSE applications. The author facilitates the use of the models with

reasonable time and effort on modest computers. The book is intended for medical researchers, medical clinicians, biophysicists, biochemists, biomedical engineers, chemical engineers, applied mathematicians, and applied numerical analysts. The book can also be used at the graduate level for courses in computer-based numerical analysis of delay differential equations. R routines are included throughout the text, and readers can access the R compiler (system) from the Internet to execute the downloaded R routines. • Introduces time delay ordinary and partial differential equations (DODE/DPDEs) and their numerical computer-based integration (solution) • Illustrates the computer implementation of DODE/DPDE models with coding (programming) in R, a quality, open-source scientific programming system readily available from the Internet • Applies DODE/DPDE models to biological/physiological systems through a series of examples • Provides the R routines for all of the illustrative applications through a download link • Facilitates the use of the models with reasonable time and effort on modest computers

Lie Symmetry Analysis of Fractional Differential Equations Cambridge University Press

This book has a two-fold purpose: An introduction to the computer-based modeling of influenza, a continuing major worldwide communicable disease. The use of (1) as an illustration of a methodology for the computer-based modeling of communicable diseases. For the purposes of (1) and (2), a basic influenza model is formulated as a system of partial differential equations (PDEs) that define the spatiotemporal evolution of four populations: susceptibles, untreated and treated infecteds, and recovereds. The requirements of a well-posed PDE model are considered, including the initial and boundary conditions. The terms of the PDEs are explained. The computer implementation of the model is illustrated with a detailed line-by-line explanation of a system of routines in R (a quality, open-source scientific computing system that is readily available from the Internet). The R routines demonstrate the straightforward numerical solution of a system of nonlinear PDEs by the method of lines (MOL), an established general algorithm for PDEs. The presentation of the PDE modeling methodology is introductory with a minumum of formal mathematics (no theorems and proofs), and with emphasis on example applications. The intent of the book is to assist in the initial understanding and use of PDE mathematical modeling of communicable diseases, and the explanation and interpretation of the computed model solutions, as illustrated with the influenza model.

Time Delay ODE/PDE Models Differential Equation Analysis in Biomedical Science and EngineeringPartial Differential Equation Applications with R

The essential introduction to the principles and applications of feedback systems—now fully revised and expanded This textbook covers the mathematics needed to model, analyze, and design feedback systems. Now more user-friendly than ever, this revised and expanded edition of Feedback Systems is a one-volume resource for students and researchers in mathematics and engineering. It has applications across a range of disciplines that utilize feedback in physical, biological, information, and economic systems. Karl Åström and Richard Murray use techniques from physics, computer science, and operations research to introduce control-oriented modeling. They begin with state space tools for analysis and design, including stability of solutions, Lyapunov functions, reachability, state feedback observability, and estimators. The matrix exponential plays a central role in the analysis of linear control systems, allowing a concise development of many of the key concepts for this class of models. Åström and Murray then develop and explain tools in the frequency domain, including transfer functions, Nyquist analysis, PID control, frequency domain design, and robustness. Features a new chapter on design principles and tools, illustrating the types of problems that can be solved using feedback Includes a new chapter on fundamental limits and new material on the Routh-Hurwitz criterion and root locus plots Provides exercises at the end of every chapter Comes with an electronic solutions manual An ideal textbook for undergraduate and graduate students Indispensable for researchers seeking a self-contained resource on control theory

Engineering Differential Equations CRC Press

Features a solid foundation of mathematical and computational tools to formulate and solve real-world ODE problems across various fields With a step-by-step approach to solving ordinary differential equations (ODEs), Differential Equation Analysis in Biomedical Science and Engineering: Ordinary Differential Equation Applications with R successfully applies computational techniques for solving real-world ODE problems that are found in a variety of fields, including chemistry, physics, biology, and physiology. The book provides readers with the necessary knowledge to reproduce and extend the computed numerical solutions and is a valuable resource for dealing with a broad class of linear and nonlinear ordinary differential equations. The author’s primary focus is on models expressed as systems of ODEs, which generally result by neglecting spatial effects so that the ODE dependent variables are uniform in space. Therefore, time is the independent variable in most applications of ODE systems. As such, the book emphasizes details of the numerical algorithms and how the solutions were computed. Featuring computer-based mathematical models for solving real-world problems in the biological and biomedical sciences and engineering, the book also includes: R routines to facilitate the immediate use of computation for solving differential equation problems without having to first learn the basic concepts of numerical analysis and programming for ODEs Models as systems of ODEs with explanations of the associated chemistry, physics, biology, and physiology as well as the algebraic equations used to calculate intermediate variables Numerical solutions of the presented model equations with a discussion of the important features of the solutions Aspects of general ODE computation through various biomolecular science and engineering applications Differential Equation Analysis in Biomedical Science and Engineering: Ordinary Differential Equation Applications with R is an excellent reference for researchers, scientists, clinicians, medical researchers, engineers, statisticians, epidemiologists, and pharmacokineticists who are interested in both clinical applications and interpretation of experimental data with mathematical models in order to efficiently solve the associated differential equations. The book is also useful as a textbook for graduate-level courses in mathematics, biomedical science and engineering, biology, biophysics, biochemistry, medicine, and engineering.

With Applications in R John Wiley & Sons

Iterative Splitting Methods for Differential Equations explains how to solve evolution equations via novel iterative-based splitting methods that efficiently use computational and memory resources. It focuses on systems of parabolic and hyperbolic equations, including convection-diffusion-reaction equations, heat

equations, and wave equations. In the theoretical part of the book, the author discusses the main theorems and results of the stability and consistency analysis for ordinary differential equations. He then presents extensions of the iterative splitting methods to partial differential equations and spatial- and time-dependent differential equations. The practical part of the text applies the methods to benchmark and real-life problems, such as waste disposal, elastics wave propagation, and complex flow phenomena. The book also examines the benefits of equation decomposition. It concludes with a discussion on several useful software packages, including r3t and FIDOS. Covering a wide range of theoretical and practical issues in multiphysics and multiscale problems, this book explores the benefits of using iterative splitting schemes to solve physical problems. It illustrates how iterative operator splitting methods are excellent decomposition methods for obtaining higher-order accuracy.

Asymptotic Analysis and the Numerical Solution of Partial Differential Equations John Wiley & Sons

Features a solid foundation of mathematical and computational tools to formulate and solve real-world PDE problems across various fields With a step-by-step approach to solving partial differential equations (PDEs), Differential Equation Analysis in Biomedical Science and Engineering: Partial Differential Equation Applications with R successfully applies computational techniques for solving real-world PDE problems that are found in a variety of fields, including chemistry, physics, biology, and physiology. The book provides readers with the necessary knowledge to reproduce and extend the computed numerical solutions and is a valuable resource for dealing with a broad class of linear and nonlinear partial differential equations. The author’s primary focus is on models expressed as systems of PDEs, which generally result from including spatial effects so that the PDE dependent variables are functions of both space and time, unlike ordinary differential equation (ODE) systems that pertain to time only. As such, the book emphasizes details of the numerical algorithms and how the solutions were computed. Featuring computer-based mathematical models for solving real-world problems in the biological and biomedical sciences and engineering, the book also includes: R routines to facilitate the immediate use of computation for solving differential equation problems without having to first learn the basic concepts of numerical analysis and programming for PDEs Models as systems of PDEs and associated initial and boundary conditions with explanations of the associated chemistry, physics, biology, and physiology Numerical solutions of the presented model equations with a discussion of the important features of the solutions Aspects of general PDE computation through various biomedical science and engineering applications Differential Equation Analysis in Biomedical Science and Engineering: Partial Differential Equation Applications with R is an excellent reference for researchers, scientists, clinicians, medical researchers, engineers, statisticians, epidemiologists, and pharmacokineticists who are interested in both clinical applications and interpretation of experimental data with mathematical models in order to efficiently solve the associated differential equations. The book is also useful as a textbook for graduate-level courses in mathematics, biomedical science and engineering, biology, biophysics, biochemistry, medicine, and engineering.

Theory and Applications CRC Press

Xie presents a systematic introduction to ordinary differential equations for engineering students and practitioners. Mathematical concepts and various techniques are presented in a clear, logical, and concise manner. Various visual features are used to highlight focus areas. Complete illustrative diagrams are used to facilitate mathematical modeling of application problems. Readers are motivated by a focus on the relevance of differential equations through their applications in various engineering disciplines. Studies of various types of differential equations are determined by engineering applications. Theory and techniques for solving differential equations are then applied to solve practical engineering problems. A step-by-step analysis is presented to model the engineering problems using differential equations from physical principles and to solve the differential equations using the easiest possible method. This book is suitable for undergraduate students in engineering.

Topics in Fourier Analysis Cambridge University Press

Stochastic differential equations are differential equations whose solutions are stochastic processes. They exhibit appealing mathematical properties that are useful in modeling uncertainties and noisy phenomena in many disciplines. This book is motivated by applications of stochastic differential equations in target tracking and medical technology and, in particular, their use in methodologies such as filtering, smoothing, parameter estimation, and machine learning. It builds an intuitive hands-on understanding of what stochastic differential equations are all about, but also covers the essentials of Ito calculus, the central theorems in the field, and such approximation schemes as stochastic Runge-Kutta. Greater emphasis is given to solution methods than to analysis of theoretical properties of the equations. The book's practical approach assumes only prior understanding of ordinary differential equations. The numerous worked examples and end-of-chapter exercises include application-driven derivations and computational assignments. MATLAB/Octave source code is available for download, promoting hands-on work with the methods.

Partial Differential Equations John Wiley & Sons

Differential Equations are very important tools in Mathematical Analysis. They are widely found in mathematics itself and in its applications to statistics, computing, electrical circuit analysis, dynamical systems, economics, biology, and so on. Recently there has been an increasing interest in and widely-extended use of differential equations and systems of fractional order (that is, of arbitrary order) as better models of phenomena in various physics, engineering, automatization, biology and biomedicine, chemistry, earth science, economics, nature, and so on. Now, new unified presentation and extensive development of special functions associated with fractional calculus are necessary tools, being related to the theory of differentiation and integration of arbitrary order (i.e., fractional calculus) and to the fractional order (or multi-order) differential and integral equations. This book provides learners with the opportunity to develop an understanding of advancements of special functions and the skills needed to apply advanced mathematical techniques to solve complex differential equations and Partial Differential Equations (PDEs). Subject matters should be strongly related to special functions involving mathematical analysis and its numerous applications. The main objective of this book is to highlight the importance of fundamental results and techniques of the theory of complex analysis for differential equations and PDEs and emphasizes articles devoted to the mathematical treatment of questions arising in physics, chemistry, biology, and engineering, particularly those that stress analytical aspects and novel problems and their solutions. Specific topics include but are not

limited to Partial differential equations Least squares on first-order system Sequence and series in functional analysis Special functions related to fractional (non-integer) order control systems and equations Various special functions related to generalized fractional calculus Operational method in fractional calculus Functional analysis and operator theory Mathematical physics Applications of numerical analysis and applied mathematics Computational mathematics Mathematical modeling This book provides the recent developments in special functions and differential equations and publishes high-quality, peer-reviewed book chapters in the area of nonlinear analysis, ordinary differential equations, partial differential equations, and related applications.

Spline Collocation Methods for Partial Differential Equations Springer

This contributed volume showcases research and survey papers devoted to a broad range of topics on functional equations, ordinary differential equations, partial differential equations, stochastic differential equations, optimization theory, network games, generalized Nash equilibria, critical point theory, calculus of variations, nonlinear functional analysis, convex analysis, variational inequalities, topology, global differential geometry, curvature flows, perturbation theory, numerical analysis, mathematical finance and a variety of applications in interdisciplinary topics. Chapters in this volume investigate compound superquadratic functions, the Hyers–Ulam Stability of functional equations, edge degenerate pseudo-hyperbolic equations, Kirchhoff wave equation, BMO norms of operators on differential forms, equilibrium points of the perturbed R3BP, complex zeros of solutions to second order differential equations, a higher-order Ginzburg–Landau-type equation, multi-symplectic numerical schemes for differential equations, the Erdős-Rényi network model, strongly m-convex functions, higher order strongly generalized convex functions, factorization and solution of second order differential equations, generalized topologically open sets in relator spaces, graphical mean curvature flow, critical point theory in infinite dimensional spaces using the Leray-Schauder index, non-radial solutions of a supercritical equation in expanding domains, the semi-discrete method for the approximation of the solution of stochastic differential equations, homotopic metric-interval L-contractions in gauge spaces, Rhoades contractions theory, network centrality measures, the Radon transform in three space dimensions via plane integration and applications in positron emission tomography boundary perturbations on medical monitoring and imaging techniques, the KdV-B equation and biomedical applications.

Fuzzy Differential Equations and Applications for Engineers and Scientists CRC Press

Based on the proceedings of the International Conference on Stochastic Partial Differential Equations and Applications-V held in Trento, Italy, this illuminating reference presents applications in filtering theory, stochastic quantization, quantum probability, and mathematical finance and identifies paths for future research in the field. Stochastic Partial Differential Equations and Applications analyzes recent developments in the study of quantum random fields, control theory, white noise, and fluid dynamics. It presents precise conditions for nontrivial and well-defined scattering, new Gaussian noise terms, models depicting the asymptotic behavior of evolution equations, and solutions to filtering dilemmas in signal processing. With contributions from more than 40 leading experts in the field, Stochastic Partial Differential Equations and Applications is an excellent resource for pure and applied mathematicians; numerical analysts; mathematical physicists; geometers; economists; probabilists; computer scientists; control, electrical, and electronics engineers; and upper-level undergraduate and graduate students in these disciplines.

Differential Equation Analysis in Biomedical Science and Engineering CRC Press

Most systems in science, engineering, and biology are of partial differential systems (PDSs) modeled by partial differential equations. Many books about partial differential equations have been written by mathematicians and mainly address some fundamental mathematic backgrounds and discuss some mathematic properties of partial differential equations. Only a few books on PDSs have been written by engineers; however, these books have focused mainly on the theoretical stabilization analysis of PDSs, especially mechanical systems. This book investigates both robust stabilization control design and robust filter design and reference tracking control design in mechanical, signal processing, and control systems to fill a gap in the study of PDSs. Robust Engineering Designs of Partial Differential Systems and Their Applications offers some fundamental background in the first two chapters. The rest of the chapters focus on a specific design topic with a corresponding deep investigation into robust H∞ filtering, stabilization, or tracking design for more complex and practical PDSs under stochastic fluctuation and external disturbance. This book is aimed at engineers and scientists and addresses the gap between the theoretical stabilization results of PDSs in academic and practical engineering designs more focused on the robust H∞ filtering, stabilization, and tracking control problems of linear and nonlinear PDSs under intrinsic random fluctuation and external disturbance in industrial applications. Part I provides backgrounds on PDSs, such as Galerkin's, and finite difference methods to approximate PDSs and a fuzzy method to approximate nonlinear PDSs. Part II examines robust H∞ filter designs for the robust state estimation of linear and nonlinear stochastic PDSs. And Part III treats robust H∞ stabilization and tracking control designs of linear and nonlinear PDSs. Every chapter focuses on an engineering design topic with both theoretical design analysis and practical design examples.

Cambridge University Press

Partial Differential Equations with Variable Exponents: Variational Methods and Qualitative Analysis provides researchers and graduate students with a thorough introduction to the theory of nonlinear partial differential equations (PDEs) with a variable exponent, particularly those of elliptic type. The book presents the most important variational methods for elliptic PDEs described by nonhomogeneous differential operators and containing one or more power-type nonlinearities with a variable exponent. The authors give a systematic treatment of the basic mathematical theory and constructive methods for these classes of nonlinear elliptic equations as well as their applications to various processes arising in the applied sciences. The analysis developed in the book is based on the notion of a generalized or weak solution. This approach leads not only to the fundamental results of existence and multiplicity of weak solutions but also to several qualitative properties, including spectral analysis, bifurcation, and asymptotic analysis. The book examines the equations from different points of view while using the calculus of variations as the unifying theme. Readers will see how all of these diverse topics are connected to other important parts of mathematics, including topology, differential geometry, mathematical physics, and potential theory.

Case Studies with MATLAB Springer Science & Business Media
A balanced guide to the essential techniques for solving elliptic partial differential equations Numerical Analysis of Partial Differential Equations provides a comprehensive, self-contained treatment of the quantitative methods used to solve elliptic partial differential equations (PDEs), with a focus on the efficiency as well as the error of the presented methods. The author utilizes coverage of theoretical PDEs, along with the nu merical solution of linear systems and various examples and exercises, to supply readers with an introduction to the essential concepts in the numerical analysis of PDEs. The book presents the three main discretization methods of elliptic PDEs: finite difference, finite elements, and spectral methods. Each topic has its own devoted chapters and is discussed alongside additional key topics, including: The mathematical theory of elliptic PDEs Numerical linear algebra Time-dependent PDEs Multigrid and domain decomposition PDEs posed on infinite domains The book concludes with a discussion of the methods for nonlinear problems, such as Newton's method, and addresses the importance of hands-on work to facilitate learning. Each chapter concludes with a set of exercises, including theoretical and programming problems, that allows readers to test their understanding of the presented theories and techniques. In addition, the book discusses important nonlinear problems in many fields of science and engineering, providing information as to how they can serve as computing projects across various disciplines. Requiring only a preliminary understanding of analysis, Numerical Analysis of Partial Differential Equations is suitable for courses on numerical PDEs at the upper-undergraduate and graduate levels. The book is also appropriate for students majoring in the mathematical sciences and engineering.

Applications in Biomedical Science and Engineering CRC Press
This book surveys the broad landscape of differential equations, including elements of partial differential equations (PDEs), and concisely presents the topics of most use to engineers. It introduces each topic with a motivating application drawn from electrical, mechanical, and aerospace engineering. The text has reviews of foundations, step-by-step explanations, and sets of solved problems. It fosters students’ abilities in the art of approximation and self-checking. The book addresses PDEs with and without boundary conditions, which demonstrates strong similarities with ordinary differential equations and clear illustrations of the nature of solutions. Furthermore, each chapter includes word problems and challenge problems. Several extended computing projects run throughout the text.