



Applications of fuzzy conformable Laplace transforms for solving fuzzy conformable differential equations

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Abstract

Conformable derivatives have deep connections with fractals and local fractional calculus. This paper presents a generalized concept of higher-order fuzzy conformable differentiability for fuzzy-valued functions and interprets higher-order fuzzy conformable differential equations using this concept. We propose the fuzzy conformable Laplace transform (FCLT) as an alternative to the fuzzy Sumudu integral transform, and fuzzy Shehu transform method; and establish some potential properties of FCLT, related to higher-order fuzzy conformable derivatives. The FCLT method is very convenient for solving fuzzy conformable linear higher-order differential equations. We illustrate linear second-order and linear fourth-order fuzzy conformable initial value problems having at most four and sixteen different solutions, respectively.

Keywords Fuzzy conformable Laplace transform · Strongly generalized conformable derivative · Fuzzy conformable differential equation · Fuzzy conformable initial value problem

1 Introduction

In the modeling of engineering and physical problems like there in classical mechanics, general relativity, electrodynamics, etc., the role of differential equations is very vast. Though on a broader perspective, the initial conditions are assumed to be defined exactly corresponding to the model, certain errors in experimental data or observational mea-

surements may effectuate incomplete, vague or uncertain information. Fuzzy differential equations can overcome these kinds of uncertainties.

Various analytical and computational methods are applied to solve fuzzy differential equations. See, for example, (Bede et al. (2007), Bede (2008), Khastan et al. (2009)). One of the adopted methods is fuzzy Laplace transform, which was introduced in Tofigh and Barkhordari (2010). Then an improved version of the results of Tofigh and Barkhordari (2010) and under what conditions fuzzy Laplace transform exists were stated in Salahshour and Allahviranloo (2013). Also, they fined out the solution for fuzzy second-order differential equations using fuzzy Laplace transform. Since then, many authors have used fuzzy Laplace transform to solve fuzzy ordinary differential equations (Latif et al. 2014; Ahmad et al. 2016; Elbassan et al. 2015). After the use of fuzzy Laplace transform, the fuzzy differential equations turn into an algebraic expression, so become easy to solve. A long ago, the fractional derivative caught the eyes of many researchers (Xiao-Jun et al. 2022, 2013). There are almost 25 definitions of fractional derivative (Ortigueira and Tenreiro 2015), but none of these definitions satisfy all the basic axioms of differentiation and integration. To overcome these drawbacks, the conformable derivative was first introduced by Roshdi et al. (2014) and after then the conformable Laplace transform was introduced by Abdeljawad (2015) and

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Advances in Fuzzy Integral and Differential Equations Tofigh Allahviranloo, Soheil Salahshour, 2021-07-25 As the title of the book suggests the topics of this book are organized into two parts The first part points out the fuzzy differential equations and the second one is related to the fuzzy integral equations The book contains nine chapters that six chapters are about fuzzy differential equations and three of them are about fuzzy integral equations In each part the chapters authors are going to discuss the topics theoretically and numerically All researchers and students in the field of mathematical computer and also engineering sciences can benefit from the subjects of the book

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Springer Handbook of Computational Intelligence Janusz Kacprzyk, Witold Pedrycz, 2015-05-28 The Springer Handbook for Computational Intelligence is the first book covering the basics the state of the art and important applications of the dynamic and rapidly expanding discipline of computational intelligence This comprehensive handbook makes readers familiar with a broad spectrum of approaches to solve various problems in science and technology Possible approaches include for example those being inspired by biology living organisms and animate systems Content is organized in seven parts foundations fuzzy logic rough sets evolutionary computation neural networks swarm intelligence and hybrid computational intelligence systems Each Part is supervised by its own Part Editor's so that high quality content as well as completeness are assured

Soft Numerical Computing in Uncertain Dynamic Systems Tofigh Allahviranloo, Witold Pedrycz, 2020-08-19 Soft Numerical Computing in Uncertain Dynamic Systems is intended for system specialists interested in dynamic systems that operate at different time scales The book discusses several types of errors and their propagation covering numerical methods including convergence and consistence properties and characteristics and proving of related theorems within the setting of soft computing Several types of uncertainty representation like interval fuzzy type 2 fuzzy granular and combined uncertain sets are discussed in detail The book can be used by engineering students in control and finite element fields as well as all engineering applied mathematics economics and computer science students One of the important topics in applied science is dynamic systems and their applications The authors develop these models and deliver

solutions with the aid of numerical methods Since they are inherently uncertain soft computations are of high relevance here This is the reason behind investigating soft numerical computing in dynamic systems If these systems are involved with complex uncertain data they will be more practical and important Real life problems work with this type of data and most of them cannot be solved exactly and easily sometimes they are impossible to solve Clearly all the numerical methods need to consider error of approximation Other important applied topics involving uncertain dynamic systems include image processing and pattern recognition which can benefit from uncertain dynamic systems as well In fact the main objective is to determine the coefficients of a matrix that acts as the frame in the image One of the effective methods exhibiting high accuracy is to use finite differences to fill the cells of the matrix Explores dynamic models how time is fundamental to the structure of the model and data and how a process unfolds Investigates the dynamic relationships between multiple components of a system in modeling using mathematical models and the concept of stability in uncertain environments Exposes readers to many soft numerical methods to simulate the solution function s behavior

Fractional Calculus - From Theory to Applications Christos Volos, Jesus Manuel Munoz-Pacheco, 2025-05-28 Over the last decade research activity in the field of fractional calculus has surged resulting in applications across a wide range of scientific disciplines From the physics of diffusion and transport phenomena to control theory and financial systems fractional calculus has proven valuable in numerous domains capturing the interest of the scientific community Therefore this book comprises six chapters each with the purpose of providing a brief overview of the subject of fractional calculus and its recent developments in theory and applications This book aims to serve as an updated and handy reference for university professors graduate students laboratory researchers as well as physicists and applied mathematicians who are interested in studying fractional calculus and its applications

Emerging Research on Applied Fuzzy Sets and Intuitionistic Fuzzy Matrices Adak, Amal Kumar, Manna, Debashree, Bhowmik, Monoranjan, 2016-11-17 The use of fuzzy logic has become prominent in a variety of fields and applications By implementing these logic sets problems and uncertainties are more effectively resolved Emerging Research on Applied Fuzzy Sets and Intuitionistic Fuzzy Matrices is a pivotal reference source for the latest scholarly perspectives on the interdisciplinary use of fuzzy logic theory focusing on the application of sets and matrices Highlighting theoretical framework and empirical research findings this book is ideally designed for academics practitioners upper level students and professionals interested in an innovative overview of fuzzy logic sets and matrices

Time Series, Fuzzy Analysis and Miscellaneous Topics Madan Lal Puri, 2011-08-02 Professor Puri is one of the most versatile and prolific researchers in the world in mathematical statistics His research areas include nonparametric statistics order statistics limit theory under mixing time series splines tests of normality generalized inverses of matrices and related topics stochastic processes statistics of directional data random sets and fuzzy sets and fuzzy measures His fundamental contributions in developing new rank based methods and precise evaluation of the standard procedures asymptotic expansions of

distributions of rank statistics as well as large deviation results concerning them span such areas as analysis of variance analysis of covariance multivariate analysis and time series to mention a few His in depth analysis has resulted in pioneering research contributions to prominent journals that have substantial impact on current research This book together with the other two volumes Volume 1 Nonparametric Methods in Statistics and Related Topics Volume 2 Probability Theory and Extreme Value Theory are a concerted effort to make his research works easily available to the research community The sheer volume of the research output by him and his collaborators coupled with the broad spectrum of the subject matters investigated and the great number of outlets where the papers were published attach special significance in making these works easily accessible The papers selected for inclusion in this work have been classified into three volumes each consisting of several parts All three volumes carry a final part consisting of the contents of the other two as well as the complete list of Professor Puri s publications

Quantum Theory and Fuzzy Systems: Traversing Uncertainty in Group Decision-Making and Social Networks Tofigh Allahviranloo, Sovan Samanta, 2025-05-21 This book dives into the fascinating intersection of quantum theory and fuzzy systems This work is inspired by quantum theory and its real world applications It bridges the gap between abstract theoretical concepts and practical implementations in quantum theory based group decision making and graph theory social networks Highlights Core concepts Begin with uncertainty in quantum theory and fuzzy systems and familiarise yourself with the basics of quantum graphs Real World Applications Explore methods for multi attribute group decision making choosing green building materials and evaluating wearable health devices renewable energy options and cell phones using quantum decision methods Advanced Exploration Investigate dynamic centrality measures for brain networks routing protocols centrality metrics link prediction and applications of quantum graphs Comprehensive topics Learn about green supplier selection investment decisions under uncertainty sustainable solar energy management and more Innovative approaches Examine topological indices dominance theory applications of quantum computing social fuzzy and quantum networks scenarios of co concurrence and optimization techniques in quantum graphs This comprehensive guide is an indispensable resource for students researchers and professionals who want to explore the applications of quantum theory in network science quantum computing and decision making Whether readers are experts or novices this book provides knowledge and practical insights to navigate the complexity of uncertainty in our networked world

Power Electronics Basics Yuriy Rozanov, Sergey E. Ryvkin, Evgeny Chaplygin, Pavel Voronin, 2015-04-23 Power Electronics Basics Operating Principles Design Formulas and Applications provides fundamental knowledge for the analysis and design of modern power electronic devices This concise and user friendly resource Explains the basic concepts and most important terms of power electronics Describes the power assemblies control and passive compon

Die Grundlagen der Ingenieurwissenschaften Horst Czichos, 2013-07-02 Die Grundlagen der Ingenieurwissenschaften in einem Band die mathematisch naturwissenschaftlichen Grundlagen Mathematik Physik Chemie die technologischen Grundlagen Werkstoffe

Technische Mechanik Technische Thermodynamik Elektrotechnik Messtechnik Regelungen und Steuerungstechnik Technische Informatik die Grundlagen der technischen Gestaltung Entwicklung und Konstruktion Produktion Betriebswirtschaft Normung Recht Patentwesen Insbesondere die Kapitel Technische Informatik Thermodynamik Werkstoffe Normung Recht und Patentwesen wurden in der 31 Auflage neu bearbeitet Das Buch ist eine wichtige Einstiegshilfe f r den Studenten und dient ihm als roter Faden f r das Studium F r den Ingenieur im Beruf ist es das aktuelle Nachschlagewerk ber alle Disziplinen hinweg **Stochastic Analysis in Production Process and Ecology Under Uncertainty** Bogusław Bieda,2012-06-02

The monograph addresses a problem of stochastic analysis based on the uncertainty assessment by simulation and application of this method in ecology and steel industry under uncertainty The first chapter defines the Monte Carlo MC method and random variables in stochastic models Chapter two deals with the contamination transport in porous media Stochastic approach for Municipal Solid Waste transit time contaminants modeling using MC simulation has been worked out The third chapter describes the risk analysis of the waste to energy facility proposal for Konin city including the financial aspects Environmental impact assessment of the ArcelorMittal Steel Power Plant in Krak w in the chapter four is given Thus four scenarios of the energy mix production processes were studied Chapter five contains examples of using ecological Life Cycle Assessment LCA a relatively new method of environmental impact assessment which help in preparing pro ecological strategy and which can lead to reducing the amount of wastes produced in the ArcelorMittal Steel Plant production processes Moreover real input and output data of selected processes under uncertainty mainly used in the LCA technique have been examined The last chapter of this monograph contains final summary The log normal probability distribution widely used in risk analysis and environmental management in order to develop a stochastic analysis of the LCA as well as uniform distribution for stochastic approach of pollution transport in porous media has been proposed The distributions employed in this monograph are assembled from site specific data data existing in the most current literature and professional judgment Trilogy Of Numbers And Arithmetic - Book 1: History Of Numbers And Arithmetic: An Information

Perspective Mark Burgin,2022-04-22 The book is the first in the trilogy which will bring you to the fascinating world of numbers and operations with them Numbers provide information about myriads of things Together with operations numbers constitute arithmetic forming in basic intellectual instruments of theoretical and practical activity of people and offering powerful tools for representation acquisition transmission processing storage and management of information about the world The history of numbers and arithmetic is the topic of a variety of books and at the same time it is extensively presented in many books on the history of mathematics However all of them at best bring the reader to the end of the 19th century without including the developments in these areas in the 20th century and later Besides such books consider and describe only the most popular classes of numbers such as whole numbers or real numbers At the same time a diversity of new classes of numbers and arithmetic were introduced in the 20th century This book looks into the chronicle of numbers and arithmetic

from ancient times all the way to 21st century It also includes the developments in these areas in the 20th century and later A unique aspect of this book is its information orientation of the exposition of the history of numbers and arithmetic

Neural Networks, Machine Learning, and Image Processing Manoj Sahni,Ritu Sahni,Jose M Merigo,2022-12-15 The text comprehensively discusses the latest mathematical modelling techniques and their applications in various areas such as fuzzy modelling signal processing neural network machine learning image processing and their numerical analysis It further covers image processing techniques like Viola Jones Method for face detection and fuzzy approach for person video emotion It will serve as an ideal reference text for graduate students and academic researchers in the fields of mechanical engineering electronics communication engineering computer engineering and mathematics This book Discusses applications of neural networks machine learning image processing and mathematical modeling Provides simulations techniques in machine learning and image processing based problems Highlights artificial intelligence and machine learning techniques in the detection of diseases Introduces mathematical modeling techniques such as wavelet transform modeling using differential equations and numerical techniques for multi dimensional data Includes real life problems for better understanding The book presents mathematical modeling techniques such as wavelet transform differential equations and numerical techniques for multi dimensional data It will serve as an ideal reference text for graduate students and academic researchers in diverse engineering fields such as mechanical electronics and communication and computer **Fuzzy**

Differential Equations and Applications for Engineers and Scientists S. Chakraverty,Smita Tapaswini,Diptiranjana Behera,2016-11-25 Differential equations play a vital role in the modeling of physical and engineering problems such as those in solid and fluid mechanics viscoelasticity biology physics and many other areas In general the parameters variables and initial conditions within a model are considered as being defined exactly In reality there may be only vague imprecise or incomplete information about the variables and parameters available This can result from errors in measurement observation or experimental data application of different operating conditions or maintenance induced errors To overcome uncertainties or lack of precision one can use a fuzzy environment in parameters variables and initial conditions in place of exact fixed ones by turning general differential equations into Fuzzy Differential Equations FDEs In real applications it can be complicated to obtain exact solution of fuzzy differential equations due to complexities in fuzzy arithmetic creating the need for use of reliable and efficient numerical techniques in the solution of fuzzy differential equations These include fuzzy ordinary and partial fuzzy linear and nonlinear and fuzzy arbitrary order differential equations This unique work provides a new direction for the reader in the use of basic concepts of fuzzy differential equations solutions and its applications It can serve as an essential reference work for students scholars practitioners researchers and academicians in engineering and science who need to model uncertain physical problems Advanced Fuzzy Logic Approaches in Engineering Science Ram, Mangey,2018-09-14 Fuzzy logic techniques have had extraordinary growth in various engineering systems The developments

in engineering sciences have caused apprehension in modern years due to high tech industrial processes with ever increasing levels of complexity Advanced Fuzzy Logic Approaches in Engineering Science provides innovative insights into a comprehensive range of soft fuzzy logic techniques applied in various fields of engineering problems like fuzzy sets theory adaptive neuro fuzzy inference system and hybrid fuzzy logic genetic algorithms belief networks in industrial and engineering settings The content within this publication represents the work of particle swarms fuzzy computing and rough sets It is a vital reference source for engineers research scientists academicians and graduate level students seeking coverage on topics centered on the applications of fuzzy logic in high tech industrial processes *Encyclopedia of Information Science and Technology, Fifth Edition* Khosrow-Pour D.B.A., Mehdi, 2020-07-24 The rise of intelligence and computation within technology has created an eruption of potential applications in numerous professional industries Techniques such as data analysis cloud computing machine learning and others have altered the traditional processes of various disciplines including healthcare economics transportation and politics Information technology in today's world is beginning to uncover opportunities for experts in these fields that they are not yet aware of The exposure of specific instances in which these devices are being implemented will assist other specialists in how to successfully utilize these transformative tools with the appropriate amount of discretion safety and awareness Considering the level of diverse uses and practices throughout the globe the fifth edition of the Encyclopedia of Information Science and Technology series continues the enduring legacy set forth by its predecessors as a premier reference that contributes the most cutting edge concepts and methodologies to the research community The Encyclopedia of Information Science and Technology Fifth Edition is a three volume set that includes 136 original and previously unpublished research chapters that present multidisciplinary research and expert insights into new methods and processes for understanding modern technological tools and their applications as well as emerging theories and ethical controversies surrounding the field of information science Highlighting a wide range of topics such as natural language processing decision support systems and electronic government this book offers strategies for implementing smart devices and analytics into various professional disciplines The techniques discussed in this publication are ideal for IT professionals developers computer scientists practitioners managers policymakers engineers data analysts and programmers seeking to understand the latest developments within this field and who are looking to apply new tools and policies in their practice Additionally academicians researchers and students in fields that include but are not limited to software engineering cybersecurity information technology media and communications urban planning computer science healthcare economics environmental science data management and political science will benefit from the extensive knowledge compiled within this publication Fuzzy Arbitrary Order System Snehashish Chakraverty, Smita Tapaswini, Diptiranjana Behera, 2016-08-09 Presents a systematic treatment of fuzzy fractional differential equations as well as newly developed computational methods to model uncertain physical problems Complete with

comprehensive results and solutions Fuzzy Arbitrary Order System Fuzzy Fractional Differential Equations and Applications details newly developed methods of fuzzy computational techniques needed to model solve uncertainty Fuzzy differential equations are solved via various analytical and numerical methodologies and this book presents their importance for problem solving prototype engineering design and systems testing in uncertain environments In recent years modeling of differential equations for arbitrary and fractional order systems has been increasing in its applicability and as such the authors feature examples from a variety of disciplines to illustrate the practicality and importance of the methods within physics applied mathematics engineering and chemistry to name a few The fundamentals of fractional differential equations and the basic preliminaries of fuzzy fractional differential equations are first introduced followed by numerical solutions comparisons of various methods and simulated results In addition fuzzy ordinary partial linear and nonlinear fractional differential equations are addressed to solve uncertainty in physical systems In addition this book features Basic preliminaries of fuzzy set theory an introduction of fuzzy arbitrary order differential equations and various analytical and numerical procedures for solving associated problems Coverage on a variety of fuzzy fractional differential equations including structural diffusion and chemical problems as well as heat equations and biomathematical applications Discussions on how to model physical problems in terms of nonprobabilistic methods and provides systematic coverage of fuzzy fractional differential equations and its applications Uncertainties in systems and processes with a fuzzy concept Fuzzy Arbitrary Order System Fuzzy Fractional Differential Equations and Applications is an ideal resource for practitioners researchers and academicians in applied mathematics physics biology engineering computer science and chemistry who need to model uncertain physical phenomena and problems The book is appropriate for graduate level courses on fractional differential equations for students majoring in applied mathematics engineering physics and computer science

Mathematical Methods in Interdisciplinary Sciences Snehashish Chakraverty, 2020-07-15 Brings mathematics to bear on your real world scientific problems

Mathematical Methods in Interdisciplinary Sciences provides a practical and usable framework for bringing a mathematical approach to modelling real life scientific and technological problems The collection of chapters Dr Snehashish Chakraverty has provided describe in detail how to bring mathematics statistics and computational methods to the fore to solve even the most stubborn problems involving the intersection of multiple fields of study Graduate students postgraduate students researchers and professors will all benefit significantly from the author's clear approach to applied mathematics The book covers a wide range of interdisciplinary topics in which mathematics can be brought to bear on challenging problems requiring creative solutions Subjects include Structural static and vibration problems Heat conduction and diffusion problems Fluid dynamics problems The book also covers topics as diverse as soft computing and machine intelligence It concludes with examinations of various fields of application like infectious diseases autonomous car and monotone inclusion problems

Recent Advances in Fuzzy Sets Theory, Fractional Calculus, Dynamic Systems and Optimization Said

Melliani,Oscar Castillo,2022-08-10 We describe in this book recent advances in fuzzy sets theory fractional calculus dynamic systems and optimization The book provides a setting for the discussion of recent developments in a wide variety of topics including partial differential equations dynamic systems optimization numerical analysis fuzzy sets theory fractional calculus and its applications The book is aimed at bringing together contributions from leading academic scientists researchers and research scholars to exchange and share their experiences and research results on all aspects of applied mathematics modeling algebra economics finance and applications It also provides an interdisciplinary platform for researchers practitioners and educators to present the most recent innovations trends and concerns as well as practical challenges encountered and solutions adopted in the fields of applied mathematics The published chapters address various aspects of academic scientists researchers and research scholars in many variety mathematical topics **New Trends in Differential and Difference Equations and Applications** Feliz Manuel Minhós,João Fialho,2019-10-14 This Special Issue aims to be a compilation of new results in the areas of differential and difference Equations covering boundary value problems systems of differential and difference equations as well as analytical and numerical methods The objective is to provide an overview of techniques used in these different areas and to emphasize their applicability to real life phenomena by the inclusion of examples These examples not only clarify the theoretical results presented but also provide insight on how to apply for future works the techniques used

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