ICAMΣ'24

The 3rd International Conference on Applied Mathematics in Engineering

ABSTRACTS BOOK

26-28 June 2024
Balikesir, Türkiye

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Abstracts Book

Edited by

Ibrahim Kucukkoc

Firat Evirgen

June, Balıkesir

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Preface

We are pleased to invite all participants to join "The 3rd International Conference on Applied Mathematics in Engineering (ICAME'24)," taking place between 26-28 June 2024 in Ayvalık, Balikesir, Türkiye.

This conference offers an ideal academic platform for researchers to present the latest research and emerging findings in optimization and applied mathematics across engineering, physics, chemistry, biology, energy, and statistics. It also provides a valuable opportunity to discuss advances in artificial intelligence and its impact on engineering and real-life challenges.

The conference will focus on contemporary applied mathematical problems worldwide, including fractional calculus and its real-life applications, operational research, mathematical modeling in engineering, artificial intelligence applications, optimization and control in engineering, non-linear dynamical systems and chaos, and optimization and control issues. In addition to 11 plenary & invited talks, 203 oral presentations will be given to an audience with over 220 participants from 26 countries.

ICAME'24 represents a significant milestone in our ongoing efforts to foster and advance international cooperation. In this scope, on behalf of the organising committee of the conference, we would particularly like to thank: plenary speakers Abdon Atangana (University of the Free State, South Africa), Ender Ozcan (University of Nottingham, United Kingdom), Albert C. J. Luo (Southern Illinois University Edwardsville, USA), Gerhard-Wilhelm Weber (Poznan University of Technology, Poland) and invited speakers Mukund N. Janardhanan (University of Warwick, United Kingdom), Eray Cakici (IBM Data Science & AI Elite, Germany), Zakia Hammouch (ENS Moulay Ismail University Morocco), Hossein Jafari (University of South Africa, South Africa) and Praveen Agarwal (Anand International College of Engineering, Jaipur, India) as well as the organisers of special sessions, and the members of the international scientific committee for their contributions and supports.

We extend our best wishes to all participants, hoping you leave with valuable insights, enhanced ideas, and newly formed or strengthened scientific networks. Wishing you an enjoyable and memorable conference.

On behalf of the organisation committee,

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Ramazan Yaman	*Dumitru Baleanu*	*Necati Ozdemir*	*Jordan Hristov*
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Conference Program

ICAME'24 - CONFERENCE PROGRAMME OUTLINE* (https://icame.balikesir.edu.tr)					
Day 1: Wednesday, 26 June 2024		**Day 2: Thursday, 27 June 2024**		**Day 3: Friday, 28 June 2024**	
08:00-09:30	**Registration**	08:30-09:00	**Registration**	08:30-09:00	**Registration**
09:30-10:00	**Opening Ceremony (Manyas Hall)** *Conference Chairs*	09:00-09:35	**Plenary Lecture-4 (Manyas Hall)** **Abdon Atangana**	09:00-10:40	**Parallel Sessions - 7** 09:00-09:20 09:20-09:40 09:40-10:00 10:00-10:20 10:20-10:40
10:00-10:35	**Plenary Lecture-1 (Manyas Hall)** **Dumitru Baleanu**	09:35-10:05	**Invited Speaker-3 (Manyas Hall)** **Zakia Hammouch**		
10:35-10:55	*Coffee Break*	*10:05-10:20*	*Coffee Break*	10:45-11:15	**Invited Speaker-6 (Manyas Hall)** **Hossein Jafari *[Online]***
10:55-11:30	**Plenary Lecture-2 (Manyas Hall)** **Ender Ozcan**	10:20-12:00	**Parallel Sessions - 4** 10:20-10:40 10:40-11:00 11:00-11:20 11:20-11:40 11:40-12:00	11:15-11:40	**Closing Ceremony**
11:35-13:15	**Parallel Sessions - 1** 11:35-11:55 11:55-12:15 12:15-12:35 12:35-12:55 12:55-13:15	12:05-12:35	**Invited Speaker-4 (Manyas Hall)** **Mukund Janardhanan**	12:00-19:00	**Social Tour** **Draft Schedule:** **12:00 Leaving from the Hotel** ***[Guided Tour]*** **14:00 Lunch - Pasalimani Rest.** ***[Scenic Tour]*** **15:45 Boat to Cunda Island** ***[1-hour free time]*** **18:00 Leaving Cunda** **19:00 Arriving at Hotel**
		12:35-13:05	**Wolfram Mathematica** ***Industry Session***		
13:15-14:25	*LUNCH*	*13:05-14:10*	*LUNCH*		
14:30-15:05	**Plenary Lecture-3 (Manyas Hall)** **Albert Luo - Online**	14:15-14:45	**Invited Speaker-5 (Manyas Hall)** **Eray Cakici**		
15:10-16:50	**Parallel Sessions - 2** 15:10-15:30 15:30-15:50 15:50-16:10 16:10-16:30 16:30-16:50	14:50-16:30	**Parallel Sessions - 5** 14:50-15:10 15:10-15:30 15:30-15:50 15:50-16:10 16:10-16:30		
16:50-17:05	*Coffee Break*	*16:30-16:45*	*Coffee Break*		
17:05-17:35	**Invited Speaker-1 (Manyas Hall)** **Jordan Hristov**	16:45-17:20	**Plenary Lecture-5 (Manyas Hall)** **Gerhard Wilhelm Weber *[Online]***		
17:35-18:05	**Invited Speaker-2 (Manyas Hall)** **Praveen Agarwal *[Online]***	17:25-19:05	**Parallel Sessions - 6** 17:25-17:45 17:45-18:05 18:05-18:25 18:25-18:45 18:45-19:05		
18:10-20:10	**Parallel Sessions - 3** 18:10-18:30 18:30-18:50 18:50-19:10 19:10-19:30 19:30-19:50 19:50-20:10				
		19:05-19:35	**Round-table Discussion** *(Manyas Hall)*		
		21:00	**GALA DINNER** *Kazdagi A La Carte*		

*This is the general outline of the conference program. The detailed program can be downloaded from the conference website.

Plenary Speakers

Dumitru Baleanu

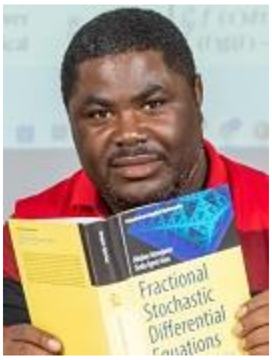
Lebanese American University, Lebanon
Institute of Space Sciences, Magurele-Bucharest, Romania, Email: dumitru.baleanu@lau.edu.lb

Fractional modelling versus the dynamics of some complicated systems

Fractional modelling is a developing concept with applications in various fields of science and engineering. In this talk I will discuss several real world problems within the fractional calculus approach.

Abdon Atangana

University of the Free State, South Africa, Email: atanganaa@ufs.ac.za



Crossover behaviors in nature: How to capture them with mathematics

Classical nonlocal behaviors can be replicated using differential operators based on kernels like power law, exponential decay, Mittag-Leffler, and others. However, processes with crossover behaviors cannot be depicted using these operators, which is why a different concept was introduced called piecewise differentiation. In this talk, the theory, method, and application of this concept will be presented.

Ender Ozcan

University of Nottingham, United Kingdom, Email: ender.ozcan@nottingham.ac.uk

Heuristic and metaheuristic approaches to topology optimisation for acoustic porous materials

Achieving specific noise reduction targets, such as lowering pollution in key frequencies, is a challenge for acoustic engineers in automotive, aerospace, and construction industries. While filling available space with sound-absorbing materials seems intuitive, strategically incorporating air cavities can lead to significantly better sound absorption, reduced weight, material savings, and potentially lower costs. This talk explores how heuristic and metaheuristic approaches empower engineers to optimise the design of acoustic porous materials. We will showcase how these methods, beyond the well-known Solid Isotropic Material with Penalisation (SIMP) technique, achieve this by efficiently handling the inherently multi-objective nature of the problem.

Albert C. J. Luo

Southern Illinois University Edwardsville, USA, Email: aluo@siue.edu

One-dimensional flows and infinite-equilibriums in planar polynomial systems

In this paper, the 1-dimensional source, sink and saddle flows are discussed first, and then the 1-dimensional parabola and inflection flows are presented. The singular source, sink, and saddle flows are the appearing and switching bifurcations for simple sink and source flow arrays, and for lower-order singular source, sink and saddle flow arrays. The singular parabola and inflection flows are the appearing and switching bifurcations of simple parabola arrays and lower-order singular parabola and inflection flows. Infinite-equilibriums in single-variable polynomial systems are discussed, which are for the appearing and switching bifurcations of source, sink, and saddle flows with parabola and inflections.

Gerhard-Wilhelm Weber

Poznan University of Technology, Poland, Email: gerhard.weber@put.poznan.pl

Optimal management of defined contribution pension funds under the effect of inflation, mortality and uncertainty

In the present work, we study the problem of optimal management of defined contribution pension funds, during the distribution phase, under the effect of inflation, mortality and model uncertainty. More precisely, we consider a class of employees, who, at the time of retirement, enter a life assurance con- tract with the same insurance firm. The fund manager of the firm collects the entry fees to a portfolio savings account and this wealth is to be invested optimally in a Black–Scholes type financial market. As such schemes usually last for many years, we extend our framework, by: (i) augmenting the financial market with an inflation-adjusted bond, and, (ii) taking into account mortality of the fund members. Model uncertainty aspects are introduced as the fund manager does not fully trust the model he/she faces. By resorting to robust control and dynamic programming techniques, we provide: (a) closed-form solutions for the case of the exponential utility function, (b) a detailed study of the qualitative features of the problem at hand that elucidates the effect of robustness and inflation on the optimal investment decisions.

Reference: I. Baltas, L. Dopierala, K. Kolodziejczyk, M. Szczepański, G.-W. Weber (presenter), A. N. Yannacopoulos (2022). Optimal management of defined contribution pension funds under the effect of inflation, mortality and uncertainty, European Journal of Operational Research, 298(3), 1162-1174.

Invited Speakers

Mukund Janardhanan

University of Warwick, United Kingdom, Email: mukund.janardhanan@warwick.ac.uk

Human-robot collaborative assembly systems

Epidemics make exciting news. They are often presented with dramatic headlines, and the pictures accompanying them are of healthcare workers dressed with protective equipment or working at labs. People often forget about the behind scenes work of mathematicians, who, with more or less simplified models, help on the understanding and prediction of infections spread. In this lecture I will focus on several within-host models useful for a deeper knowledge of virus dynamics with different specificities, namely HIV, HCV, HSV-2, etc.

Jordan Hristov

University of Chemical Technology and Metallurgy, Bulgaria

Fractional modeling approaches to transport phenomena: Causality as a guiding concept and model construction

The talk addresses basic principles in fractional modeling related to problems merging in nonlocal continua such as heat, mass, and momentum transfer, applied rheology, and other dynamic hereditary models. Two approaches have been considered: the constitutive approach based on fading memory and thermodynamic consistency and formalistic fractionalization. The analysis stresses the attention on the correct model build-up when kernels of various types, dictated by the relaxation behavior of the physical process modeled, have to be applied and their physical and mathematical adequacies.

Eray Cakici

IBM Data Science & AI Elite, Germany, Email: eray.cakici1@ibm.com

Constraint Programming - An Alternative Approach to Heuristics in Scheduling

This presentation will give an overview of constraint programming (CP) studies that involve different job scheduling problems. Mixed integer programming (MIP) and CP models are developed and tested on a set of common problem instances in the literature. Then, performances of models are compared against heuristics proposed in the literature for same type of problems. Computational results show that CP outperforms heuristics with respect to both solution time and solution quality. And when compared to optimal solutions, the results demonstrate that CP is capable of generating optimal or near optimal solutions in very short amount of times. Future adoption areas of CP will also be discussed along with deployment challenges of operations research (OR) projects.

Zakia Hammouch

Department of Medical Research, China Medical University Hospital, Taichung, Taiwan
ENS Moulay Ismail University Morocco, Morocco, Email: z.hammouch@umi.ac.ma

Towards a linear decoupled physical-property-preserving difference method for solving a fractional-order generalized Zakharov system

The talk aims to present an efficient physical-property-preserving algorithm for the space fractional-order generalized Zakharov system. Firstly, the space fractional-order generalized Zakharov system is reformulated as an equivalent system of equations by introducing the auxiliary equation. Then the spatial fourth-order physical-property-preserving linearly implicit difference scheme is developed for the transformed system. Subsequently, with the aid of the cut-off function and discrete energy analysis method, the underlying scheme are proven to be with the optimal order of $O(\Delta t2 + h4)$ in discrete L1 and L2 norms. The main feature of the new scheme is physical-property-preserving, linearly decoupled and easy to be applied in parallel computing, especially in long time simulations and large-scale problems. At last, numerical results are exhibited to substantiate the efficiency and preservation properties of our scheme, and investigate the dynamic behaviors of the collision of different solitary waves with subsonic and supersonic propagation speeds, respectively.

Hossein Jafari

Department of Mathematical Sciences, University of South Africa
Department of Applied Mathematics, University of Mazandaran, Babolsar, Iran, Email: jafari.usern@gmail.com

Application of Wavelet Operational Matrix Algorithms for Nonlinear and Fractional Differential Equations*

In this research work, an efficient Machine Learning-based Legendre wavelet method (ML-LWM) is utilised to estimate the parameters in ship damping models. Damping is critical for the roll motion response of a ship in waves. To the best of our knowledge, there is no Legendre Wavelet Method (LWM) has been reported to estimate the damping and restoring moments in ship dynamics models. LWM is applied to estimate roll angle, damping coefficients and restoring moments. Some numerical examples are given to demonstrate the validity and applicability of the proposed ML-LWM. The ML-LWM results are compared with the results obtained by the Homotopy Perturbation Method (HPM). Also, the proposed results are validated with the experimental data. Satisfactory agreement with experimental and HPM is noticed. The efficiency of the proposed wavelet method is confirmed by CPU runtime.

**In cooperation with G. Hariharan (SASTRA Deemed University, India)*

Praveen Agarwal

Anand International College of Engineering, Jaipur, India, Email: goyal.praveen2011@gmail.com

Extended Caputo k- type fractional derivative operator

Some fractional integral and derivative operators of any arbitrary order have gained considerable popularity and importance during the past few decades. The Caputo fractional derivative operator is one of the most popular of them which provides an improved formula for fractional derivatives. In this talk, we present some extensions of the k- hypergeometric functions and then develop the extended Caputo k- type fractional derivative operator by using two parameters k- Mittag-Leffler function. We also discuss some properties like generating functions and Mellin transform of the new extended Caputo k- type fractional derivative operator.

Special Sessions

Modelling & Optimization in Engineering

Ramazan Yaman, Istanbul Atlas University, Turkey
Ahmet Sahiner, Suleyman Demirel University, Turkey
Fırat Evirgen, Balikesir University, Turkey

Theme

The goal of this session is to discuss recent developments in applications of optimization methods by bringing together researchers and practitioners working in the field of optimization theory, methods, software and related areas.

Topics

Mathematical programming
Global optimization
Nondifferential optimization
Continuous optimization
Combinatorial optimization
Multicriteria optimization
Equilibrium programming
Game theory
Data mining
Population based algorithms
Artificial intelligence technologies
Applications of optimization in natural sciences
Applications of optimization in engineering

Operational Research

Gerhard-Wilhelm Weber, Poznan University of Technology, Poland
Aslan Deniz Karaoglan, Balikesir University, Turkey
Ibrahim Kucukkoc, Balikesir University, Turkey
Burcu Gurbuz, Johannes Gutenberg-University Mainz, Germany

Theme

This session aims to bring together researchers working on the topics related to operational research to discuss recent developments in the theory and application of operational research techniques.

Topics

Business analytics for manufacturing systems
Analytics, optimization and machine learning in manufacturing and supply chains
Intelligent manufacturing systems
Intelligent transpportation
Protfolio optimization
Network models
Inventory control, production planning and scheduling
Sustainable manufacturing
Robotics in manufacturing
Modeling, simulation, control and monitoring of manufacturing processes
Logistics, supply chains and networks
Facility planning and materials handling
Energy systems modelling
Design and reconfiguration of manufacturing systems

Fractional Calculus, Differential Equations and Artificial Intelligence in Complex Systems

Dumitru Baleanu, Lebanese American University, Lebanon
Yeliz Karaca, University of Massachusetts Chan Medical School (UMASS), Worcester, United States

Theme

Processes of fractional dynamics, differentiation and systems in complex systems as well as the dynamical processes and dynamical systems of fractional order with respect to natural and artificial phenomena are critical in terms of their modeling by ordinary or partial differential equations with integer order, ordinary and partial differential equations. Accordingly, fractional calculus and fractional-order calculus approach to provide novel mathematical models with fractional-order calculus employed in machine learning algorithms can ensure the obtaining of optimized solutions besides the justification of the requirement towards developing analytical and numerical methods. In that regards, complex systems and nonlinear dynamical systems are considered to be among the thriving models of natural phenomena, which are frequently characterized by unpredictable behavior whose analysis is challenging to be performed. The root of the problem lies in the understanding of which sort of information, especially concerned with their long-term evolution and memory properties, can be expected to be derived from those systems. Correspondingly, complexity, chaos, order and evolution all unravel the relationship between natural and social worlds, representing a modern process of thinking. Dynamical processes and dynamical systems of fractional order in relation to natural and artificial phenomena can be modeled by ordinary or partial differential equations with integer order, which can be described aptly by employing ordinary and partial differential equations. Thereafter, while the employment of artificial intelligence allows model accuracy maximization and functions' minimization like those of computational burden, novel mathematical-informed frameworks can enable a reliable and robust understanding of various complex processes that involve a variety of heterogeneous temporal and spatial scales. Such complexities necessitate a holistic understanding of different processes through integrative models with multi stages, being capable of capturing the significant attributes and peculiarities on the respective scales to expound complex systems whose behavior is confounding to predict and control with the ultimate goal of achieving a global understanding, while at the same time catching up with actuality along the evolutionary and historical path. Hence, the importance of generating applicable solutions to problems for various engineering areas, medicine, biology, mathematical science, applied disciplines and data science, among many others, requires predictability, interpretability and reliance on mathematical sciences, with Artificial Intelligence (AI) and machine learning being at the intersection with different fields marked by complex, chaotic, nonlinear, dynamic and transient components to validate the significance of the attained optimized approaches.

Based on this sophisticated integrative and multiscale approach with computer-assisted translations and applications, our special session aims at providing a bridge to merge an interdisciplinary perspective to open up new pathways and crossroads both in real systems and in other related realms.

Topics

Differentiability of solutions of differential equations with initial data
Advances of mathematical sciences, fractional calculus and differentiation
Fractional order differential, integral equations and systems
Computational methods of fractional order
Synchronization of dynamic systems on time scales
Data-driven fractional biological modeling
Data mining with fractional calculus methods
Fractional order observer design for nonlinear systems
Nonlinear modeling for epidemic/biological/neurological diseases
Fractional differential equations with uncertainty

Fractional dynamic processes in medicine
Image/signal analyses based on soft computing
Wavelet analysis and synthesis
Entropy of complex dynamics, processes and systems
Computational applied sciences
Control and dynamics of multi-agent network systems
Computational complexity
Nonlinear integral equations within fractional calculus in nonlinear science
Fractional dynamic processes in medicine
Fractional-calculus-based control scheme for uncertain dynamical systems
Computational intelligence-based methodologies and techniques
Bifurcation and chaos in complex systems
Mathematical analysis and modeling in complex systems
Quantum computation and optimization models of complex systems
Fractional mathematical modeling with computational complexity
Mathematical modeling and Artificial Intelligence in complex systems
Among many other related points with mathematical modeling

Control Theory & Applications

Metin Demirtas, Balıkesir University, Turkey
Amin Jajarmi, University of Bojnord, Iran

Theme
This session aims to discuss a broad range of topics including current trends of linear, nonlinear, discrete and fractional control systems as well as new developments in robotics and mechatronics, unmanned systems, energy systems with the goal of strengthening cooperation of control and automation scientists with industry.

Topics
Adaptive control
Linear and nonlinear control systems
Optimal control
Discrete time control systems
Robust control
Fractional order systems and control
Chaotic systems and control
Evolutionary and heuristic control
Robotic control
Energy management and control
Control of unmanned air and undersea vehicles

Fractional Calculus with Applications in Biology

Dumitru Baleanu, Lebanese American University, Lebanon
Zakia Hammouch, ENS Moulay Ismail University Morocco, Morocco
Necati Ozdemir, Balikesir University, Turkey

Theme
The goal of this session is to bring together creative and active researchers, in theoretical analysis and numerical tools, to discuss recent developments in applications of fractional order models of biological models. Fractional order models have become ubiquitous research topics in the last few decades. Their memory property contributes to a better and profound understanding of the dynamics of real world

models, namely of biological population problems. Stochastic and deterministic models and coinfection models, as well as computational models, are welcome for HIV, HCV, Ebola, Zika, etc, in this session.

Topics

New numerical methods to solve fractional differential equations
Deterministic and stochastic fractional differential equations
Computational methods for fractional differential equations
Bifurcation theory
Stability theory
Cancer development models: chaos, synchronization
Applications in bioengineering, medicine, ecology, biology, epidemiology

Numerical Methods in Fractional Calculus

Saptarshi Das, University of Exeter, United Kingdom
Mehmet Yavuz, Necmettin Erbakan University, Türkiye

Theme

In the few decades, fractional differential equations have played a very important role in various fields. Based on the wide applications in engineering and sciences such as physics, mechanics, chemistry, and biology, research on fractional ordinary or partial differential equations and other relative topics is active and extensive around the world. In the past few years, the increase of the subject is witnessed by hundreds of research papers, several monographs, and many international conferences. The objective of this special session is to highlight the importance of numerical methods and their applications and let the readers of this journal know about the possibilities of this new tool.

Topics

New methods for solving fractional differential equations
Controllability of fractional systems of differential equations or numerical methods applied to the solutions of fractional differential equations applications in physics, mechanics, and so forth
Iteration methods for solving partial and ordinary fractional equations
Numerical methods for solving fractional integro-differential equations
Numerical functional analysis and applications
Local and nonlocal boundary value problems for fractional partial differential equations
Stochastic partial fractional differential equations and applications
Computational methods in fractional partial differential equations
Numerical methods for solving variable order differential equations
Perturbation methods for fractional differential equations

Nonlinear Dynamical Systems and Chaos

Huseyin Merdan, TOBB ETU, Turkey
Songul Kaya Merdan, METU, Turkey

Theme

This special session focuses on the dynamics of complex systems, which are one of the most attractive subjects of the modern sciences. The attractiveness of this particular area arises from two different aspects: The first one is that it provides challenges, which are connected with many uncertainties in description of irregular motions. The second one is methods of investigation, which are not yet well developed and established. Applications of complex dynamics investigations are very important and deal with a wide range of problems. They begin with mechanical problems and extend to earthquake prediction and social sciences problems. We are interested in those investigations in electrical and mechanical engineering, physics, biology, economics, finance, neuroscience, computer sciences, fluid dynamics and earthquake monitoring, which urgently need mathematical modeling of their problems and analysis through nonlinear dynamical systems approach.

Topics

ODE, DDE and PDE based modelling for complex systems
Dynamical systems and chaos
Bifurcation theory
Synchronization
Control theory
Fluid Dynamics
Stochastic complex dynamical systems and randomness
Hybrid systems
Complex networks based-models
Neural Networks
Bio-engineering, bio-imaging and bio-fluids
Population dynamics and conservation biology
Ecosystems
Evolution and ecology
Epidemiology and disease modeling
Neuroscience
Regulatory networks
Cell and Tissue biophysics
Evolution and populations genetics
Cell and developmental biology
Cancer and immunology
Environmental sciences
Social economy systems
Climate change
Financial engineering
Mathematical finance

Nonlinear Transport Phenomena and Models

Jordan Hristov, Univ. of Chemical Tech. and Metallurgy, Bulgaria

Theme

The special session focuses on modelling of nonlinear transport phenomena (heat, mass and momentum) as well as models related to real world application. Models with both local and fractional differential operators involved in modelling in such models are welcome. The topics drawn below are the main directions but no restrictive and any new problems outside them are welcome.

Topics

Nonlinear diffusion and heat transfer (conduction)
Nonlinear viscoelasticity and plasticity
Modelling rheology of complex fluids, solids and granular systems (hydrodynamics, large strain deformations and mixing)
Nonlinear kinetic and rate equations and irreversible thermodynamics
Models of nonlinear biological and medical problems for real-world applications
Models for treatment of nonlinear signal processing and control
Nonlinear electrical and magnetic phenomena and nonlinear applied models in electrotechnics (nonlinear magnetic circuits, high frequency skin effects, supercapacitors, etc.)
Inverse problems in nonlinear models of transport phenomena
New nonlinear models (broad aspect)
Analytical and numerical methods for solution of nonlinear models
Scaling and dimensional analysis

Energy Management and Optimization

Ramazan Yaman, Istanbul Atlas University, Türkiye
Mutlu Yilmaz, Istanbul Atlas University, Türkiye
Necip Erman Atilla, TREDAS, Türkiye

Theme

This session aims to gather researchers in the field of power and energy systems to delve into recent developments in both the theoretical aspects and practical applications of electricity markets, including power system applications.

Topics

Optimization in Power Delivery and Generation
Demand Response and Participation in Electric and Energy Systems
Hybrid Electricity Markets and Their Integration into Existing Market Structures
Energy Storage Technologies and Solutions in Electric Industry
Energy Use in Residential Areas
Energy Usage in the Transport Sector and Electric Vehicles
Robust/Stochastic/Heuristic Control and Optimization Methods for Energy Systems
Decision Support Systems for Energy Systems
AI/ML-Based Energy Optimization Techniques
The Optimization of Distributed Renewable Energy Resources and the Electricity Market Control
Transmission Markets, Congestion Management, and Grid Reliability
Consolidation of Smart and/or Micro Grids and Distribution Networks, and Integrating in Electricity Markets
Geothermal Energy Systems
Energy Efficiency and Conservation

Theories and Applications of Discrete Fractional Operators

Thabet Abdeljawad, Department of Mathematics and Sciences, Prince Sultan University, Saudi Arabia
Sumati Kumari Panda, Department of Mathematics, GMR Institute of Technology, India

Theme

Fractional calculus was first proposed in the year 1695. Many well-known mathematicians, including Leibniz, L' Hospital, Riemann, and others, contributed to this study. The fractional calculus has been widely employed in a variety of fields due to its interesting memory effects and non-locality. In the last decade, it has become one of the most popular fields of applied mathematics.
Discrete fractional calculus was proposed very recently. Although discrete and fractional mathematics have always played an important role in mathematics, their importance has recently grown in several branches, including but not limited to topological indices, polynomials in graphs, molecular descriptors, differential of graphs, alliances in graphs, domination theory, complex systems, discrete fractional delta operator, discrete fractional nebla operators, discrete geometry, fractional differential equations, discrete fractional integral inequalities, discrete fractional differences, discrete fractional sums and more.
The collection will bring together primary research studies that explore the applications of discrete fractional with applications in engineering and the natural sciences.

Topics

Existence theory of discrete fractional order systems
New numerical methods for the solution of fractional difference equations
Dynamics of discrete fractional-order systems in engineering and natural sciences
Theory and application of q-fractional operators
Stability analysis of discrete fractional-order neural networks systems
Discrete fractional inequalities and iterative methods
Existence and uniqueness of solutions for discrete fractional equations
Monotonicity and convexity of fractional difference operators

Contents

Abstracts

Analyzing auto- and cross-correlation curves of Fluorescence Correlation Spectroscopy data by Brownian dynamics simulations and Monte-Carlo importance sampling

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Abstract

Total Internal Reflection Fluorescence Cross-Correlation Spectroscopy (TIR-FCCS) was developed as an experimental technique [1] for investigating hydrodynamic flows in close proximity to surfaces, operating on scales of tens of nanometers. Its primary advantage lies in the selective fluorescence emission from tracer particles near the surface, thus ensuring high sensitivity. The resultant correlation curves depend on flow parameters of interest, such as shear rate and slip length. An important parameter that defines the flow velocity on the surface is the so called slip length - non-zero slip length implies that the boundary velocity on the interface is non-zero. This boundary condition is important to know in order to describe flow behaviour correctly. In the present contribution we demonstrate the integration of detailed and reasonably realistic theoretical modeling using Brownian Dynamics simulations with precise correlation curve measurements using Monte-Carlo importance sampling to establish a quantitative method for deducing flow properties from experiments [2]. The approach is well-suited for efficient parallel computing, facilitating data analysis within reasonable computational timeframes. The methodology is applied to flow near a hydrophilic surface, revealing a slip length of less than 10nm, which can be taken for zero for all practical purposes.

Keywords: Brownian Dynamics, Cross-Correlation Spectroscopy, Monte-Carlo simulation

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A Decision Support System for Constrained Mechanical Design Problems: A Case Study for Aircraft Structural Optimization

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Abstract

With striking and notable characteristics, metaheuristic algorithms offer quite unique opportunities in solving particularly constrained optimization problems. In this context, the aim of this project is to develop a decision support system that adopts some well-regarded population based meta-heuristic algorithms for aerospace mechanical design optimization in a real-life case study. Thus, this study focuses on optimizing the stiffened panel, which is known to be one of the main components of aircraft fuselage. With the help of the MATLAB GUI extension, an interface is designed first. The aim here is to obtain parameters such as moment, shear forces, tensile strength, extensional forces and compressive strenght used in strength calculations of the stiffened panel from decision makers. Moreover, users are also allowed to set meta-heuristic algorithm parameters in accordance with such parameters. The calculations of the stiffened plate are carried out considering both strength and buckling specification constraints. As mentioned earlier, due to shortcomings of mathematical models under nonlinearity, the developed design optimization model is optimized via using a group of metaheuristic algorithms, which are shown to exhibiting outstanding performances in numerous studies. In this regard, population-based metaheuristic algorithms, namely the Particle Swarm Optimization Algorithm [1], Differential Evolution Algorithm [2] and Arithmetic Optimization Algorithm [3] are adopted by the developed decision support system to optimize geometric parameters. A comprehensive experimental study is carried out including calibration of several optimization parameters is conducted. Finally, as appropriate non-parametric statistical tests point out, significantly promising results can be obtained by the proposed approach.

Keywords: Metaheuristic Optimization Algorithms, Aircraft Fuselage Design Optimization, Structural Analysis, Population-based Metaheuristic Algorithms

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A New Method to Design Timelike Developable Surface with A Common Line of Curvature

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Abstract

The study aims to solve the problem of designing a timelike developable surface with a diagonalizable shape operator that has a non-null parametric curve as a line of curvature in three-dimensional Minkowski space. There are three cases for a given curve on the surface such as: first one is a timelike curvature line, the second case is a spacelike curvature line and its principal normal vector is a spacelike one as well as the third one is a spacelike curvature line whose principal normal vector is a timelike vector. This work is performed with the appropriate Serret-Frenet and Darboux frames for the non-null line of curvature and the timelike developable surface pair. The study describes the conditions that need to be satisfied for a surface to be categorized as a tangent surface, conical surface, or cylindrical surface. There are also provided examples and graphics.

Keywords: Timelike developable surfaces, Minkowski space, curvature line, Serret-Frenet frame, Darboux frame.

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Particle Swarm Optimization of the Mechanical Alloying Process for Magnesium-Based Composite

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Abstract

Mechanical alloying is an effective method for processing metallic powders. This method involves the use of mechanical forces to achieve atomic-level mixing between metallic powders [1]. This process entails the consolidation of one or more metallic powders under the influence of high-energy collisions and friction. Typically conducted using mechanical milling devices such as high-energy ball milling, this process results in atomic-level mixing due to collisions and deformation between the powders. The high-energy process can induce significant changes in the microstructure of the powders, thereby achieving the desired mechanical and physical properties [2]. Mechanical alloying finds widespread use in various industrial applications, particularly in enhancing the strength, hardness, wear resistance, and corrosion resistance of metallic materials. The homogeneous distribution of the alloy components can significantly improve the material performance. Moreover, this method is effective in the production of nanomaterials, enabling various applications in nanotechnology [2-3].

Particle Swarm Optimization (PSO) is an optimizing algorithm that mimics the collective behavior of natural phenomena. Designed to solve problems by drawing inspiration from social interactions, this algorithm operates through a group of particles searching for potential solutions within a solution space. These particles share potential solutions with each other to find the best solution and navigate through the problem domain accordingly. The simplicity, flexibility, and effectiveness of the algorithm have increased its popularity in various application domains. Optimization of the mechanical alloying process requires careful adjustment and control of various parameters. Parameters such as milling time and speed directly influence the microstructure of the material [3]. Determining the optimum milling time and speed is crucial for achieving the desired alloy homogeneity and material properties. In this context, this study applies the mechanical alloying process to AZ31 magnesium alloy with SiC reinforcement and produces the desired design through hot pressing. Parameters such as mechanical alloying time, milling rotation speed, and sintering temperature are defined as input values, whereas the compressive strength is evaluated as the output PSO is applied as an optimization method for composite production, resulting in cost and time savings.

Keywords: Mechanical alloying, composites, particle swarm optimization

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A Numerical Method Based on Boole Polynomial For the Hyperbolic Partial Differential Equations and the Error Analysis

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Abstract

In this study, a numerical method is presented for the approximate solution of hyperbolic partial differential equations. The Boole polynomial, its derivatives, and the collocation points are utilized in this numerical method. The problem of the hyperbolic partial differential equation, given as an algebraic equation, is transformed into a matrix equation containing the unknown Boole coefficients through the steps of the Boole collocation method. The Boole coefficients are determined by solving this matrix equation and then incorporated into the solution. As a result, a solution to the given problem is obtained in the form of the truncated Boole series. The Boole collocation method is applied to numerical examples of hyperbolic partial differential equations. In the first example, the exact solution of the problem is obtained, while in the others, the Boole solutions to the problem are derived for various values of N. Additionally, the values of the Boole solutions are compared in a table with the values obtained by using various numerical methods. In order to demonstrate the accuracy and reliability of the Boole collocation method, error analysis based on the residual function is developed. This method is implemented using MATLAB computer program codes, enabling quick access to results. Additionally, the results are presented in tables and a figure for comparison. In the conclusion section of the paper, it is mentioned that the Boole collocation method provides effective and accurate results, and it is suggested that it can be further developed to obtain solutions for other types of equations in future studies.

Keywords: Hyperbolic partial differential equations, Boole collocation method, error analysis

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A Comparative Study on the Automated Detection of Tuberculosis Bacteria in Sputum images through the use of Machine Learning Algorithms

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Abstract

Mycobacterium tuberculosis (MTB) bacteria are the common cause of tuberculosis (TB), an infectious disease that predominantly affects the lungs and other body areas. Latent tuberculosis infections frequently show no symptoms, but active infections can cause fever, weight loss, night sweats, coughing (sometimes with blood), and other symptoms (Bobba et al., 2023). This research aims to help develop automated technologies for tuberculosis diagnosis, which could enhance the efficacy and precision of tuberculosis screening and diagnosis procedures. The dataset used for this investigation consists of 928 sputum images with bounding boxes representing 3734 bacilli. When there is a distinct margin of separation between the classes of bacilli and non-bacilli regions, a Support Vector Machine (SVM) would help separate TB bacilli from background noise in the sputum images. A straightforward and understandable baseline for classification would be provided by using Logistic Regression (RL) to model the likelihood that a particular area in an image contains TB bacilli. TB bacilli clusters could be easily identified using K Nearest Neighbor (K-NN). This technique classifies regions of an image based on how similar their features are to those of neighbouring regions. Complex patterns in the sputum image that can be challenging to model using more straightforward methods could be captured by an artificial neural network (ANN). Naïve Bayes would be helpful for categorizing areas in sputum images according to the likelihood of noticing features given the class designation. Random Forest (RF) could help integrate many decision trees to increase classification accuracy when working with complicated, high-dimensional image data. The results demonstrate the dataset's ability to train precise classification algorithms for detecting TB. The dataset, which includes 928 sputum images with 3734 bacilli's bounding boxes annotated, would help develop and analyze classification models (Smith et al., 2023). This dataset is invaluable for developing sophisticated tuberculosis detection models and enhancing the diagnosis and treatment approaches for this pervasive infectious illness. Future work may entail improving the models and investigating new techniques to increase detection efficiency and accuracy.

Keywords: Infectious disease, modelling, machine learning, Tuberculosis.

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Statistical Properties of The Generalized Logistic-Type Function and Its Application to A Real-Life Dataset

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Abstract

In this paper, we investigate the generalized logistic-type function [1] and its first derivative as probability density function (pdf) and cumulative distribution function (cdf), respectively. For these distributions, we analyse important statistical properties such as hazard ratio, survival function, quantile function, moment, missing moments residual-life function, Renyi entropy, q-entropy and order statistics [2-3]. We also present graphs of the pdf and the hazard ratio of the generalized logistic-type function with respect to the parameters. Parameter estimation for the distribution of this generalized logistic-type function is performed using the maximum likelihood (MLL) technique. The dataset considered in this paper was collected by Professor Carlos Caldas of the Cambridge Research Institute and Professor Sam Aparicio of the British Columbia Cancer Centre in Canada. Briefly, the dataset consists of the clinical findings of 1904 individuals with breast cancer. The type_of_breast_surgery, cancer_type, cancer_type_detailed columns of our data indicate the types of breast cancer, and we first separate the data for each type of breast cancer according to these types. The most important column in the data for us is the overall_survival_months column. This is the column that shows the length of time (in months) that people with breast cancer lived from the time of the procedure until they died. The characteristics in the other columns show the clinical outcomes of the patients. We also perform parameter estimation for this dataset using the maximum likelihood method and compare the results with other distributions. We demonstrate the effectiveness of the generalized logistic-type function in modelling these selected datasets. Finally, the results of this study confirm the successful performance of the generalized logistic-type function on real-life datasets. These results support the usability of this function as a powerful modelling tool.

Keywords: Generalized logistic-type function, maximum likelihood method, moments, survival analysis, order statistics, entropy.

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The Circular Grid on Microstructure Stainless Steel Image using Correspondence Analysis with K-Means Clustering

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Abstract

Stainless steel (SS) is a material extensively used in daily life. However, when exposed to high temperatures, the sigma phase can occur and reduce the corrosion resistance. Five colors in this phase appear gradually from light brown (LBr), dark brown (DBr), bluish brown (BBr), light blue (LBl), to dark blue (DBl) which indicates a condition that is starting to corrode until rust forms. A series of laboratory processes were carried out to obtain corrosion images and then three observation locations (A, B, and C) were selected which were considered to have temperature differences. The independence between the color of the phase and three locations will be tested using a Correspondence Analysis (CA). To be able to carry out CA, the corrosion image goes through a color classification process using K-Means Clustering and other image processing. The result is that location A is independent of DBl, B with BBr, and C with LBr. This indicates that location A, which was affected by higher temperatures, was more corroded compared to other locations. Apart from that, this research will also look at the effects of the griding process, which is a form of data transformation and reduction, and its relationship with CA. The results show that the griding process can be carried out in sizes that are not too large, up to 8 pixels in diameter. The griding process is optimal at diameter 4 pixel, with data reduced by 94%, and CA results that are similar to the original. This research can become a basis for processing corrosion images on stainless steel and the benefits of the griding process in performing CA.

Keywords: Stainless steel, correspondence analysis, kmeans clustering

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A Novel Perspective for Solutions of the Gardner Equation using two Reliable Methods

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Abstract

The main goal of this article is to find different and new analytical and numerical solutions of the Gardner equation. The equation also known as the combined KdV–mKdV equation, clarifies several interesting physical phenomena, such as internal waves in a stratified ocean [1], long wave propagation in an inhomogeneous two-layer shallow liquid [2] and ion acoustic waves in plasma with negative ion [3]. In the study, based on septic B-spline approximation, a collocation method has been presented and implemented for the numerical solution of Gardner equation considering different parameter values of test problems. Also, Von-Neumann stability analysis has been performed which guarantees that the scheme is unconditionally stable [4-6]. Two test problems are properly solved by computing L_2 and L_∞ error norms for illustrate the suitability and credibility of the method and emphasized the importance of the method. It is made an inference that the numerical results match well with the analytical solutions, which indicates that the current B-spline collocation algorithm is an attractive and powerful algorithm. Also to indicate productivity of the method, the results are described both modally and in tabular form. The obtained results from both analytical and numerical methods show us that this study will be very useful for scientists concern with searching characteristics features of nonlinear phenomena in several fields of science.

Keywords: Gardner equation, collocation, septic B-Spline.

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A New Mathematical Model for Parallel Unrelated Additive Manufacturing Scheduling Problem

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Abstract

Additive manufacturing (AM) technologies have transformed modern manufacturing by allowing the production of complex shapes with specific mechanical properties [1,2]. The interest in this field has been growing day by day among academics and practitioners. Despite this, efficient scheduling of these processes can be difficult, especially when dealing with multiple parts with different specifications. This research tackles this issue by presenting a new mixed-integer linear programming (MILP) model designed for the parallel unrelated additive manufacturing scheduling problem. The goal of the model is to minimize the time taken to complete all tasks (makespan). A thorough computational analysis is carried out to assess the performance of the model via comparison with the existing model [3] in the literature. The MILP model is coded in Python and solved with Gurobi Optimizer. Results demonstrate improvements in algorithmic efficiency, paving the way for enhanced productivity and cost-effectiveness in additive manufacturing operations. This research contributes to the advancement of scheduling methodologies in AM.

Keywords: Additive manufacturing, scheduling, mathematical modelling, mixed-integer linear programming

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Case Study of Production Line Planning by Using Artificial Bee Colony Algorithm

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Abstract

Production process capacity management is crucial for the successful operation of businesses and meeting customer demands. Capacity refers to the maximum output a business can produce at a given time. Effective capacity management in response to demand increases customer satisfaction. Insufficient capacity during high demand periods can lead to delays, inventory issues and failure to fulfill customer orders on time. Appropriate capacity management enhances overall business efficiency. If capacity exceeds demand, resources are wasted and costs increase. On the other hand, if capacity is lower than demand, the business becomes inefficient, production processes suffer and costs rise. Good planning involves forecasting demand, efficiently managing production processes, allocating resources accurately and adjusting capacity according to demand. This study aims to find solutions for the multiple production planning problem using intuitive and artificial bee colony algorithms. The goal of this study is to place product models on the production line according to constraints. A Java-based application was developed for this purpose, and various placement tests were conducted. Currently, production plans are manually prepared based on the user's experience without using any scientific method, which is both time-consuming and cumbersome. To overcome such challenges, this study introduces a rule-based expert system, Artificial Bee Colony intuitive methods for production planning through the development of a visual application

Keywords: Scheduling, optimization, artificial bee colony algorithm, production, production planning

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Improving Diagnosis of Pneumonia Among Population: A Machine Learning Method Using Deep Learning, Reinforcement Learning, and Agent-Based Modeling on Chest X-Ray Images

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Abstract

Pneumonia is a serious illness that inflames the air sacs in the lungs. It is a major cause of death, more so than other infectious diseases like HIV, malaria, and tuberculosis, especially in children under the age of five (Shermila & Anusha, 2023). Pneumonia is usually diagnosed based on physical examination findings and symptoms, frequently corroborated by chest X-ray results. The research aims to increase the efficiency and accuracy of pneumonia diagnosis, especially in pediatric populations, by achieving high classification accuracy, sensitivity, and specificity. There are 5,856 validated chest X-ray images in the dataset utilized in this research. There are training and testing sets of these images from different patients. The disease state (NORMAL/BACTERIA/VIRUS), an image number, and a randomized patient ID are all labelled on each image. The dataset is meant for classification model development, training, and testing. The dataset is meant to be used in the development, training, and testing of classification models, particularly those that make use of agent-based modelling (ABM), deep learning (DL), and reinforcement learning (RL). These models are intended to increase the precision and efficacy of pneumonia diagnosis, particularly in younger patients (less than 5 years old). The dataset is helpful in developing and evaluating pneumonia diagnosis classification models. Particularly in pediatric populations, machine learning algorithms like DL, RL, and ABM exhibit the potential for enhancing the precision of pneumonia diagnosis (Shankar et al., 2023). Utilizing machine learning techniques such as DL, RL, and ABM can potentially enhance patient outcomes by increasing pneumonia diagnosis accuracy and efficiency. To further enhance pneumonia diagnosis and therapy, future research endeavors may optimise these models and broaden the dataset.

Keywords: Infectious disease, modelling, machine learning, pneumonia

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Fermat Collocation Method for Solving Fractional Order Differential Equations with Variable Coefficients

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Abstract

A new method has been developed to obtain approximate solutions of fractional order linear differential equations under given initial conditions. In this method, called Fermat Collocation Method (FCM), fractional differential equations for ordering points are converted into matrix equations by using Fermat polynomials and Caputo fractional derivative of power function. Since algebra operations in matrices are easy, the applied method does not have any difficulties. Moreover, calculations can be made easily by entering the necessary codes into ready-made package programs by making use of computers. Thus, it can be said that Fermat Collocation Method is an alternative and effective method that can be used to obtain analytical or approximate solutions of fractional differential equations. Here, the formation of the method and how to calculate the error of the solutions found with the method used are mentioned.

Keywords: Fermat polynomial, fractional differantial equations, systems of fractional differantial equations, collocation method, residuel error

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Performance Evaluation of Linear Regression Models Based on Specific Features in the Turkish Second-Hand Car Market

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Abstract

The automotive industry experiences steady growth and intense competition annually. In the second-hand car market, accurate pricing is critical for both sellers and customers [1]. Customers, especially those unfamiliar with automotive details, often face challenges during car purchases, making reliable price predictions valuable [2]. Linear regression methods can assist in providing these accurate price estimates by analyzing various car attributes [3,4]. This study aims to evaluate the performance of linear regression models in predicting second-hand car prices in Turkey by considering various car attributes. Using data from Turkey's leading second-hand car platform, arabam.com, we developed and compared several linear regression-based models, including Linear Regression, Ridge, Lasso, and Elastic Net. The dataset, collected over three months in 2023, included over 17,000 records with 25 different attributes, such as brand, model, age, mileage, and fuel type. Our findings indicate that while traditional Linear Regression provides a solid baseline, models like Ridge, Lasso, and Elastic Net significantly improve prediction accuracy by addressing multicollinearity and enhancing feature selection. The performance of these models was thoroughly compared to determine their effectiveness in price prediction.
This study demonstrates the potential of linear regression algorithms to enhance the transparency and efficiency of the second-hand car market in Turkey. By providing accurate price estimates, these models can help customers make informed buying decisions and assist sellers in setting competitive prices, ultimately contributing to a fairer and more efficient marketplace.

Keywords: Car Price Prediction, Regression Techniques, Ridge, Lasso, Elastic net

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Predicting Cryptocurrency Prices Using Artificial Intelligence Methods: The Case of Bitcoin

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Abstract

Cryptocurrencies are one of the most talked about, discussed and interesting financial assets recently. In this study, Bitcoin prices, which represent approximately 52% of the crypto asset markets in terms of market capitalization, are predicted by machine learning and deep learning algorithms. As forecast input variables, Bitcoin's high, low and opening prices, Bitcoin trading volume, four US stock market indices (NASDAQ, Dow Jones Industrial Average, S&P500, Russell 2000), two commodity price indices (gold, crude oil), CBOE 10-year interest rate, DAX performance index, volatility index (VIX) and various technical indicators are used. The findings obtained as a result of the study are evaluated in terms of R2, MAPE, RSE and MAE performance measurement methods and it is determined which method has the more successful prediction performance. According to the findings of the study, machine learning algorithms were found to be more successful than deep learning algorithms in predicting the closing price of Bitcoin, and the most successful methods were determined to be random forest (RF) and extreme gradient boosting (XGBoost), respectively. Finally, the results of the study are important for Bitcoin investors to make informed decisions in the crypto asset market and for risk optimization of risk managers. The parameter information used in this prediction can be generalized for subsequent Bitcoin predictions.

Keywords: Bitcoin, Cryptocurrency, Machine Learning, Deep Learning, Artificial Intelligence.

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Investigation of Volatility Relationships among Global Indices: TVP-VAR Approach

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Abstract

The aim of this study is to analyze the dynamic connectedness relationship between global indices. In this context, the volatility relationships between Bitcoin, oil, gold, S&P 500 index, US 10-year bond interest and US dollar index are examined for the period 24.04.2015-19.03.2024. The analysis period also includes the period during which the Covid-19 pandemic occurred. The TVP-VAR approach with a time-varying covariance structure developed by Antonakakis and Gabauer (2017) is used as the analysis method in the study. As a result of the study, it was determined that the relevant variables, the US 10-year bond rate and S&P500 variables, emit net volatility to other variables; oil, gold, US dollar index and Bitcoin variables have also been found to be net volatility receivers. On the other hand, the fact that Bitcoin has less volatility relationship with other variables shows that Bitcoin can provide potential benefits in terms of portfolio diversification with relevant variables. In addition, since the total volatility value among the variables is low, the relevant variables can be used together in international portfolio diversification. This situation is important for decision makers on issues such as portfolio management and risk management.

Keywords: Covid-19, Global Indices, TVP-VAR Approach, Volatility Spillover.

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Stability analysis of the solution of coupled sine-Gordon equations via the dual reciprocity boundary element method

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Abstract

In this study, two-dimensional, time dependent, nonlinear, coupled sine-Gordon equations (CSGE) is solved using the dual reciprocity boundary element method (DRBEM). The DRBEM provides to transform the domain integral, caused by the inhomogeneous terms, into the boundary integral by approximating with thin plate spline [1]. DRBEM formulation is derived using the fundamental solution of the modified Helmholtz equations (MHE)'s [2]. In order to write the original equations in the form of MHE, time dervatives are expanded using finite difference. The principle purpose of this study is to show that DRBEM is a successful alternative for the solution of CSGE. The numerical stability of DRBEM applied to CSGE's using the matrix of the difference scheme by following and modifying the references [3] and [4]. Method is tested with the examples which have the analitical solution. The study also includes the solutions of other examples in the literature. Numerical experiments show that obtained results are in good agreement with other studies where the problem has been solved before and thus DRBEM is effective and accurate for the solution of CSGE [5].

Keywords: Coupled sine-Gordon equation (CSGE), Dual Reciprocity Boundary Element Method (DRBEM), Finite Difference Method (FDM), modified Helmholtz equation (MHE).

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Application of dual reciprocity boundary element method for 2D coupled sine-Gordon equations

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Abstract

This research paper introduces an application of dual reciprocity boundary element method (DRBEM) for the solution of coupled sine-Gordon equation (SGE) in two-space-dimension. Initially, the time derivatives are expanded using central difference schemes. After inserting the finite difference approximations into the governing equation, the pattern of the modified Helmholtz equation is obtained. The fundamental solution of modified Helmholtz equation is employed in the integral equation formulation. The inhomogeneous terms of the equation cause a domain integral in the integral equation formulation which leads to loss of advantage of the method. The DRBEM provides to transform the domain integral into the boundary integral by approximating the inhomogeneous term of the equation with thin plate spline [1] and [2]. First, code validation of the procedure is done using a test problem and then proposed method is applied for several cases of ring solitons to display its capacity to treat of the problem. Presented numerical results are observed to be in good agreement with other numerical results available in the literature [3].

Keywords: Coupled sine-Gordon equation (CSGE), Dual Reciprocity Boundary Element Method (DRBEM), Finite Difference Method (FDM), modified Helmholtz equation (MHE).

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On The Use of Genetic Algorithms for Dynamic Employee Assignment Problem

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Abstract

In today's dynamic and fast-paced work environments, ensuring balanced assignments among employees is a critical challenge. Considering the cost of acquiring and training new employees, it is essential to nurture a sense of justice through a balanced distribution of assignments. The goal is to distribute the assignments to employees with minimized workload disparity with consideration of employee's experience. The literature includes various studies on static optimization problems where the data remains constant; however, most real-life problems continuously change due to uncertainties introduced by future events [1]. In this study, we define an assignment problem in which the assignments are 1 to many, and the workload of workstations and the number of employees are dynamic over time. This problem can be modeled as a Multidimensional Assignment Problem (MAP), which is a higher-dimensional version of the linear assignment problem [2,3]. MAP is NP-hard and the dynamic nature of our problem requires it to be solved periodically. Although there are established polynomial time algorithms such as the Hungarian Algorithm, their efficiency decreases while the size of data increases and the problem is dynamic. Meta-heuristic algorithms are shown to be more efficient in finding a near optimal solution in a reasonable time for complex problems [4,5]. Genetic algorithms provide a robust search technique for problems with potentially intricate relationships and dynamic elements [6]. This paper explores the application of a genetic algorithm to find optimal, periodic assignments that minimize workload disparity while ensuring every employee has an assignment within par of their experience at each evaluation period.

Keywords: Multidimensional assignment problem (MAP), Dynamic Assignment Problem, Genetic Algorithm, Meta-Heuristics

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Investigation of the Countries According to Mining Raw Material Production by Cluster Analysis

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Abstract

The energy economy is important for both finance and politics. The economic impact depends on the continuity of the industry or the creation of new occupations. Future prices depend on the amount of production. In this study, the trend of the producer countries is determined by the cluster analysis of the mineral raw material production amount (meters) of the countries in 2018. In the clustering method, no predictions are made for the future. Similarity and dissimilarity measures in the data set are taken into account. According to the results, China is in the first cluster as a raw material producer country. USA and Russia are in the second cluster and Turkey is in the third cluster. The fouth cluster consists of Australia, India, Saudi Arabia and Indonesia. The contribution of this study to the sector is to increase the production of nuclear energy resources such as uranium, which we lack, and other mineral production, and to become one of the world's states that produce the most.

Keywords: Mineral raw materials, production, cluster analysis, trend

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Boole Matrix Method For the Numerical Solution of the Nonlinear Delay Differential Equation And the Error Analysis

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Abstract

In this article, we present a numerical method developed using Boole polynomials, their derivatives, and the collocation points to investigate solutions of nonlinear delay differential equations. Firstly, by employing the matrix form of the serial solution, the algebraic equation is converted into a matrix equation that includes the unknown Boole coefficients. The matrix forms of the problem's conditions are applied to this matrix equation, resulting in a new matrix equation. From the solution of this matrix equation, the Boole coefficients are obtained and written in the solution. As a result, the solution is expressed in truncated Boole series form. Numerical examples of linear and nonlinear delay differential equations are included in the study to demonstrate the applicability and reliability of the Boole matrix method. The exact solution of the given problem of the nonlinear delay differential equations in the first example has been obtained using the developed method. In other numerical examples, linear and nonlinear delay differential equations have been considered. The Boole solutions of these examples have been investigated for various values of N. Additionally, absolute error analysis has been applied to verify the accuracy of the results. The results obtained have been compared with the help of tables and graphics. The Boole matrix method has been written in MATLAB computer program code, thus allowing quick access to the results. The Boole matrix method is an effective and reliable approach for solving delay differential equations. This method can be applied to equations such as partial differential equations and nonlinear integro-differential equations.

Keywords: Nonlinear delay differential equations, Boole matrix method, error analysis

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Closed Form Expressions of the Resonance Frequencies and Bifurcation Criteria for Common Compensation Schemes in Inductive WPT Systems

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Abstract

Wireless power transfer (WPT) systems find applications in many different fields such as electric vehicles (EVs), mobile devices, drones, biomedical devices and home appliances [1]-[5]. Two widely-studied types are capacitive WPT systems and inductive WPT systems; The first type uses a pair of capacitors (four plates) in which energy is transferred via an electric field, while the second type uses a pair of loosely coupled coils in which energy is transferred via a magnetic field. For high-power applications such as electric vehicle chargers, inductive WPT systems are preferred because the maximum electric field levels allowed in capacitive WPT systems are limited by the relevant authorities [6]. The inductive reactance of the coils needs to be compensated for maximizing the transferred power level from source to the load. A suitable compensation scheme depends on the application and design specs such as power level, tolerance to load and coupling level.

In this abstract, compensation schemes commonly used in inductive WPT systems are presented in a comparative manner, along with their pros and cons. Lumped element circuit models are generally used in the design and analysis process. Based on these models, closed-form expressions of resonance frequencies and bifurcation criteria are provided for all these compensation schemes, with special emphasis on series-series (SS) and series-parallel (SP) schemes. These expressions can be considered as resources that can be easily found during the initial design process. Moreover, such statements can be easily applied to embedded system codes in the controllers of WPT systems. The correctness of derived expressions is verified by comparing the results obtained from these expressions with the results obtained from a circuit simulator.

Keywords: Wireless power transfer systems, compensation schemes, bifurcation

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Demand Forecast and Inventory Replenishment Framework for Retail Industry

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Abstract

The key obstacles in retail operations include limited warehouse space, operational complications, inventory issues, and unfulfilled orders. In this study, we focus on challenges in demand forecasting-based inventory planning, stock optimization, and supply chain management through the establishment of inventory management plans. The main goal of this study is to create an effective inventory management policy that prevents excess stock and ensures timely placement of products on the shelves, while also increasing warehouse efficiency and space utilization. It also aims to improve the distribution process between the existing warehouse and stores by using data-based demand forecasting.

In this study, we proposed a framework that uses a variety of strategies to tackle the problems arising in inventory management. In the first phase of the framework, an ABC analysis is employed to oversee items according to projected demand. In the second part of the framework, the K-means Clustering Method is used to find the stores with similar characteristics by using the categorization found in ABC analysis. In the third phase, demand forecasting of stores in similar clusters was made using methods such as Multilinear Regression, XGBoost, Decision Tree, and Random Forest analysis. Finally, through the projected demand found, we introduce a mathematical model to determine the optimal inventory replenishment policy for stores located within the same region.

We have tested the proposed framework in a fast-fashion clothing company that is operating with nearly 240 stores. The preliminary results show that a substantial cost reduction in the inventory operations could be achieved via the proposed framework. This study has the potential to help retailers develop more effective inventory management systems and increase customer satisfaction.

Keywords: Fashion retail industry, Inventory management, Demand forecasting, Optimization

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Searching for Efficient Inference in Belief Networks by Using Artificial Immune Systems

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Abstract

A Bayesian belief network also known as Bayesian network, causal network, belief network or causal probabilistic network is directed acyclic graph (DAG), where each node represents a random variable with a number of possible states (domains). Arcs represent the direct causal relationships between the linked variables, and the strength of these relationships is measured by conditional probabilities.

The process of calculating the probability of a set of variables in a belief network, given evidence on a subset of the remaining variables, is known as probabilistic inference [2]. The computational cost of inference is mainly the cost of multiplying joint probabilities. The full joint probability distribution of a belief network can be computed with a time complexity that grows exponentially with the number of nodes of the network. It is proved that this computation is NP-Hard [1].

Li and D'Ambrossio [2] stated that finding an efficient solution for inference problem in belief networks is similar to the problem called "Optimal-Factoring Problem", which is also an NP-Hard problem. The efficiency of probabilistic inference in a belief network depends on finding a factoring of the expression for the joint over the relevant set of variables which enables early marginalization of variables not included in the query [2].

The NP-Hard nature of the problem has motivated researchers to apply heuristic and metaheuristic methods [3-6] to solve it. In this study, we aim to investigate the applicability of an Artificial Immune System (AIS) algorithm to find an efficient factoring order for the inference problem. The algorithm's performance is evaluated on some test cases, and successful results are obtained for these instances.

Keywords: Belief Networks, Probabilistic Inference, Artificial Immune System

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A Variety of Solutions of the Nonlinear Schrödinger Equation in a White Noise Environment

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Abstract

It is commonly known that the nonlinear Schrödinger equations (NLSE) are essential for comprehending a wide range of physical phenomena that arise in several scientific fields [1-4]. It is also known that solving stochastic nonlinear partial differential equations (NPDEs) is more complex and challenging than deterministic equations due to additional random terms [5]. In this study, it is considered Wick-type stochastic nonlinear Schrödinger equation with conformable derivatives. It is obtained a variety of solutions such as travelling wave and optical soliton solutions and also stochastic solutions using two powerful techniques. It is also used Hermite transforms and White noise theory to get these solutions. Additionally, it is demonstrated by two examples how the stochastic solutions can be written as Brownian motion functional solutions.

Keywords: Stochastic Wick-type NLSE, optical solitons, travelling wave solutions, conformable derivatives, White noise theory

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Determination of Criteria for Selection of Candidate Sites for Temporary Debris Storage

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Abstract

Disasters are difficult-to-control situations that have a profound impact on human life and result in significant material and moral losses. Disasters occur suddenly and frequently without warning, resulting in increased losses both during and after the situation. By making plans and taking the necessary precautions, natural and human hazards can be mitigated or avoided. Disaster management plans are being prepared all over the world, including various actions for disaster preparedness, disaster response and post-disaster. The importance and necessity of disaster management plans cannot be ignored in our country, which has frequently encountered disasters from past to present and suffered great loss of life and property. Disaster management is the process by which society, all organizations, and resources work together to reduce or prevent harm before, during, and after a disaster. Disaster management consists of four basic stages: preparation, response, recovery and harm reduction. The preparation and harm reduction phases cover the work to be done prior to the disaster, while the response phase covers the work to be done during the disaster and the recovery phase covers the work to be done afterward. People's ability to return to their normal lives quickly and effectively is dependent on the successful management of activities in the recovery phase, the final stage of disaster management. The problems in the recovery phase mainly consist of debris management and road-infrastructure renewal activities. Debris management is a concept that includes the processes of collecting, transporting, storing, separating and processing debris from the disaster area. In this context, the study aimed to determine the criteria required for the selection of candidate areas for temporary debris storage sites, which are very important after the disaster. The importance weights of the criteria obtained through literature research were determined by soliciting expert opinions via the AHP method, which is one of the multi-criteria decision-making methods. The criteria with the highest importance weight are listed.

Keywords: Disaster management, debris management, multi-criteria decision making, AHP

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Dynamic Equations with Modulo Periodic Poisson Stable Oscillations on Periodic Time Scales

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Abstract

The notion of modulo periodic Poisson stable solutions was first introduced by Akhmet et al. [1]. In this study, modulo periodic Poisson stable functions on time scales are defined, and the existence and uniqueness of such solutions in dynamic equations on a periodic time scale are investigated. The model under consideration is constructed by implementing a perturbation attained through a Poisson stable sequence. The main result is achieved via the reduction technique to impulsive systems proposed in [2].

Keywords: Modulo periodic Poisson stable oscillations, Poisson stable sequences, dynamic equations on time scales, impulsive systems

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Artificial Neural Network Solution Of Two-Dimensional Convection-Diffusion Equation

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Abstract

Artificial neural networks (ANNs) are a type of neural network that relies on the working principles of the human brain. ANNs are used in a wide range of scientific areas for data analysis, numerical solutions of partial differential equations, and more. The usage of ANNs in numerical analysis is growing increasingly. In [1], ordinary and partial differential equations have been solved using artificial neural networks. A finite element neural network architecture has been created to solve differential equations in [2]. A unified deep artificial neural network approach has been proposed to solve partial differential equations in [3]. Convection-diffusion equations are utilized in the transfer of movement or processes, in fluid mechanics, and in the transfer of heat or other atmospheric properties in the atmosphere. Therefore, the numerical solution of this type of equation has been acquired using various traditional numerical methods such as the finite element method, finite difference method, boundary element method, etc. In [4], the finite element method has been applied to convection-diffusion equations to obtain the numerical solution, and error analysis has also been provided.

In this study, we analyzed the 2D steady-state convection-diffusion equation with Dirichlet boundary conditions using feed-forward artificial neural networks. The convection-diffusion equation plays an important role in engineering, physics, environmental sciences, and many disciplines. It is possible to solve this type of equation with conventional numerical methods; however, precision issues may arise in problems that have sharp boundary conditions. Therefore, this study explores the potential of solving this type of problem more effectively using a feed-forward artificial neural network (ANN) model. The obtained results show that feed-forward ANNs can produce precise and accurate solutions to convection-diffusion equations with Dirichlet boundary conditions. It emphasizes the ability of ANN to handle problems with this type of difficult boundary conditions. Feed-forward ANN offers new opportunities to science, engineering, and industrial applications in solving numerical differential equations. The increasing role of artificial neural networks in this field represents the capacity to solve more complex and large-scale problems more effectively.

Keywords: Feed-forward artificial neural network, Partial differential equations, 2- Dimensional Convection-Diffusion equation,

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Genetic Algorithm with Various Encoding Techniques for a Constrained Mechanical Design Problem: A Case Study for Aircraft Structural Optimization

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Abstract

Genetic algorithms [1] are well-known and commonly used meta-heuristic algorithms in the related literature. Due to their demonstrated capabilities in handling optimization problems [2], it grabs attention of various researchers and practitioners from various disciplines including artificial intelligence community. It is shown to be capable of achieving remarkable results in solution spaces with different characteristics. However, one should pay attention while choosing a solution encoding technique in genetic algorithms, since, all adopted evolutionary operators, excluding natural selection mechanism, mostly depend on the adopted representation technique that forms up solution vectors, known as chromosomes. In this context, the aim of the present study is to analyze the performances of two different encoding techniques namely, direct and indirect encoding technique. Thus, this study focuses on the design optimization of the stiffened panel, which is one of the main components of the aircraft fuselage. An interface design has been implemented using MATLAB GUI extension to obtain parameters such as moment, shear forces, tensile strength, extensional forces and compressive strenght which are used in the strength calculations of the stiffened panel. Moreover, users are allowed to set also the algorithm related parameters via this developed GUI. The strength calculations of the stiffened panel have been investigated under both strength and buckling constraints. In order to satisfy these constraints, the variable values within certain limits have been optimized using a genetic algorithm. A comprehensive experimental study is carried out. In what follows, statistical tests are conducted to compare the performances of the reported solution encoding techniques. The obtained results point out notable outcomes.

Keywords: Metaheuristic Optimization Algorithms, Aircraft Fuselage Design Optimization, Structural Analysis, Genetic Algorithm

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Genetic Algorithms based pre-trained Transformer model optimization

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Abstract

Pre-trained models are frequently used with the prevalence of deep learning tools and attract the attention of many researchers who cannot perform extensive pre-training at the beginning of their research. After the selection of a pre-trained model, subsequent work mostly involves transfer learning which adapts the pre-trained model to different domains to accomplish diverse tasks. Although transfer learning is effective in providing domain adaptation to pre-trained models, some of the knowledge contained by these pre-trained models (referred to teacher) can be transferred to smaller models by distilling the knowledge [1], resulting in obtaining smaller variants of pre-trained models which are named student models. According to knowledge distillation [2], the teacher can share its knowledge to enhance the student's performance as far as possible. This work aims to leverage the efficiency of a pre-trained transformer [3] model which is pre-trained for semantic search tasks [4] by addressing concerns related to memory consumption and computational costs. We employ genetic algorithms and a knowledge distillation framework to achieve these goals. Our implementation consists of iterating on student variants derived from the teacher model's weighted layers with an evaluation process supervised by the teacher model. Genetic algorithms are located in the center of this implementation for the selection and reproduction of the most successful student models. By gradually reproducing and evaluating these student model variants over the iterations, we achieve improvements in both reducing the teacher model size and time consumption during the inference phase. Our experimental results show that the best student model, often referred to as the global best in the context of genetic algorithms, achieved an accuracy of 98.21% on the same evaluation dataset with two fewer encoder layers [5] compared to the teacher model.

Keywords: genetic algorithms, knowledge distillation, optimization, pre-trained transformers

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RBF Approximation of Fe3O4-Water Nanofluid containing Magnetotactic Bacteria

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Abstract

The aim of this study is to investigate the impact of magnetotactic bacteria on heat and mass transfer of Fe3O4-water nanofluid in a square cavity. The left wall is the hot wall, the right wall is the cold wall and the others are adiabatic walls. This problem is governed by the steady and nondimensional equations of continuity, momentum, energy, nanoparticle concentration and the number of microorganism [1]. The buoyancy effect is included, but the radiation effect, Joule heating effect, the Brownian and Thermophoresis effects and the viscous dissipation are neglected in the governing equations. Polyharmonic spline radial basis function (RBF) approximation [2] is employed to simulate the contours of stream function, temperature, concentration and the number of bacteria for several values of physical parameters which are Rayleigh number ($10^2 \leq Ra \leq 10^5$), bioconvection Rayleigh number ($10 \leq Ra_b \leq 100$), Peclet number ($0.01 \leq Pe \leq 10$) and Lewis number ($1 \leq Le \leq 10$). Also, the average Nusselt (Nu) number and the average Sherwood (Sh) number on the hot wall are tabulated to analyze the effects of parameters on the heat and mass transfer. It is obtained that as either Ra or Pe increases, Nu increases, but Sh decreases. The increase in Ra_b enhances the heat transfer. However, the mass transfer decreases. The secondary cell of the flow with an opposite direction is formed as Ra_b or Pe increases. The augmentation of Le increases Nu and reduces Sh since Le is the ratio of thermal diffusivity to mass diffusivity. Moreover, the significant change in the concentration contour is observed with an increase in Le. The maximum value of the magnitude of the stream function increases as Le increases or Pe decreases.

Keywords: Radial Basis Functions, Fe3O4-water, magnetotactic bacteria, bioconvection

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On a uniqueness results for fractional ordinary differential equations with some applications

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Abstract

Fractional ordinary differential equations have emerged as a powerful tool for modeling complex dynamical systems exhibiting memory and long-range dependencies. This work investigates uniqueness results for solutions of fractional ordinary differential equations and explores their applications in various scientific and engineering domains. We present rigorous mathematical proofs establishing conditions under which solutions to fractional differential equations are unique within specified intervals. Through an intricate analysis leveraging techniques from functional analysis and fractional calculus, we provide a comprehensive framework for understanding the uniqueness of solutions in fractional dynamics.

Furthermore, we delve into the implications of these uniqueness results on the stability and behavior of dynamical systems described by fractional order differential equations. By elucidating the connection between uniqueness and stability, we offer insights into the fundamental properties of fractional order systems, enhancing our ability to predict and control their behavior. This understanding is crucial for a wide range of applications, from modeling biological processes with fractional derivatives to designing control systems for complex engineering systems.

Through a series of illustrative examples and applications, spanning disciplines such as physics, biology, and engineering, we demonstrate the relevance and practical significance of the uniqueness results obtained. By showcasing how these results enable precise predictions and control of complex systems, we underscore the transformative impact of fractional calculus in addressing real-world challenges.

In conclusion, this study contributes to the theoretical foundation of fractional calculus and provides actionable insights into the behavior of systems governed by fractional differential equations. By enriching our understanding of this burgeoning field, we pave the way for advancements in mathematical analysis and modeling, with far-reaching implications across diverse scientific and engineering disciplines.

Keywords: Fractional differential equation, uniqueness, fractional order modelling.

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Determination of Cell Formation and Efficiency in a Gear Manufacturing Company

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Abstract

Product diversity is rapidly increasing in today's increasingly competitive environment, while product lifespan is decreasing. In such a competitive environment, businesses can improve their performance by producing a wide range of high-quality products quickly and selling them at competitive prices. While companies produce the quality product desired by the customer at the lowest possible cost, with increasing competition, they have to minimize delivery time and ensure delivery reliability. Traditional manufacturing systems have become insufficient over time, reducing the efficiency of business operations. As a result, in today's competitive environment, businesses have turned to modern manufacturing systems to ensure their survival while also providing customers with high-quality products at low prices. Cellular manufacturing systems, which are integrated into modern manufacturing systems, provide significant benefits in terms of shorter transportation times and lower overall production costs, particularly by grouping part families and the machines that will process them. Cellular manufacturing systems are a method of increasing productivity by producing a wide range of products in the shortest amount of time and for the lowest possible cost. In the study, a cellular manufacturing system was proposed, and a cell formation was made to increase efficiency in a gear manufacturing company. Rank Order Clustering 2 (ROC 2), Direct Clustering Algorithm (DCA), Single Linkage Clustering (SLC) and Modified Single Linkage Clustering (MOD-SLC) cell formation methods were used. The cell formation methods used were measured and compared to the efficiency metrics, which are commonly used in the literature, and a choice was made between alternative cell layouts.

Keywords: Cellular manufacturing systems; cell formation; group efficiency

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Which Stock Market is More Predictable? Comparison of Machine Learning and Deep Learning Algorithms for Stock Price Prediction of Company with Dual-Listed Stocks

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Abstract

With globalization, companies have started to prefer foreign markets for the capital they need for their investments. While many companies are evaluating debt instruments such as Euro or Eurobonds, many have offered shares to the public on international exchanges to provide equity financing. When naming such companies, name them as dual-listed stock companies. With this method, both companies can find investors from different markets and investors can have the chance to buy the same company from the stock market they want [1]. It is an important problem for an investor who has the power to invest in both stock exchanges, which stock exchange will meet it with a better price [6]. What increases the accuracy of this estimation is the correct evaluation of the historical data. With the development of technology, artificial intelligence has been included in these forecasting systems, and it has even been found to support investors with better results than traditional forecasting methods[2]. The main purpose of this research is to measure the predictive power of artificial intelligence. When the literature is examined, it is seen that stock price estimates are made after and before the dual-listed stock companies shares are registered on larger stock exchanges outside the country where they are related to companies[4]. The data of the dual-listed stock companies selected in the study are important in terms of comparing the pricing of more than one stock exchange [2] [3] [5]. For this purpose, price estimation analyzes of the dual-listed Turkcell company will be performed with machine learning and deep learning algorithms. The data set of the research consists of the daily frequency prices of Turkcell company in two separate stock exchanges for the period 2010-2023. In the study, Repetitive Neural Networks (RNN) and Long Short-Term Memory (LSTM), which are deep learning methods, and Polynomial Regression and Random Forest Regression methods, which are machine learning methods, were used.

Keywords: Dual-listed stocks, machine learning, deep learning

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ε Height Auxiliary Function Technique in Global Optimization

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Abstract

In this study, we used the auxiliary function method used to solve global optimization problems. Most existing auxiliary functions had disadvantages such as discontinuity, inability to differentiate, or inability to find local minima when they were very close. In order to eliminate these disadvantages, thanks to the new auxiliary function with height ε (the difference of the local minima closest to each other), we obtained a new auxiliary function that guarantees that our function changes sign when it reaches a lower local minimum, without using any parameters.

Keywords: Global Optimization , Optimization, Filled Function Method

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Numerical Solution of Time Fractional Partial Differential Equations for a Mathematical Model of Diabetic Atherosclerosis

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Abstract

One major health concern is atherosclerosis, which is a substantial contributor to global death rates. To further this worry, the International Diabetes Federation (IDF) states that seven million Turkish adults between the ages of 20 and 79, or roughly 15% of the total adult population, are estimated to have diabetes. Notably, inflammation linked to atherosclerosis is made worse by diabetes. Patients with diabetes are twice as likely to have a heart attack or stroke. The paper, we use the systems of partial differential equations that represent a mathematical model of diabetic atherosclerosis we modify the order of equations to fractional differential equations and solve it by numerical methods.

Keywords: Numerical Solution, Fractional Differential Equations, Atherosclerosis.

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Efficient Research Navigation: Automated Paper Recommendations via Machine Learning

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Abstract

Recommendation systems, widespread across diverse industries from e-commerce and entertainment to social media and education, play a crucial role in enhancing user experiences by providing tailored suggestions based on preferences, behaviors, and past interactions [1],[2]. In the field of scientific writing, it is crucial to be able to identify and choose relevant publications. However, due to the increasing number of papers being published, researchers face difficulties in manually navigating through the vast amount of literature. In response to the challenge of navigating the growing volume of academic literature, automated paper recommendation systems have emerged to assist researchers in finding relevant publications [3]. These systems also address the need to establish connections between research outcomes and academic journal subjects for article submissions. Traditional text representation models have limitations in capturing semantic relationships between words and addressing the diverse range of topics across different journals, which affects classification and recommendation results. In this study, a dataset sourced from Kaggle, comprising titles and abstracts of research articles, has been expanded to a total of 60,286 instances. This expansion includes 40,000 additional instances from the National Library of Medicine alongside the original 20,286 instances. These instances are categorized into four classes: physics, mathematics, statistics, and computer science. The research employs various feature extraction methods, including doc2vec, TF-IDF, and Bag of Words, and evaluates the performance of classical machine learning algorithms and deep learning models on the feature vectors. The resulting model functions as a recommendation system, offering content-based suggestions for authors seeking papers relevant to their research interests.

Keywords: content-based recommender systems, research paper recommendation, feature extraction, machine learning

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Optimizing Vehicle Routing: A Comprehensive Literature Review of Mixed Integer Linear Programming Solutions

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Abstract

Combinatorial optimization is a sub-branch of mathematical optimization. In logistics and transportation, especially, the Vehicle Routing Problem (VRP) becomes prominent as an example for the combinatorial optimization problems with different implementations. Minimizing operational costs and satisfying resource utilization are very critical objectives for companies and decision makers in this field. It is proved in the literature that the Mixed Integer Linear Programming (MINLP) is very useful tool to solve VRPs efficiently due to its capability to handle complicated decision variables and constraints [1-3]. This study shows an extensive literature review that focuses on the implementation of MILP to the VRP. The study investigates the historical development of MILP-based approaches, underlying the evolution of mathematical formulations, solution methodologies, and computational methods. It also examines the main outcomes and contributions from existing research studies in the area, categorizing them depending on problem types, constraints, and solution algorithms. In addition to that, the review searches the theoretical underpinnings of MILP in solving VRPs, discussing the benefits and limitations of this approach when compared to other optimization methods. It underlines the operational function of MILP in ensuring optimal or near-optimal solutions, allowing productive fleet management, and addressing real-world constraints such as time windows, capacity constraints, and heterogeneous fleets. Consequently, this literature review investigates the collective knowledge in the study area, providing precious insights into the state-of-the-art methods and challenges. It is aimed that the proposed study will be very useful guide for the decision makers working in the field.

Keywords: Combinatorial optimization, Mixed integer linear programming, vehicle routing problem

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Numerical modeling of geological medium utilizing anology between solute and heat transfer equations

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Abstract

Numerical modeling plays a crucial role in understanding solute and heat transport phenomena within geological media for various applications such as groundwater management, contaminant remediation, and geothermal energy utilization. This study presents a comparative analysis of two prominent numerical modeling approaches: Modflow MT3D, widely used in hydrogeological studies, and Computational Fluid Dynamics (CFD), traditionally applied in fluid mechanics and heat transfer analyses. Both approaches rely on the advection-diffusion equation to describe the movement of solutes or heat through geological formations, with additional terms accounting for dispersion, reactions, and thermal gradients. Also, numerical discretization techniques utilized by Modflow MT3D and CFD to solve the governing equations, highlighting the similarities in finite difference, finite volume, or finite element schemes employed to approximate spatial and temporal derivatives. It discusses the challenges associated with accurately capturing complex transport phenomena, including heterogeneity, anisotropy, and non-linear reactions, and the strategies employed by both methodologies to address these challenges. In this study, problems taken from MT3DMS documentation and user guide (Zheng and Wang 1999) is benchmarked to get the familiarity of MODFLOW and MT3DMS uses. For the aim of this study, results of CFD model and MT3DMS model are compared to validate the CFD groundwater-coupled heat transport process through porous media, which has not been shown by previous studies. Hence, this study offers a comprehensive analysis of the analogies between MODFLOW MT3D and CFD in the context of solute and heat transport modeling in geological media, emphasizing their complementary roles and potential for advancing predictive capabilities in geoscience and engineering applications.

Keywords: MODFLOW MT3D, CFD, heat and mass transport in porous media, shallow geothermal energy

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Identifying Key Drivers at Different Volatility Levels in BIST100 Firms through Machine Learning Segmentation

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Abstract

This study conducts a comprehensive clustering analysis of volatility among firms listed on the BIST100 index using machine learning techniques, focusing on identifying volatility levels and their influencing factors[1]. The sample excludes financial companies due to their distinct financial statement structures and companies with incomplete data, resulting in a dataset comprising 46 firms from the period 2006 to 2023. The research process involves four main stages: data collection and descriptive statistical analysis, computation of Parkinson volatility scores, volatility-based clustering analysis, and regression analysis to explore the relationship between volatility levels and various financial ratios [2]. The regression analysis utilizes the Parkinson volatility coefficient as the dependent variable, with independent variables including Return on Assets (ROA), Return on Equity (ROE), liquidity ratios, and financial leverage among others [3]. The study's methodology allows for a nuanced understanding of how different financial metrics influence firm-level volatility, offering insights into risk management and investment decision-making processes within the Turkish market. This research not only contributes to the academic literature by applying machine learning techniques to financial volatility analysis but also provides practical implications for investors and policymakers in assessing and managing economic risks [4].

Keywords: BIST, Machine Learning, Regression Analysis, Regression Analysis

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Weighting and Analysis of Sustainable Disaster Logistics Maturity Model Criteria using Best-Worst Method

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Abstract

In each of the four phases (mitigation, preparedness, response, and recovery) of disaster management, it is very important for the success of the process that the needed material is available on time and in the right place. Disaster logistics, which is also frequently used with the expression humanitarian aid logistics, covers the process of transferring the goods, health and food materials, support teams and all activities needed by the living beings and the society from the points where the disaster occurs to the people in need [1]. Humanitarian aid logistics activities are not cost-orientated, far from the traditional approach. Of course, economic concerns are taken into account for sustainability, but environmental and social impacts should also be prioritised. From this point of view, it is an important issue for humanitarian aid logistics to ensure its sustainability [2]. In order to ensure sustainability in humanitarian aid logistics, the current situation must first be analysed. In other words, measuring the sustainability levels of organisations, companies, non-governmental organisations or countries in humanitarian aid logistics processes and determining how they are doing is one of the priority actions for the preparation of road maps on this path. One of the most appropriate approaches that can be used at this stage is maturity models. According to the literature review, there is no comprehensive maturity model for sustainable humanitarian aid logistics [3]. Again, one of the biggest shortcomings in the literature is that the weights of the performance indicators under the maturity models are not handled with an appropriate methodology (e.g. multi-criteria decision-making techniques). Within the scope of this study, 61 sub-criteria under four main criteria for the maturity model of sustainable humanitarian aid logistics were weighted with the best-worst method (BWM) [4]. The expert team at the criterion weighting stage consists of five members. A comprehensive maturity model will be designed with the information to be obtained at the end of the study.

Keywords: Humanitarian aid logistics, maturity model, best-worst method.

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Integer Programming Models to Solve Matching Problems

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Abstract

Matching problems have applications in many areas, changing from social networks to communication networks, making them a subject of keen interest for researchers across various disciplines. However, researchers often examine the properties of matching problems and propose algorithms tailored to address them. The algorithms here are either for special graphs (e.g., tree graphs [1], bipartite graphs, and planar graphs [2,3]) to find the exact solution or for regular graphs (e.g., as provided by [4]) to obtain the approximate solutions to the problem. While there is a considerable body of research in the field, there have been a limited number of Operation Research (OR)-based studies. For example, [5] proposes the first edge-based Integer Programming (IP) model to solve the maximal induced matching problem, while [6] introduces an alternative node-based optimization model for the same problem. The authors of [6] show that their model outperforms the model introduced in [5] for many graphs, especially for dense ones. [7] solves the minimum weighted maximal matching problem, whereas [8] decomposes the same problem and obtains the optimal solution in a shorter time. Given that OR models proposed for solving matching problems are limited to these recent studies [5-8], this work proposes alternative IP formulations- the IP formulations with reduced constraints and variables- that solve the same graph instances more quickly. This improvement enables to optimally solve many more medium-sized graphs within a predefined time constraint, as well as facilities the more effective testing of both existing algorithms and those that will be developed in the matching problem literature.

Keywords: Matching Problems, Mathematical Models, Network Optimization, Integer Programming

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An investigation on the optimality condition of Caputo fractional time delay system

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Abstract

This article applies traditional control theory principles to a fractional differential system within a bounded domain. The focus is on analyzing the fractional optimal control problem for a differential system with time delay using the Caputo interpretation of fractional time derivatives. The initial step involves studying the solution's existence and uniqueness in a Hilbert space using the Lax-Milgram Theorem. It is subsequently shown that the optimal control problem has a unique solution. The performance index of this problem is considered a function that encompasses both state and control variables, with dynamic constraints formulated as a partial fractional differential equation. The time horizon remains consistent in our analysis, and restrictions are implemented on the boundary control. By integrating the Euler-Lagrange first-order optimality condition with an adjoint problem defined by the right fractional Caputo derivative, an optimality system for the optimal control is established. This work includes detailed examples and expands upon earlier references [1] and [2] to explore different systems, particularly fractional partial time delay differential equations involving second-order operators with Neumann boundary conditions. We will investigate the control problem of following type:

$$\left.\begin{aligned} D_+^{\alpha} z(u) + A(t)z(u) + Fz(u) = g, &\quad in\ Z, \\ \frac{\partial z(u)}{\partial \gamma_{A(t)}} = u, &\quad on\ \Lambda, \\ z(y,0;u) = z_0(y), &\quad y \in \Sigma. \end{aligned}\right\} \tag{1}$$

where, D_+^{α} denotes Caputo derivative of order $\alpha \in (0,1)$. Let $\Sigma \subset R^n$ which is open and bounded with a smooth boundary $\Gamma \in C^2$. Let time period $T > 0$, we define $Z = \Sigma \times (0, T)$ and $\Lambda = \Gamma \times (0,T)$. The state function $z(u) \in H^1(\Sigma)$ is the solution of (1) and control function $u \in U = L^2(\Lambda)$. The operator $A(t) \in L\left(H_0^1(\Sigma), H_0^{-1}(\Sigma)\right)$ is a self-adjoint operator of second order and operator F will be defined in the manuscript. The function $g \in L^2(Z)$ and $z_0(y) \in H^2(\Sigma) \cap H_0^{-1}(\Sigma)$.

Keywords: Optimal control, fractional differential system, Caputo derivative, Neumann condition

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Variational Iteration method for time fractional Schrödinger Equations

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Abstract

One of the most important partial differential equations in fractional quantum mechanics is the fractional Schrödinger equation which discovered and developed with expansion of the Feynman path integral. In the fractional Schrödinger equation, there is non-integer fractional derivative instead of the first order derivative of the usual Schrödinger equation. Therefore, the fractional Schrödinger equation is a fractional partial differential equation. Mark Naber investigated the properties of the time fractional Schrödinger equation and introduced the time fractional Schrödinger equation is equivalent to the usual Schrödinger equation with time dependent Hamiltonian. Solution methods of important problems in various fields such as physics, mathematics and engineering for time fractional Schrödinger equation become focus of many researchers in recent years. In this paper, approximate solutions of linear and nonlinear time fractional Schrödinger equations depending on initial and boundary value conditions are considered with the variational iteration method. The iteration formulas have constructed for the solution of the time fractional Schrödinger equation using the variational iteration method. The numerical examples are given for the accuracy of approximate solutions of the time fractional Schrödinger equations. The approximate solutions of the example problems of the time fractional Schrödinger equations have obtained using the iteration formulas of the variational iteration method. It has demonstrated with the iteration formulas used that approximations that converge more rapid to the exact solution can be obtained. Graphics comparing the imaginary and real parts of the exact solution and approximate solutions are included. It has seen that the variational iteration method provides rapid approximations to the exact solution with the compatibility of the results.

Keywords: Variational iteration method, time fractional Schrödinger equation, fractional derivative

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On Better Approximation Order for the Nonlinear Truncated Favard-Szász-Mirakjan Operator of Max-Product Kind

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Abstract

To answer the questions whether all approximation operators must be linear and whether the algebraic structure used must be sum and product (algebraic operations in the linear space structure of real numbers), Bede et al. introduced nonlinear operators. The max-product operators are one of these nonlinear operators. Over the set of $\mathbb{R}_+$, the operations $\vee$ (maksimum) and $\cdot$ (product), a semi-ring structure called max-product algebra $(\mathbb{R}_+, \vee, \cdot)$ is constructed (see [2], [3]). Bede et al. presented the max-product types of important classes of linear and positive operators. They also examined the approximation properties and some shape preserving properties of these operators and gathered them in [1]. One of these operators is the nonlinear max-product Truncated Favard-Szász-Mirakjan operator [4]. In [4], the approximation order of this operator is obtained as $1 / \sqrt{n}$ with the help of the modulus of continuity. And it is noted that this approximation order cannot be improved except for some subclasses of functions, such as concave functions.

The main topic of the current paper is to obtain a better approximation order for the nonlinear max-product Truncated Favard-Szász-Mirakjan operator than in [4], without reducing the function classes. Our motivation is that the Cauchy Schwarz inequality is not used when finding the approximation of these operators (with modulus of continuity). After making the necessary revisions, we obtain the approximation order for this operator as $1 / n^{1-\frac{1}{\alpha}}$ for $\alpha = 2,3,\ldots$. In fact, these results for $\alpha = 2$ return to in [4]. Since $1 - \frac{1}{\alpha}$ tends to 1 for enough big α, therefore, we improve this degree of approximation.

Keywords: Nonlinear Truncated Favard-Szász-Mirakjan operator, max-product operators, modulus of continuity.

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Controllability of neutral fractional stochastic differential equations with infinite delay

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Abstract

In the present work, we are concerned with a control system governed by a neutral fractional stochastic differential equation with infinite delay in a separable Hilbert space $(X, ||\cdot||)$ and investigate some controllability results. The mathematical model of the considered problem is as follows:

$$\begin{cases} {}^C D^\alpha[x(t) - f(t, x_t)] = -A(t)x(t) + Bu(t) + g\big(t, x_t, x(t)\big) \\ \qquad\qquad + h(t, x(t))\dfrac{dw(t)}{dt}, \qquad t \in J = [0, T] \\ x_0(t) = A^{-1}(0)\emptyset(t) \in L_2(\Omega, \mathfrak{B}), \qquad t \in J_0 = (-\infty, 0]. \end{cases}$$

Here, ${}^C D^\alpha$ denotes the Caputo fractional derivative of order $0 < \alpha < 1$, $A(t)$ is a densely defined closed linear operator on a separable Hilbert space X. Let Y be another separable Hilbert space and the notation $||\cdot||$ denotes the norm of the spaces X, Y and $L(Y, X)$. $x: J \to X$ is the state function. The function $x_t: (-\infty, 0] \to X$, $x_t(s) = x(t+s)$ belongs to some abstract phase space $\mathfrak{B}$. The control function u takes values in a separable Hilbert space U and the linear operator $B \in L(U, X)$ is bounded. Let $\{w(t)\}_{t\geq 0}$ be a Q-Weiner process on complete filtered probability space (Ω, Y, P) with the linear bounded covariance operator Q such that $Tr(Q) < \infty$. The functions $f: J \times \mathfrak{B} \to X$, $g: J \times \mathfrak{B} \times X \to X$ and $h: J \times X \to L_0^2(Y, X)$ satisfy some conditions. Here $L_0^2(Y, X)$ denotes the space of all Q-Hilbert Schmidt operators.

To establish the results, we used the semigroup theory of bounded linear operators, measure of noncompactness, fixed point theorems, k-set contraction. The obtained result is verified by an example.

Keywords: Fractional system, Non-autonoumous, Neutral differential equation

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Application of the variational iteration method to space fractional Schrödinger equation

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Abstract

Differential equations emerge as mathematical modeling of many problems encountered in science, engineering and other applied sciences. The equations that best describe most real world processes are differential equations that involve fractional order derivatives. The basic mathematical model that gives information about a quantum system in mathematical physics is the Schrödinger equation. By expressing the Schrödinger equation using fractional derivatives, space fractional, time fractional and space-time fractional Schrödinger equations were formulated. Fractional Schrödinger equations have attracted much attention by many researchers for its important applications in fractional quantum mechanics. In this study, linear and nonlinear space fractional Schrödinger equations are considered. Variational iteration method is implemented for approximate solutions of linear and nonlinear space fractional Schrödinger equations. Different correctional functionals are constructed with Lagrange multipliers. The correctional functionals are also constructed without handling the space fractional derivative term as a restricted variation. The Lagrange multipliers are identified by the variational theory. Using the identified Lagrange multipliers, different iteration formulas are formed. Example problems for the linear and nonlinear space fractional Schrödinger equations are given to illustrate the efficiency of the variational iteration method. For every example problem, two different iteration formulas are used. Approximate solutions are compared with exact solutions in graphical form. The numerical results shows that the variational iteration method is efficient in searching for approximate solutions of the linear and nonlinear space fractional Schrödinger equations. Moreover, depending on the choice of iteration formula, the variational iteration method gives approximate solutions that converge to the exact solution more rapid.

Keywords: Variational iteration method, space fractional Schrödinger equation, fractional derivative

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Optimizing Solar Drying Efficiency: Impact of Zeolite on Thin-Layered Solar Drying

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Abstract

This study investigates the effectiveness of zeolite as a desiccant in solar drying of green peas in a forced convection solar dryer. Several drying experiments were conducted in Balıkesir, in April 2023, coinciding with the beginning of spring, a period characterized by moderately lower solar irradiance *(458W/m^2 and 8.7 sun hours, 12.6°C avg. temp)* and elevated relative humidity *(68%)* compared to peak summer months *(689 W/m^2, 53%, 11.7 sun hours, 24.8°C avg. temp in July)* [1]. Since both the high relative humidity and the low solar irradiance were two factors that would cause prolonged drying times [2], it was aimed to optimize this time by using a drying agent. Therefore, zeolite (clinoptilolite), a readily available and cost-effective adsorbent was incorporated into the drying system to enhance moisture removal from the drying air.

The results of two meteorologically similar days are discussed after several experiments carried out. In the first experiment, a thin-layer solar drying of 150g green peas without zeolite was conducted. The drying rate and moisture ratio were monitored throughout the process, and a subsequent drying curve was generated by fitting the data to five established mathematical models. The second experiment employed 5kg of 1-3mm zeolite(klinoptilolite) that was spread out beneath the drying tray, ensuring air passed through the zeolite first for enhanced dehumidification. Similar measurements were conducted with zeolite, and a separate drying curve was modeled. The zeolite's moisture absorption capacity was quantified by measuring its weight change before and after the experiment [3]. The drying time for 150g of green beans with an initial moisture content of 77% (wb) to reach a safe storage level of 10.37% (wb) was significantly reduced [4]. First experiment conducted without zeolite, required 6 to 6.5 hours while zeolite integrated drying achieved the target moisture content within 5.5 hours.

These findings demonstrate the positive impact of zeolite as a desiccant in accelerating the solar drying process of green peas under challenging conditions of high humidity and moderate solar radiation. While this study focused on drying kinetics and did not investigate the potential food safety implications of using zeolite directly with food products, this research contributes to the exploration of low-cost materials for optimizing solar drying efficiency, particularly in unfavorable environmental conditions.

Keywords: Optimizing, solar drying efficiency, drying agent, zeolite, desiccant

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Workload Balancing in Non-Identical Parallel Machine Scheduling: A Case Study in Cardboard Box Manufacturing

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Abstract

Efficient resource utilization is crucial for both service and production systems, making workload balancing a key priority. In our study, we tackle the job assignment problem, aiming to balance workload in non-identical parallel machine scheduling scenarios. Here, diverse jobs with varying processing times must be allocated across different machines, each with its own unique characteristics. These machines have specific capabilities, dictating which jobs they can accommodate based on factors like processing and setup times. Our goal is to distribute jobs across machines to ensure workload balance. To illustrate this problem, we present a case study involving a cardboard box manufacturing company. This company operates various printing machines used for applying logos to cardboard boxes. Assigning boxes to these machines involves considering factors such as box size, color requirements, and the need for specialized molds. We've developed a mathematical model to optimize this process, aiming to balance workload across machines by minimizing the disparity in total workload. By solving this mathematical model for the jobs in our case study, we've obtained insightful results. Our analysis demonstrates that by effectively assigning jobs to suitable printing machines, we can achieve a balanced workload distribution. In our case, each job is currently assigned to a single machine. However, we further explored the possibility of partially assigning jobs to multiple machines through a what-if analysis. Our findings demonstrate that allowing partial assignment of jobs can lead to a more balanced workload across machines. By implementing our proposed mathematical model, our objective is to provide practical insights and strategies that can substantially improve operational efficiency.

Keywords: Job assignment, Workload Balancing, Parallel Machine Scheduling, Optimization, Mathematical Modeling

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Optimal Precaution Strategies to Reduce Crimes Caused by Unemployment

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Abstract

Mathematical modeling is a discipline that used to analyze various real world problems such as matter diffusion, chemical reactions, cancer research, criminal, technolojical addictions, psychological problem, physical, criminal psychology, addiction, chemical and economic processes. One of its main purposes is to model the relevant process to gain insight and make accurate predictions. [1] As a result of economic catastrophe that in social sciences, unemployment, addiction, drug addiction, and terrorism negatively affects society, have increased the importance of mathematical modeling in this field. Because of the fact that the dynamics of society also exhibit a spreading behavior like epidemiological diseases.

Unemployment constantly increases due to rapid population growth worldwide. The increase in unemployment not only leads to negative consequences in the psychology of individuals but also causes deterioration in the country's economy and an increase in crime rates. Additionally, unemployment leads to an increase in crimes against the state. With unemployment, people become more prone to crime. Social scientists have been focusing on the relationship between unemployment and crime for many years. In this field, researchers are conducting studies examining the relationships between unemployment and crime, and they are revealing the connection between them.[2-3]

In this paper, we are examining a model that incorporates the effect of the increase in unemployment on the crime rate. [4] Next, we discuss some control strategies to reduce crime rate and unemployment within the scope of the model. Then, we are examining the application of optimal control strategies to the model. [5] We perform the optimal control analysis for the proposed model using Pontryagin's Maximum Principle. [6] Furthermore, to verify the results obtained from the optimal control analysis, we are conducting a series of numerical simulations. Through these simulations, we are examining the effect of optimal control strategies.

To sum up, thanks to added control variability, it is declared with decreasing unemployment, crime rate reduces.

Keywords: Mathematical Modeling, Crime, Unemployment, Pontryagin's Maximum Principle

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Optimizing Dynamic UAV Base Station Placement for Enhanced Communication in Disaster Response

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Abstract

The effective provision of communication in post-disaster scenarios is vital for coordinating emergency response efforts. In situations where conventional communication infrastructure such as base stations is damaged or inadequate, Unmanned Aerial Vehicles (UAVs) equipped with base station capabilities can offer temporary communication support. This study focuses on optimizing the placement of UAV base stations in disaster-affected areas to enhance communication capabilities. Contrary to much of the prevailing literature, which frequently neglects considerations such as UAV battery endurance and operational flight times, our methodology incorporates these limitations to enhance communication scope and dependability [1-4]. The aim is to develop an optimization model that will take into account the charging times of UAVs and provide flexibility for periodic relocation. In this approach, UAVs are allowed to return to the main charging station if needed, and once recharged, they are repositioned in the sky to continue serving as base stations. The primary objective of this study is to periodically deploy UAV base stations to restore mobile network connectivity in disaster-stricken areas. We aim at developing a heuristic approach consider user movements by periodically updating UAV placements to adapt to changing conditions. This study's significance lies in its potential to enhance emergency communication systems in disaster management. By integrating UAV flight constraints into the optimization process, our approach offers more realistic and effective solutions for deploying UAV base stations in post-disaster scenarios. Additionally, this research contributes to the existing literature by addressing a gap and presenting a comprehensive framework for optimizing UAV base station placement in disaster-affected areas and improve the effectiveness of UAV-based communication support in post-disaster environments. The findings of this study and the developed solution procedures will be presented.

Keywords: Disaster management, UAV base station placement, optimization

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Call Center Staff Scheduling with a Mathematical Model that Ensures Service Level Agreements and Equitable Workload Balancing

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Abstract

In today's dynamic and competitive business environment, effective communication has become a key factor for success. Call centres have proven to be an invaluable asset for various industries to establish a strong connection with their customers and provide timely solutions to their queries. With 24/7 availability and a team of highly skilled professionals, call centres offer seamless management of high call volumes. In order to meet service level agreements (SLAs) and ensure a fair distribution of workload among agents, efficient scheduling of call centre staff is essential. While existing literature provides valuable insights into call center staffing problems, our research presents a practical and insightful case study that sheds light on call center staffing problems. This study presents a mathematical model that schedules call center staff to meet SLA service levels, taking into account agent availability. The outsourcing contract specifies a service level agreement that must be met over a period e.g; a week or a month. The objective function of our model is to minimize the difference between predicted call volume and call volume of availabe staff which will ultimately lead to a significant reduction in the deviation between scheduled servers and staffing requirements. In order to achieve this, we include break times in the modeling of the availability of the agents and take into account the regulatory constraints. The focus of the study is on a real-world scenario in a call center that provides customer experience solutions to a global mobile phone operator. Our approach, based on mathematical modeling, offers a systematic and efficient solution to optimize call center staffing, ensuring compliance with service level agreements (SLAs) while balancing agent workloads.

Keywords: Call Center Staff Scheduling, Equitable Workload Balancing, Service Level Agreements (SLAs), Mathematical Modeling

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Comparison of covering models for pharmacy-on-duty problems with the equity levels

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Abstract

Pharmacies serve as crucial access points for medication within the healthcare system. The limited number of studies in the literature have addressed the pharmacy-on-duty problem however, there has been significant research on the location of healthcare system elements. Commonly location problems have been modeled using two main approaches: covering-based models and median-based models. This study focuses on a model for assigning duties to pharmacies during non-working hours over a planning period using a coverage approach, addressing the issue of uneven distribution of tasks. Two modeling approaches are presented: the widely used maximum coverage modeling approach and its extension, gradual covering which has never been employed in pharmacy-on-duty problems. The essential difference between these two approaches is the covering value assignment. The study proposes a novel objective function that maximizes the difference between total coverage and uncoverage of demand points. Other highlights of the study are twofold: the use of equity constraint in terms of the workload of pharmacies, and the multi-period planning approach. To compare models, 1000 random demand points with evenly distributed sizes and 60 random pharmacy points are generated within a 5km-by-5km area. For the partial coverage case, inner circles of coverage have radius of 250, 500, and 750, while the outer circle radius are 1250, 2500, and 3750 respectively. The maximum coverage model uses the same outer circle radius to match the partial coverage model. The experiments are conducted for different equity levels with a demonstration of 52 instances. Two main conclusions are drawn from the experiments: determining the imposable equity level of a particular region, and the comparison of maximum and gradual coverage models. The former can be obtained by examining the change in the objective function value. In the extreme cases, either the covered or uncovered demand term will dominate the other term resulting in the same objective function value for different equity levels. Therefore, to determine the imposable equity level, it is necessary to consider both the demand coverage dispersion, that is the standard deviation of the total coverage values on a daily basis, and the objective function value together. The latter conclusion is drawn by analyzing the mean uncovered demand. The daily mean of uncovered demands is nearly identical when equity is not considered. In contrast, the total uncovered demand is higher in the maximum coverage model compared to gradual for the same level of equity. In addition to these conclusions, the effect of gradual distance threshold and equity level change is notable. In the gradual model, as the distance threshold increases, the average uncovered demand decreases, and the imposable equity level increases. As the equity level decreases to a smaller number, the uncovered demand will rise to maintain equity between pharmacies. In conclusion, with minor adjustments to the model used and by assessing the results of the imposable equity level, further planning for established pharmacies can be conducted. This could facilitate potential location planning to enhance accessibility for all demand points. The findings suggest assignment of duty to pharmacies significantly impacts the profitability of pharmacies in the region.

Keywords: Pharmacy-on-duty, Maximum Covering, Gradual Covering, Equity

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Classification of Metastatic Tumor Types Using Radiomic Features

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Abstract

The accurate classification of metastatic tumor types is important for the treatment decisions and prognostic assessments[1]. However, achieving precise classification can be challenging. Radiomic feature analysis, which involves extracting quantitative features from medical images, improves classification accuracy[2]. The aim of this study is to classify metastatic tumor types using radiomic features extracted from standard MRI sequences. Images of 200 patients with non-small cell lung cancer, melanoma, breast cancer, small cell lung cancer, renal cell carcinoma, and gastrointestinal cancers will be obtained from The Cancer Imaging Archive [3]. Acquired images were T1, T1 post-contrast, T2, and FLAIR. Radiomics features will be extracted using PyRadiomics 2.2.0 (https://github.com/Radiomics/pyradiomics). Input images included all 4 individual image contrasts: T1, T1 post-contrast, T2, and FLAIR MR images. The default set of radiomics features will be extracted including 3D shape features (n=17), first order grayscale features (n=19), and higher order grayscale features (n=75). Implementation details of the default set of radiomics features are provided in the PyRadiomics 2.2.0 documentation (https://pyradiomics.readthedocs.io/en/latest/features.html).All non-quantitative image data will be intensity normalized prior to feature extraction using the built-in zero mean unit standard deviation normalization method across the entire image including the tumor. Machine learning algorithms will be employed to classify metastatic tumor types using radiomic features**.** By using radiomic features extracted from standard MRI sequences, our approach may be helpful for improving diagnostic accuracy and guiding personalized treatment strategies for patients with brain metastases.

Keywords: Brain Tumors, Radiomic Features, Machine Learning

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Portfolio Optimization by using Mean-Variance Model

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Abstract

A portfolio is a pool consisting of at least two types of investment instruments with the aim of providing the investor with the highest return according to the risk he/she takes. Although the portfolio consists of different assets, it is treated as an asset with its own measurable attributes. Portfolio management is determining the weights in which various instruments should be included in the portfolio according to both the needs of investors and current economic conditions. The main goal is to get the highest return while reducing the risk undertaken through diversification.

Portfolio management is concerned with evaluating the risks and returns of instruments such as stocks and making optimum decisions. According to classical portfolio theory, the portfolio return is the dividend and the value increase of the instruments forming the portfolio in a certain period. Traditional portfolio optimization is also an effort to make an optimum choice between the rate of return and risk for securities. While the classical approach focuses on increasing the number of securities to reduce risk, it does not take into account the relationships between these securities. On the other hand, modern portfolio theory, which is based on Markowitz model, aims maximizing expected return and at the same time minimizing risk.

In this study, portfolios were created with Markowitz's mean variance model using the data of some selected stocks in the BIST30 index and a comparison was made between these portfolios.

Keywords: Portfolio optimization, Markowitz's mean-variance model, efficient frontier, sharp ratio

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A hybrid method for simulating biochemical reaction networks with time-delay involving monomolecular reactions

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Abstract

A biochemical reaction network (BRN) is a mixture of different species that interact with each other through various reactions. Stochastic models analyze the stochasticity hidden in the nature of BRNs by using the Chemical Master Equation (CME), which describes the time evolution of the transition probabilities modeling the system. An analytical solution of the CME can be obtained for BRNs involving monomolecular reactions (MNRs), whose reactant and product are only a single species [5]. For more complicated BRNs, Stochastic Simulation Algorithms (SSAs) sample trajectories from the transition probabilities satisfying the CME [2]. In addition to the stochasticity, many BRNs can involve reactions with time-delays. Similar to the CME for BRNs without time-delays, stochastic models for BRNs with time-delays utilize Delay Chemical Master Equation (DCME) to describe the dynamics of the transition probabilities modeling the system. Delay Stochastic Simulation Algorithm (DSSA), which can be considered as an extension of the SSA, can be utilized to generate the realizations of the BRNs with time-delay satisfying the DCME [1,3].

In this talk, we will present a hybrid method to generate realizations of the BRNs with time-delays modeled with the DCME. The strategy of the method is to divide the BRNs with time-delay into two different reaction groups. The first group will involve MNRs without time-delays, and its dynamics will be analyzed analytically. The second group will involve more complicated reactions with/without time-delays, and its dynamics will be analyzed via the DSSA. The dynamics of these two different groups will be compounded via the Strang splitting method [4]. Finally, we present numerical methods to validate the efficiency of the method.

Keywords: Biochemical reaction network, Delay chemical master equation, Monomolecular reactions, Delay stochastic simulation algorithm

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An Asymmetric and Nonlinear Hankel Matrix and its Some Algebraic Properties

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Abstract

In this presentation, we will examine Hankel type matrix families, which are combinatorial matrix families with specially structured and parametric inputs. We will use q-versions of the generalized Fibonacci and Lucas numbers when defining these matrices. Our goal is to obtain mathematical formulas, expressions and recurrence relations that allow calculating various algebraic properties of these matrix families more efficiently and accurately than classical methods. We will discuss some algebraic properties of these matrices (determinant, eigenvalue, inverse, LU-decomposition, decompositions of inverse matrices, etc.). We will use classical proof methods to prove the claimed results.

Keywords: Filbert matrix, Lilbert matrix, q-analogue, LU -decomposition, inverse matrix, determinant

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Modeling Microbial Growth Dynamics: Integrating Differential Equation-Based and Nonlinear Regression Approaches

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Abstract

This study aims to model the growth dynamics of microorganisms using various regression techniques derived from differential equations. Given the complex nature of the growth of microorganisms, conventional linear regression often fails to capture the underlying biological processes. Therefore, this study incorporates polynomial regression as well as nonlinear regression approaches, as well as Baranyi and Gompertz growth models, to provide a comprehensive model fit of growth rates. Differential equation-based models facilitate the understanding of instantaneous growth rates and their dependence on environmental and biological factors. The performance of the models is evaluated based on goodness of fit with coefficient of determination (R^2) and Root Mean Square Error (RMSE) as primary metrics. In addition, prediction accuracy is assessed by comparing observed and model-simulated values through cross-validation techniques. Our findings emphasize the importance of selecting appropriate models for biological data analysis and demonstrate the clear advantages of using differential equation-based and nonlinear regression models in microbial growth studies.

Keywords: Baranyi model, Gompertz model, Polynomial regression

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Local RBF-Enhanced Finite Difference Method and an Application to MHD Flow

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Abstract

One of the most widely used numerical methods for solving heat transfer and flow problems in complex regions (such as L, T, and Z) is the domain decomposition method [1-3]. Solutions are obtained in each sub-domain of the domain and solutions are matched at the interfaces for continuity of the solution. However, the singularity problem arises at interface points. To improve the solution at the singular points and hence the overall solution, the weights in the derivative approximation at the interface points will be calculated by radial basis function-based finite difference (RBF-FD). In calculating the weights, the basis function in RBF will be chosen as a polynomial of r, where r is the Euclidean norm between two points. The developed method will be applied to magneto-hydrodynamic (MHD) flow whose governing equations consist of Navier-Stokes and Maxwell laws [4]. The coupled equations are solved iteratively in an L-shaped region with a single moving lid, which has not been previously reported in the literature. Flow patterns and vortex formations are exhibited for various strengths of magnetic fields (M) and angles (α).

Keywords: RBF-FD, MHD Flow, Finite Difference Method

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The Type of the Hull and the Number of Codes over Rings

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Abstract

The theory of error correcting codes is a branch of mathematics which designs optimal codes that can correct a maximal number of errors with efficient encoding and decoding algorithms. One of the main problems in the theory is to classify codes in terms of their parameters. For example, LCD codes and self-dual codes are highly sought after codes and the counting formulas are a key step in determining when an exhaustive search for such codes is complete. The aim of this study is to aid in the classification of codes over rings which have a hull of given type.

The hull of a linear code is defined to be the intersection of a linear code and its dual with respect to the Euclidean inner product. This notion was first introduced in [1], and was used to study the codes of finite projective and affine planes. Additionally, the hull of a code plays an important role in determining the complexity of algorithms for studying the permutation equivalence of two linear codes and the automorphism group of a linear code. Recently, codes with a trivial hull have gained much attention. A linear code which meets its dual trivially is called a linear code with a complementary dual (LCD). These codes were first introduced by Massey in [2] and provide an optimum linear coding solution for the two-user binary adder channel. Moreover, LCD codes meet the asymptotic Gilbert-Varshamov bound in [3]. These codes have applications in counter-measures to passive and active side-channel analyses on embedded cryptosystems [4]. We study the hull of linear codes over the commutative rings with unity of order 4, that is, the ring of integers modulo 4 and the ring $F_2[u]/< u^2 >$, where the orthogonal is the Euclidean orthogonal. We define the type of a linear code, and we give the number of linear codes over the rings of order 4 which have a hull of given type.

Keywords: Hull, linear codes, gray maps, LCD codes.

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The Exact Formulation of the First Transition Number in Nonlinear Reaction-Diffusion Equations

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Abstract

Reaction-diffusion equations in one spatial dimension are expressed with partial differential equations as

$$u_t = L_\lambda u + g(u, u_x).$$

Here, u represents an unknown function which depends on the variables x (space) and t (time). The operator L_λ represents the linear part of the equation, while the operator $g(u, u_x)$ represents the nonlinear part of the equation. λ is a real control parameter. At a certain critical value of this control parameter, dynamics transitions between different stable states of the system occur [1]. One of the main assumptions regarding the linear operator is that its eigenvalues are real and that is satisfies the principle of exchange of stabilities for $\lambda = \lambda_c$. Another assumption is that the eigenvectors of the linear operator are in the form of $\sin(n\, x)$. The fundamental assumption regarding the nonlinear operator is that it depends solely on u and u_x terms, and this dependence is of at least second order or higher. The dynamic transitions of a one-dimensional nonlinear reaction-diffusion equation were previously studied based solely on the second and third-order terms [2]. The mentioned constraint has been removed in this study. Using the center manifold theory, the equation has been reduced to an ordinary differential equation in the form of $\frac{du_1}{dt} = \beta_1(\lambda)u_1 + P\, u_1^m + o(|u_1^m|), \quad u_1 \to 0.$

In this study, the exact relationship between the number of terms, P and the power of m in the nonlinear term with Taylor coefficients has been obtained. The exact formulation of P which is referred to as the first transition number, has been obtained.

Keywords: Dynamic Transition Theory, Center Manifold Theory, Reaction-diffusion Equations

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Implicit time discretization and quasi-linearization for numerical solution of nonlinear heat transfer problems

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Abstract

This work presents a numerical method for solving the one-dimensional heat equation with temperature dependent thermal conductivity. General nonlinear boundary conditions that can depend on time explicitly are considered. First, using an implicit scheme, the heat equation is discretized in time, whereby, at each time level, a nonlinear two-point boundary value problem (TPBVP) is obtained. To solve the nonlinear TPBVPs, the quasi-linearization method is applied. The obtained linear sub-problems are solved by the finite difference method. Since the time-discretization scheme is implicit, the whole method is unconditionally stable. Several examples are presented and solved using the proposed approach. The results indicate excellent computational efficiency and confirm the unconditional stability of the method.

Keywords: nonlinear, heat equation, PDE, ODE, boundary value problem, numerical method

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Developing a Genetic Algorithm-based Tool for Design Optimization

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Abstract

This study aims to facilitate the creation of optimal designs and accelerate the design process by developing optimization software using meta-heuristic algorithms. The output of this study is designed to be used in processes determining optimal thickness. In this context, a literature review was conducted to determine the method for conducting the study. Douglas J. Bayley et al. [1] used genetic algorithms to optimize the design of a spacecraft. By using genetic algorithms in design optimization, they aimed to ensure that the spacecraft meets the desired parameters in the target orbit and minimize costs by reducing its total mass. This effort was the first attempt to minimize the cost of a solid rocket launch vehicle at the preliminary design stage. Chaudhry and Ali Ahmed [2] stated that aircraft design is a multidisciplinary problem and presented a genetic algorithm (GA) approach to optimize aircraft preliminary design. Based on these studies, genetic algorithm was selected as the meta-heuristic method used to solve the problem in our own study. As the first stage of the study, a sample finite element analysis model obtained by the company we collaborate with was taken. The data of interest in the study were extracted from a text file containing all the data of the model through a Python code snippet. This data consists of material properties and stress values. Thus, groundwork was laid for the use of genetic algorithm. In the thickness optimization stage of the study, the initial thickness value in the transferred data to Excel and the stress values obtained after this thickness selection were used as an initial solution. The fitness of the solution was checked based on stress constraints. In solutions determined to be unsuitable, thickness changes were made. In determining the new thickness value to be used in this change, genetic operators such as cross-over and mutation were used. The finite element analysis file was updated according to the thickness change made. The updated data were solved in the Nastran solver to obtain new stress values corresponding to that thickness. The genetic algorithm runs until the termination criteria met.

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Keywords: Metaheuristic Optimization, Design Optimization, Genetic Algorithm, Engineering Design Processes.

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Transient Performance Improvement of Induction Motor Drive Systems Using PSO Optimised Interval Type-2 Fuzzy PID Controller

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Abstract

This study investigates interval type-2 fuzzy PID (IT2-FPID) method, whose parameters are improved using the particle swarm optimization (PSO) metaheuristic algorithm, to improve the dynamic transient and steady state response in the speed control of a three-phase induction motor. The efficient implementation of variable speed motor applications is crucial nowadays, since they have become indispensable in the industrial sector. Induction motors are one of the prime candidates for such applications due to their simple structure, long life, high efficiency, low maintenance and relatively low cost. Induction motors, on the other hand, have a nonlinear, tightly coupled model with uncertainty. Indirect field-oriented vector control approach, which allows torque and flux components of the motor to be regulated independently, is utilized to take advantage of the properties of the induction motor and overcome the coupling problem. Fuzzy logic (FL) based controllers do not require knowledge of motor parameters and at the same time have a robust behavior in controlling against disturbances and uncertainties. Nevertheless, type 2 fuzzy logic controllers are recognized to provide better results in the presence of disturbances, uncertainties and oscillations compared with type-1 FL algorithm. In this study, the input and output parameters of IT2-FPID control algorithm are optimised to obtain the best control response in addition to these properties. Simulation of the speed control of induction motor is carried out under sudden changes of speed and load torque, which require fast and robust dynamic response. The acquired simulation results are compared to the performances of conventional PI control, FL control, and IT2-FPID with optimised parameters controller. The results reveal that IT2-FPID controller with optimised parameters has superior speed control performance, with a shorter rise time, reduced overshoot, and faster acceleration in speed response.

Keywords: IT2-FPID, induction motor, fuzzy logic control

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Optimization-Based Intelligent Energy Management Strategy for Photovoltaic System Integrated Electric Vehicle Wireless Charging System

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Abstract

The increasing number of electric vehicles poses significant challenges in determining the source and methods of energy transfer for charging. Grid to vehicle (G2V) and wireless power transfer technologies represent crucial milestones in this field. During the charging of electric vehicles from the grid, issues stemming from overloading can emerge, especially during peak demand periods. Introducing renewable energy sources into charging stations offers a sustainable and eco-friendly charging infrastructure as a solution to this problem. Effective energy management algorithms are necessary for the efficient operation of these systems. These algorithms play a critical role in optimizing the energy flow between electric vehicles, renewable energy sources, and the grid. This study proposes a system where the energy required for charging electric vehicles is provided both from the grid and photovoltaic panels and transferred wirelessly. The wireless power transfer system [1] is recommended for its convenience to users and for enhancing the safety of the charging process. The energy flow in the system is controlled by an optimization-based energy management algorithm. This algorithm maximizes system performance by optimizing energy flow both to electric vehicles (G2V) and the grid (V2G) [2]. The primary objective of the algorithm is to charge the electric vehicle. Energy for charging will primarily come from the photovoltaic system, with support from the grid when necessary. Additionally, surplus energy generated from the photovoltaic system can be transferred to the grid when the electric vehicle is not charging. Similarly, excess energy in the electric vehicle can also be transferred back to the grid. Furthermore, it has been observed that power converter circuits within the system operate with over 90% efficiency thanks to this energy management algorithm. This study presents an important solution to enhance the effectiveness of wireless charging stations integrated with renewable energy sources and to ensure energy efficiency.

Keywords: Energy management, Electric vehicle charge, Bidrectional flow, Photovoltaic sytem

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H-polyhedral Separation for Cybersecurity

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Abstract

The developments in digital technologies, encompassing devices and systems capable of creating, storing, and managing data, have necessitated a paradigm shift in business operations and daily life. Most businesses utilize digital technologies to streamline operations, enhance the customer experience and increase profitability. Not only in businesses but also in our daily lives, we use digital technologies in various areas owing to their convenience in accessing various services and to help us save time. While digital technologies offer numerous opportunities to store data in cloud-based systems, they also necessitate addressing challenging security issues, such as attacks, malware, ransomware, and scams. Therefore, cybersecurity, the practice of protecting systems, networks, and programs from digital attacks, emerges as a critical factor in protecting data from various threats. Another challenge in threat detection is the scale of the data we need to analyze. The utilization of machine learning, which focuses on leveraging data and algorithms, enables the detection of threats within massive datasets in a reasonable computational time. This study investigates the classification efficiency of h-polyhedral separation, a machine-learning algorithm based on the construction of a piecewise linear error function and the iterative solution of successive Linear Programs, applied to various cybersecurity datasets. Although there are studies in the literature where h-polyhedral separation is used for classification, to the best of the authors' knowledge, studies have yet to be applied to Cybersecurity datasets. The results reveal that this approach performs well in terms of classification accuracy. Furthermore, it is competitive when its efficiency is compared to some other classification algorithms in the literature.

Keywords: Cybersecurity, h-polyhedral separation, classification, optimisation, linear programming

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Efficiency of Regression Models and Differential Systems in Predicting S-I-R Groups in Pandemic Processes and Hybrid Modeling

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Abstract

This study aims to evaluate the performance of different regression models to predict the number of S-I-R groups, which are composed of healthy individuals who have not contracted the disease (S), individuals who have contracted the disease (I), and individuals who have had the disease or died (R) during pandemic processes. COVID-19 data in Turkey is obtained from the official website of the Ministry of Health of the Republic of Turkey. The dataset used in the study covers the selected time period from the beginning of the pandemic and includes the daily number of S-I-R groups. Different regression models such as polynomial regression, Fourier regression, Gaussian regression and sum of sin regression are examined and their forecasting performances are analyzed. They are also compared with the differential solutions of the SIR model, which is a system of nonlinear equations based on Chebyshev polynomials. R-square (RSquare) and Root Mean Square Error (RMSE) are used as performance measures. The findings contribute to the determination of the most appropriate model for the analysis of pandemic processes by evaluating the effectiveness of different regression models in predicting the number of S-I-R groups.

Keywords: Gaussian regression, Polynomial regression, Mathematical modeling

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Solution of Fredholm Volterra Fractional Integro-Differential Equation in Terms of Gegenbauer Wavelets Compared with the Solutions by Genocchi Polynomial

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Abstract

In this study, the solutions based on Gegenbauer wavelets are presented to solve Fredholm Volterra fractional integro-differential equations, and those are compared with the solutions obtained with Genocchi polynomials by using test problems. Gegenbauer wavelet method provides effective and accurate solutions. Solutions were obtained by calculating different values of resolution parameters and taking different degrees of Gegenbauer polynomials.

Keywords: Integro-differential equations, Gegenbauer wavelets, Orthogonal polynomials

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Analysis of the threshold dependence of degree related indices in weighted random graphs and complex networks

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Abstract

The average degree, global efficiency and related network characteristics are often used as features in machine learning problems for graph classification problems [1]. Such applications are these days seen in almost every field requiring graph based identification such as finance, neuroscience and disease detection ([2], [3]). In most cases among these and other problems, the network of interest is indeed a weighted one and the corresponding unweighted network is built via the weighted one by using the threshold approach. For example, assuming that the weights are non-negative correlation values, and letting T be a real number in (0,1) that is the specific threshold selected, one keeps each edge whose weight exceeds T. Naturally, in this case, as T moves through 0 to 1, the network begins from a clique, gets sparser, and eventually reaches to an empty graph. The selection of the right value of T often depends on the specific application worked on, but is critical for the underlying algorithms as the networks will vary drastically for distinct values.

The purpose of this study is analyze a non-linear function of the degree sequence of a random weighted network and its dependence on the threshold value selected. The function that is to be studied is related to a certain type of the degree irregularity of the graph. In our case, in an unweighted setup the c level degree irregularity of a network $G = (V, E)$ is considered similar to [4] and is defined to be $DI_c = \sum_{u,w \in V} |d_u - d_w|^c$ where d_u is the degree of vertex u. In our work, we first introduce weighted version $DI_{c,w}$ of this graph characteristics. We then analyze the weighted degree irregularity $DI_{c,w}$ in cases where the weights are assigned independently from a probability distribution. Afterwards, we move on to the threshold based formed graphs as described above and introduce the corresponding irregularity $DI^T_{c,w}$ which is a function of the threshold as well. We then obtain results on $DI^T_{c,w}$ for the cases where c is either 1 or 2 when the weights are sampled independently as described above. The corresponding behaviors as a function of T are also interpreted and commented in terms of linearity.

Two real life weighted networks are selected for analysis; a brain activity network, and a financial network. The transition in $DI^T_{c,w}$ with respect to T is analyzed in both of these, and comparisons are done with the random graphs approach discussed.

Keywords: weighted graphs, thresholding, degree irregularity

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Fetal Health Assessment Using an Adaptive Neural Fuzzy Inference System

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Abstract

From past to present, people continue to search for and develop new methods that are intelligent and controllable, capable of making decisions in order to make their lives easier. Artificial Neural Networks, which combine the learning abilities of artificial intelligence, and Fuzzy Logic approaches with the advantage of if-then rules that reflect human thought and knowledge, have become very popular in order to give machines the ability to work through programs by processing human data and experiences with various methods. As in many fields, especially in the medical field, these popular developments are being utilized. Artificial neural networks and fuzzy logic methodologies, which are used for classification, recognition, prediction, data association, diagnosis, interpretation, and decision-making, are widely applied in the medical field.

Predicting the health of the fetus, which is one of the diagnostic-based studies in the medical field, is of great importance in terms of reducing maternal and infant mortality and rapid intervention.

In this study, an Adaptive Neural Fuzzy Inference System (ANFIS), an approach that integrates fuzzy logic methods and artificial neural networks to assess fetal health, is used to design a prediction model of the health status (healthy- suspicious- pathological) of the unborn baby based on the features extracted from the Cardiotocogram (NST) examination of pregnant women. The obtained prediction results were evaluated based on the root mean square error (RMSE). As a result of the study, the ANFIS algorithm was found to be a successful algorithm for data classification. The system can be used in clinical information systems to obtain information on fetal health status.

Keywords: Artificial neural networks, fuzzy logic, fetal health

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An Optimal Hybrid Harmonic Filter Design for Maximization of Transformer Loading Capability under Non-linear Loading Conditions

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Abstract

Harmonic distortion is a power quality problem that can be expressed as a deviation of the alternating voltage and current from the sinusoidal form. Harmonics have various adverse effects on energy transfer equipment and loads in electrical networks such as poor power factor, reduced efficiency, extra losses, and reduced life expectancy. Today, electric power networks have renewable-based distributed generation units such as wind turbines and photovoltaic power plants, as well as various loads such as power converters, fluorescent discharge lamps, and switched-mode power supplies. All this power system equipment can distort the waveforms of voltage and current in the system since they have non-linear characteristics [1].

Thus, to mitigate harmonic distortion in the systems, passive and active filters are employed [1, 2]. Passive filters have lower installation costs compared to active filters. However, active ones have superior harmonic mitigation performance [2]. Due to this, the collective use of both filter types, called hybrid harmonic filters, is preferred for cost-effective performance at high-power ratings [3]. Designs of harmonic filters are conventionally addressed in the literature as an optimization problem by considering several objectives. These are the filter's investment cost minimization, filter's loss minimization, current harmonic and/or voltage harmonic distortion minimization, and maximization of power factor [4]. Apart from these goals, in [2] and [5], passive filters are designed to maximize the loading capacity of transformers under distorted voltages and currents by the authors.

In this paper, the optimal design of a hybrid filter, which consists of single-tuned passive and active ones, is proposed to maximize the transformer loading capacity with the minimum filter investment cost. The studied optimal design problem has constraints as harmonic limitations defined in IEEE standard 519 and the desired power factor interval. It is solved by using the Particle Swarm Optimization algorithm [5].

Keywords: Hybrid filters, optimal design, harmonic distortion, transformers, loading capability.

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HNSG: A Hybrid Algorithm for Nonlinear Unconstrained Optimization:Brief Reveiw, Parameters Test and comparative results

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Abstract

Unconstrained optimization of differentiable functions, is considered. In this work we complete the study of HNSG algorithm [1]. We demonstrate the capability of the algorithm by performing additional tests on different benchmark functions.

The HNSG is a hybrid method that combines the Global Barzilai Borwein (GBB) method [2] with Particle Swarm Optimization (PSO)[3]. In the proposed algorithm, in every iteration of the GBB method, we perform a local search, by PSO method.

Because of the stochastic nature of the results given by metaheuristic based method, we discuss the appropriate value of the parameters of the algorithm. We give also a comparative study to prove the performance of the HNSG method.

Keywords: HNSG method, particle swarm Optimization, Global Barzilai Borwein

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Estimation and Feedback Control of Comorbidity using Historic COVID-19 Data

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Abstract

After the COVID-19 pandemic, many countries are still suffering from managing the hospitals/health services, since it has aggravated the mortality rate due to other diseases, especially in the vulnerable groups. Different country-wise daily mortality rates due to the predominant killer diseases are not easy to obtain which may help the Governments to design a suitable disease portfolio management strategy or feedback control action. For example, globally the top 10 killing diseases are ischaemic heart diseases, stroke, pulmonary diseases, neonatal conditions, lung cancer, Alzheimer's disease/dementia, diarrhoea, diabetes, kidney diseases which may vary depending on high, medium and low income countries and environment [1]. However, these proportions can serve as a good estimate of the historic killing diseases in a country. After COVID-19, the chance of comodbidity became much higher for the vulnerable groups who had already a killer disease and later was infected by COVID-19 [2]. Using the granular information of the COVID-19 data, we aim to first fit a 6D nonlinear compartmental model of the SEIQRD (Susceptible, Exposed, Infected, Quarantined, Recovered and Death) structure, followed by the use of state estimation algorithms e.g. extended Kalman filter (EKF) to obtain the unmeasurable or hidden states of the pandemic system [3]-[5]. However, most countries released the COVID-19 death data without the information of any presence of comodbidity or multimorbidity. Therefore, we aim to divide new class of pandemic models into different compartments with only COVID-19 and those with the history of other ailments due to comodbidity or multimorbidity. This renders an increase in the order and complexity of the nonlinear ordinary differential equation (ODE) model of the pandemic, making the parameter and state estimation far more challenging than the usual 6D model. However, such a model, estimated with the proportion of the historic killing diseases in a country may help getting approximate death cases from comodbidity factors. This detailed state information for different diseases may help design a feedback controller as the next step, for optimal management of portfolio of diseases, helping the Governments understand seasonal and disease specific granular control actions needed [6].

Keywords: comorbidity, multimorbidity, COVID-10, Kalman filter, state estimation, disease control

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Location Analysis Under Uncertainty

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Abstract

Drawing attention of many researchers, location analysis pertains to the process of modeling, formulating, and solving a category of problems focused on determining optimal facility placement within a specified area. One of the challenges faced within location analysis problems is that uncertainty in problem parameters is inherent in many real-world applications. Uncertainty may stem from various factors such as the unknown demand volume or imprecise locations of points to be covered. In disaster management applications, for instance, uncertainty in the severity of the disaster poses additional challenges. To hedge against the uncertainty within optimization problems, stochastic and robust optimization techniques are used.

This study explores the modeling challenges and solution approaches for location problems in the presence of uncertainty in problem parameters. In particular, robust optimization techniques are explored to tackle the uncertainty. We present mathematical formulations, discuss linear approximation techniques and solution approaches. Furthermore, illustrative research studies are presented that utilize various robust optimization techniques, showcasing the practical application of these concepts. The first application addresses target location uncertainty phenomenon in point coverage problem [1], while the second and third applications deal with humanitarian relief operations during earthquakes [2] and pandemics [3], respectively.

Keywords: Location analysis, robust optimization, uncertainty.

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Logistics Plan with Different Transportation Modes

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Abstract

In the realm of logistics management, the selection of transportation modes plays a pivotal role in ensuring timely deliveries while minimizing operational costs. Our study delves into the problem of scheduling demand transportation across various days within a predetermined planning horizon, all while selecting from a range of transportation options. In our study, we have a real-world scenario encountered by a logistics provider tasked with distributing spare parts to dealers across a network spanning 12 provinces. With daily demand forecasts available for each province, the company is confronted with the decision of utilizing either lorries or trucks for transportation. Lorries boast higher capacity and lower unit transportation costs, whereas trucks offer lower capacity alongside higher unit transportation costs. Additionally, there exist constraints regarding the maximum number of provinces that can be serviced within a given transportation route. To address this multifaceted challenge, we have developed a mathematical model. This model provides a structured framework for scheduling transportation, ensuring seamless operations across different transportation options while adhering to the overarching objective of minimizing transportation costs. Preliminary computational experiments with the mathematical model have yielded promising results. What-if analysis is also conducted to provide additional insights and ideas to the company. Through the application of our proposed mathematical model, we aim to offer actionable insights and strategies that can significantly enhance the efficiency and cost-effectiveness of logistics operations in similar contexts. Our goal is to help make logistics smoother and more efficient, leading to better overall success for companies.

Keywords: Logistics, Transportation Modes, Mathematical Modeling

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Gradual and Joint Coverage in Location Problems: Modeling Challenges and Solution Approaches

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Abstract

Location problems constitute a fundamental area of study within operations research and decision science with wide-ranging applications spanning facility location, network design, emergency response, transportation, and defense. One critical aspect of location problems is the coverage of demand or service areas by facilities, which can have significant economic, social, and environmental implications. Conventional models often assume binary or deterministic coverage, where a facility either fully covers a demand point or does not cover it at all. Although this simplification is useful for theoretical derivations, back-of-the-envelope calculations, and performance comparison, it overlooks the nuances and complexities of real-world scenarios.

In this study we explore and discuss the modeling challenges and solution approaches for location problems in the presence of gradual and joint coverage, where multiple facilities provide partial and cooperative coverage to demand points. We introduce mathematical formulations, explore techniques for linearization and approximation, and propose solution strategies applicable to various models in retail operations and defense contexts. Initially, we consider the nonlinear mathematical model given in [1] that aims at maximizing total joint coverage within a given region. Subsequently, we analyze three integer linear programming formulations [2], that can be solved with off-the-shelf solvers. The first two formulations entail linear approximations based on a separable programming approach and a tangent line approximation method, while the third involves an exact reformulation employing a specialized network mapping technique. We then assess the impact of linearization approximation errors on the performance of the first two formulations and perform numerical experiments to compare solution times and solution quality among the formulations. Through solving them for a set of reasonably large problem instances, we observe that the approximations outperform the exact reformulation, yielding higher-quality solutions with an acceptable level of objective function value error.

Keywords: Location science, coverage, approximation algorithms

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Steady MHD Flow in a Duct with Non-Rectangular Cross-Section Using the Stabilized FEM Solution

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Abstract

This study investigates the effects of small boundary perturbation on the steady magnetohydrodynamic (MHD) duct flow [1] when the Hartmann upper and/or bottom walls are curved and perturbed, perfectly conducting while the side walls are insulated and plane [2]. The numerical results are obtained by solving the steady MHD flow equations with the stabilized finite element method (FEM) for Hartmann number values $Ha \leq 50$ and for curved surfaced parameters ε=0.1, 0.2, 0.3 [3]. The velocity and the induced magnetic field sensitivity to the curved wall shapes are investigated in terms of equivelocity and current lines, and also their level curves. It is focused that the flow and the induced current are affected by the curved boundary shapes especially near those boundaries and also, to some extent, in the whole duct. It is also observed that increasing the Hartman number Ha affects the flow behavior especially near the upper boundary compared to the bottom boundary if both of them are selected as perturbed. Further increase in Ha delays the effect of the curved boundaries leaving its place flattened flow with side layers and stagnant fluid at the central part of the duct.

Keywords: Steady MHD duct flow, Stabilized FEM, Perturbed boundary

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Operational Matrix based in Bernoulli polynomials for solving fractional Burgess equation

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Abstract

Recently, operational matrices are utilized for solving several kinds of fractional differential equations (DFEs). These differential equations have non-integer order derivatives [1]. The non-integer operator presents additional complexity in fractional calculus and numerical methods are required when solving FDEs [2].

In this study, we present a mathematical model derived from fractional operators in terms of Caputo. Bernoulli polynomails are used as basic functions to obtain operational matrices together with collocation method to find numerical solutions for FDEs. Lastly, we apply a technique based on the operational matrix to solve the fractional Burgess equations to confirms the effectiveness of the operational matrix.

Keywords: Bernoulli polynomails 1, Operational matrix 2, Collocation method 3

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Optimization Framework for Cell Culture Plate Positioning in Microbiological Safety Cabinets: Addressing Adverse Acoustic Effects and Advancing Regenerative Medicine

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Abstract

In the field of cell culture, the effects of mechanical stimulation applied via acoustic vibration on cell cultures at low frequencies have garnered significant interest due to their potential to influence cell behavior [1]. Recent literature suggests that continuous stimulations at low frequencies and short periods of time can induce effects such as action potential kinetics as well [2]. Cell culture plates, essential for growing and maintaining cells in vitro (outside of the organism), are stored in microbiological safety cabinets (MSCs) to provide a controlled and sterile environment for maintaining the integrity of cell cultures. While international standards define limits for environmental stimuli generated by MSCs, the potential adverse effects of these stimuli on cell cultures remain understudied [3]. This study proposes an optimization framework for cell culture plate positioning within MSCs using an open-source finite element script [4]. The two-fold approach of this investigation involves acoustic modal analysis to characterize wave distribution, focusing on low-frequency modes, and experimental validation by observing cell responses to short-term alarm sounds under various positioning scenarios. The research aims to inform best practices for maintaining cell viability and experimental integrity, potentially aiding in mitigating adverse acoustic effects on cell cultures and advancing regenerative medicine and tissue engineering.

Keywords: acoustic analysis, cell culture, microbiological safety

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A Methodology for Robust Constrained Optimization involving Expensive Function Evaluations with Application to Airfoil Design Optimization

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Abstract

We consider optimization problems that are based on quantities of interest(QoI) computed via computationally expensive routines and contain uncertainities. In such a setting, each realization of the uncertain QoI requires an execution of the computationally expensive routine (possibly a simulation). Robust formulations of the optimization problem are stated over all possible realizations of those quantities (i.e. over the set of uncertainties) with the aim of generating solutions less sensitive to uncertainties[1]. In particular, the objective/constraints of the robust formulation stand somewhere in between the expected-case and the worst-case scenarios regarding the uncertainties, and are generally stated in terms of the mean and the variance of the random QoI. In a setting where QoI are computed via complex routines, numerical techniques must be used for evaluations of the resulting objective/constraints (i.e. for the statistical estimation of the mean and the variance). A generic optimization approach is computationally very demanding since the optimization process requires several function evaluations, which in turn requires a large number of realizations of QoI. In this work, we suggest a new methodology that employs Bayesian optimization to approximate objective/constraint values at the iterates of a noise-aware sequential optimization algorithm. The key ideas of our methodology are the following: (1)within the optimization process, the objective/constraints are evaluated only approximately, (2)uncertainty propagation is modeled by a Gaussian process and sampling is guided by Bayesian optimization to get good approximations of the objective/constraints with less realizations of QoI at each iterate of the optimization algorithm, (3)since approximate evaluations are noisy (i.e. they contain approximation error), the robust optimization problem is solved by a noise-aware optimization algorithm. We apply the proposed methodology to robust airfoil design optimization under uncertainties in operating conditions, where the realizations are obtained via RANS simulations[2]. We provide numerical results on the performance of our approach in terms of the quality of the solutions and the overall computational efficiency.

Keywords: constrained robust optimization, Gaussian process, airfoil design optimization

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An Artificial Intelligence Approach to Parameter Estimation for An Addiction Model

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Abstract

Recent technological advancement has offered numerous benefits but also has brought drawbacks, one of which has been the increased use of social media, potentially leading to pathological addiction among individuals of all age groups. Such addiction has significantly impacted individuals' quality of life, educational achievements, and overall health negatively. The purpose of this study has been to explore a mathematical model that captures the dynamics of social media addiction.

A comprehensive dataset, collected from surveys of 217 individuals, has been utilized to train our artificial intelligence algorithms. Clustering methods have been applied to effectively categorize individuals into four distinct groups: sensitive, mildly addicted, heavily addicted, and afflicted. The language employed has been clear, objective, and value-neutral, steering clear of bias, emotional, figurative, or ornamental language. The text is characterized by a passive tone and impersonal construction, eschewing first-person perspectives unless necessary and is devoid of grammatical, spelling, and punctuation errors. The content of the improved text has adhered closely to the source text without introducing new elements. Furthermore, artificial intelligence techniques have been employed for conducting sensitivity and stability analyses of the model, aiming to enhance parameter predictions to better mirror real-life scenarios with our meticulously trained model.

Our mathematical model, underpinned by parameter predictions enabled by artificial intelligence, has allowed us to attain realistic insights into the realm of social media addiction. It has been imperative to highlight the pivotal role of artificial intelligence in making accurate parameter predictions, as evidenced by our findings. This study has introduced a novel method for understanding and addressing the issue of social media addiction and aims to make a significant contribution to the efforts to alleviate its adverse effects.

Keywords: Artificial Intelligence, Parameter Estimation, Mathematical Modelling

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Investigation of the Nonlinear Flexural Characteristics of Shear Deformable Carbon Nanotube Reinforced Hybrid (CNTRH) Composite Beams

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Abstract

In this study, the geometrically nonlinear behavior of carbon nanotube (CNTRH) reinforced hybrid composite beams is investigated numerically. These are advanced materials in which carbon nanotube (CNT) are incorporated into a matrix to enhance mechanical, thermal, and electrical properties. The basic structure of these composites consists of a metallic material such as aluminum or titanium serving as the matrix, with carbon nanotubes dispersed within it. The carbon nanotubes, which are cylindrical structures with diameters on the order of nanometers, behave as reinforcements within the matrix material. The integration of CNTs into metal matrices offers significant enhancements in mechanical properties, rendering matrix as purposive materials for diverse structural applications. Mechanical bending response of CNTRH beams under varying loading conditions is analyzed with employing mixed finite element method. Specifically, the focus lies on determination of geometric nonlinearity of beams to accurately depict the composite beam's complex behavior. Through systematic exploration of parameters such as CNT volume fraction and distribution pattern, the study elucidates their influence on the mechanical performance of the composite beams. The numerical findings shed light on crucial aspects including load carrying capacity and deformation characteristics, thus enhancing the understanding of CNTRH behavior. Moreover, parametric investigations enable optimization of design parameters to further enhance mechanical properties. It can be said that, their nanoscale dimensions also allow for efficient load transfer within the composite material. This research contributes to advancing the comprehension of structural behavior in CNTRH, offering valuable insights for the design and optimization of composite structures in aerospace, automotive, electronics, bioengineering, construction and various engineering fields.

Keywords: Carbon nanotube, CNT reinforced, composite beams, nonlinear analysis, finite elements

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BEM and DRBEM Solutions of 3-D MHD Flow Equations

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Abstract

We have considered the numerical solutions of MHD equations [1] in 3-D domain defined on different geometrical sections having insulating walls. An externally applied uniform magnetic field is imposed different angles with the flow direction. Due to the coupled nature of the equations, both coupled and decoupled solution procedures are considered using the fundamental solutions of the Laplace equations in the DRBEM formulation[2]. As an alternative solution method using the fundamental solution of the convection-diffusion equation [3] is also considered for the comparison purpose. In this method, first a particular solution is considered in order to get the homogenous form of the system of equations. Then, the resulting decoupled partial differential equations are numerically solved using BEM formulation with different element types. Due to the huge size of the obtained linear system of equations, an efficient iterative system solver from the NAG library is used in the numerical solution procedure. The obtained solutions are displayed in terms of figures as the 2-D slices of the 3-D solutions. The well-known characteristic of the MHD flow is visualized for the increasing the Hartman number values.

Keywords: 3-D MHD flow, BEM, DRBEM

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Site Selection for Small Modular Reactors

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Abstract

Small Modular Reactor (SMR) refers to the small, compact versions of traditional nuclear power plants, offering various advantages in the energy sector. They are seen as an environmentally friendly energy source by providing more flexible, cost-effective, safe, and carbon-free energy production [1]. SMRs have significant potential for a sustainable energy future and the technology will see significant development in the coming years. There are many SMR designs being worked on worldwide, and each has different technical requirements [2]. There are very few site selection studies for SMR technologies in the literature, and these studies have developed solution methods with the assumption of a uniform type of SMR [3-5]. However, the factors affecting site selection are quite diverse and involve different disciplines, making expert opinion crucial. Especially since the degree of importance of each factor can directly affect the outcome of the model, design and type selection are significant factors influencing decisions in this problem. This study addresses identifying suitable sites for the siting of SMRs by using Multi-Criteria Decision Making (MCDM) methods such as TOPSIS and VIKOR. To define the weights of factors which will have impact on site selection of SMRs, the survey filled out by the experts has taken into consideration. The role of factors such as geographical location, infrastructure condition, population density, access to the electricity grid and regulations in determining the most suitable regions for SMRs is emphasized [2]. An application for the site selection of SMRs for Turkey will be presented and the importance weight of the factors and specific possible candidate sites will be defined in this study.

Keywords: Small Modular Reactors, Site Selection, Multi-Criteria Decision Making, Nuclear Energy

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Bifurcations and Chaotic Behavior of Lotka-Volterra Predator Prey System Involving Refuge Effect

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Abstract

This study examined a prey-predator system that includes a refuge effect. First, the Euler method was used, and a discrete-time model was obtained from the continuous-time predator-prey system. Afterward, the existence of equilibrium points was examined under certain conditions to be determined. Local stability analysis will be performed for each equilibrium point. It is shown here how the refuge effect changes the stability of the equilibrium points. In addition, the conditions under which flip and Neimark-Sacker bifurcation occur were determined theoretically, and finally, all obtained theoretical analyses were supported with the help of numerical simulations.

Keywords: Refuge effect, stability, Lotka-Volterra predator prey system, bifurcation analysis

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Design of Passive Harmonic Filter for the Claw-Pole Synchronous Generators under Non-linear Loading

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Abstract

Claw-pole synchronous (CPSG) machines have been used as generators in internal combustion engine vehicles for a long time [1] due to their low cost, robust rotor structure, and ease of manufacturing [2]. To supply the loads and charge the battery in the vehicles, generally, the AC voltage generated by the CPSG is converted to DC voltage using the rectifiers connected to its terminal [2]. The six-pulse rectifiers, a type of non-linear load that draws harmonically distorted current, can lead to highly distorted voltages at the terminal of the CPSGs [2, 3]. It is well known in the literature that the rise in losses caused by harmonic pollution may result in overheating of the electric machines and a decrease in their life expectancy [2].

There are many studies in the literature on the use of passive filters to reduce current and voltage harmonic distortion caused by nonlinear loads in electrical power systems [4, 5]. However, to the best of the authors' knowledge, in the accessible literature, there is no study on the implementation of passive filters to mitigate the harmonic distortion of terminal voltages and winding currents of the CPSGs under non-linear loading [2].

In this study, firstly, the harmonic distortions of terminal voltage and current of a three-phase 1.5 kVA, 150V, 50 Hz, and 4 poles permanent magnet CPSG dedicated to supplying a six-pulse rectifier load are simulated via 3D Finite Element analysis in Ansys Maxwell software environment. Secondly, several low-pass passive filters are practically designed to reduce the voltage and current harmonics in the analysis system. Finally, for the six-pulse rectifier load cases with the designed filters, the terminal voltage and current harmonic distortions, losses, and torque oscillations of the modeled CPSG are comparatively evaluated, and the filter providing the best results is determined. It is concluded from the obtained numerical results that the employment of the low-pass type filters considerably reduces the terminal voltage and current harmonic distortion levels, losses, and torque oscillation of the modeled permanent magnet CPSG supplying a six-pulse rectifier load.

Keywords: Harmonic distortion, passive filter design, FEM, claw-pole synchronous generators.

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Approximation of Laplace-Steklov Eigenvalue Problems by a Dual Reciprocity Boundary Element Method

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Abstract

In this work, a numerical analysis of a novel eigenvalue problem (EVP) that is called as the Laplace-Steklov EVP is performed by means of a boundary element method. One of the unique features of the problem considered is that the spectral parameter resides both in the defining partial differential equation and in one of the boundary conditions. Such generalised problems can be the subject of physical problems that of significant importance, an instance being the Fourier analysis of a heat problem in which one of the boundaries is considered to have a heat storing capacity [1]. In such situations, the problem is defined by a Wentzell type of boundary condition which leads to the existence of the eigenvalue along that boundary as well as being in the differential equation. The discretisation of the EVP is carried out with the use of a dual reciprocity boundary element method (DRBEM). In this approach, a boundary integral formulation is proposed that importantly has the advantage of discretising the boundary only, being crucial for the problem at hand due to the existence of the eigenvalue in the definition of a part of the boundary. The method is implemented by utilising the fundamental solution of the Laplace equation by appropriately assuming the rest of the terms as inhomogeneity. This is essentially the extension of the study [2] in which DRBEM approximations of a number of Steklov EVPs have been proposed. The followed strategy results in algebraic problems of moderate size that can be handled efficiently in general. Consequently, the first numerical results of the Laplace-Steklov EVP defined in several two-dimensional configurations are presented in this study to the best of the authors' knowledge.

Keywords: Laplace-Steklov EVP, boundary elements, DRBEM

Acknowledgements

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Optimizing Sustainable Food Waste Management: A Mathematical Modelling Approach for Retailers

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Abstract

Each day, a considerable amount of food produced is wasted, with a significant portion stemming from grocery stores. Not all products that are placed on the shelves of the market can reach the customer. Those that cannot reach customers are directly discarded at the end of their shelf lives, resulting in a huge amount of waste that should be managed periodically. Conventional food waste management typically involves landfill disposal, a practice with its negative environmental impacts. Which is why; retailers explore more sustainable alternatives for managing their food waste, such as biogas production. Such alternatives require the collection of waste from grocery stores to energy plants (e.g. biogas energy plants) resulting in an important transportation challenge.

In this study, we used mathematical modelling techniques to design the optimal collection network, determine the required vehicle capacity and transfer the waste products of the groceries to a designated biogas plant. The goal of the mathematical model is to minimize the CO2 emitted by using the optimal collecting network. Thus, this study provides valuable insight into the optimal collection network and vehicle capacity in order to reduce the carbon footprint of groceries.

The proposed model has been tested using data collected from over one hundred grocery stores located in various places in Kayseri, Türkiye. The preliminary result of the study demonstrates the feasibility of the project and to promote its dissemination. Via adopting this approach, retailers and grocery stores may achieve a more sustainable organization in their waste management programmes. As such, this model may be a useful tool for retailers and grocery stores to responsibly manage their waste.

Keywords: Mathematical Modeling, Food Waste Management, Sustainable Alternatives

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Determination of Mixed Element Network Structures via Artificial Neural Networks

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Abstract

Especially, at high frequencies, the connection points between lumped elements destroy the performance of the circuit. To be able to solve this problem, the effect of these connection points must be considered during design process, and they must be considered as circuit elements. In this case, the circuit will contain two different type of circuit elements, lumped and distributed elements as seen in Fig. 1, where UE, PLE and SLE represent distributed, parallel connected lumped and series connected lumped elements. Mixed element two-port network is described via three two-variable polynomials in terms of two frequency variables [1,2]. Each variable in the polynomials represents one of the frequency variables.

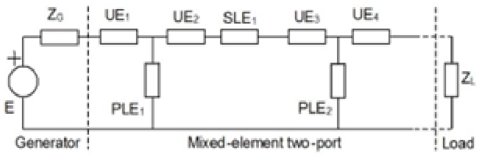

Fig. 1. Mixed-element two-port network.

After completing the design of a mixed element two-port network, the designer will get three two-variable polynomials completely describing the mixed element network. Then, by means of these polynomials, mixed element network structure (component connection order) must be obtained, and component values must be calculated. But, in literature only some of the possible network structures are determined via the obtained polynomials [3-6]. In this work, an artificial neural network (ANN) based approach is proposed to determine all of the possible mixed element network structures via two-variable polynomials, and shown that the proposed approach can determine all of the possible mixed element structures with 100% accuracy.

Keywords: Artificial neural networks, lumped elements, mixed elements, network structure

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Simulation-Based Analysis of Dengue Fever Considering Mosquito Aquatic Development Stages

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Abstract

In this study, an integer vector-host model is considered and qualitatively analysed to investigate the spread of dengue fever. This model mainly considers the factors during the developmental period of mosquitoes in water. Firstly, the positivity and boundedness of the solution are shown. Then, the equilibrium points of the model are obtained, and stability analysis is performed. Finally, numerical simulations are performed and interpreted with the help of appropriate model parameters.

Keywords: Mathematical model, dengue fever, numerical simulations

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1D cutting optimization model with adjustable cutting cost and leftover threshold

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Abstract

1 dimensional cutting optimization has been a popular topic among researchers and the metal industry for decades. The purpose of such models is to find the cheapest work plan that determines the assignments between orders and materials in stock (e.g. steel bars). Due to the the complexity of the problem, several objectives need to be taken into account. The total cost is a combination of the very high cutting cost, the loss of unusable parts and possibly the number of bars moved. Different models in the litriture consider one or two of these goals at the same time with different priorities ([1],[2]).

In this paper we present our Linear Programming optimization model for 1D cutting, where users can set the cost of cutting, the limit below which the leftovers can no longer be reused and the unit cost of the trim loss. Our model manages all the mentioned cost components at a time.

We selected some commercial software to compare the performance and features of our implemented model. We also studied the limitations of the model in terms of the size of the input data and required runtime, given that models that do not use heuristics may have enormous computational requirements in case of large number of orders or stock.

Keywords: 1D cutting, Linear-Programming, Optimization

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A machine-learning based methodology for optimal site selection of electric vehicle charging stations in Turkey

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Abstract

Given the depletion of fossil fuels and the environmental impact of transportation, one approach to address this issue is to replace outdated conventional fuel cars with eco-friendly Electric Vehicles (EVs). However, the use of EVs presents challenges, such as limited range and the need for recharging. In order to promote the widespread adoption of EVs, strategically located charging stations (CSs) are crucial. This study proposes a machine-learning based modeling approach to predict the electric consumption for charging electric vehicles in Turkey, taking into account various factors such as demographic data from NextGeo for all districts in Turkey, district boundaries based on Hexagon H3 for processing large-scale geographic data, road structures in each location based on district mapping, and the number of shopping locations in each district. The dependent variable for the study is kilowatt-hour (kWh) usage, and its data has been collected from the CSs of a private company. Ten different models, based on multivariable-linear regression techniques, have been implemented to forecast the required kWh. Out of these ten different models, Support Vector Regression (SVR) has provided the most promising results without overfitting/underfitting. The effectiveness of the proposed model is measured using the Normalized Root Mean Square Error. By implementing this model across Turkey, we can predict the kW usage in areas that do not yet have CSs. The kW usages obtained from the calculations will be clustered/classified using the Jenks-Break Algorithm, allowing us to determine whether certain regions are suitable or unsuitable for constructing CSs.

Keywords: electric vehicle, charging station site selection, machine learning

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Pharmacy Location Selection with Geographical Information System: The Case of İzmir Province

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Abstract

The location of a pharmacy is pivotal for ensuring accessibility and convenience to the community it serves. Strategically situated pharmacies, especially those near hospitals, clinics, or within densely populated or underserved areas, ensure that medications and healthcare services are readily available to a broad spectrum of the population, including the elderly and those with limited transportation options [1]. Therefore, the location of a pharmacy directly impacts public health outcomes and the overall well-being of the community it intends to serve. However, the choice of the most appropriate location is directly dependent on geographical features. The use of geographical information systems (GIS) is highly recommended for such problems [2]. GIS are invaluable for site selection due to their ability to layer and analyze diverse spatial data, offering insights into geographical, demographic, and environmental aspects critical for making informed decisions [3, 4]. In this study, the pharmacy location selection problem for İzmir province (including all districts) is addressed. For this purpose, eleven different geographical criteria were determined. These are; proximity to pharmacies, proximity to health centres, proximity to hospitals, proximity to education and research hospitals, proximity to hospitals with emergency services, proximity to shopping malls, proximity to pharmaceutical warehouses, proximity to places with high pedestrian density, proximity to tram and metro stops, proximity to main roads and proximity to places with high population. Geographical information related to the criteria from the relevant data sources were entered into Esri ArcGIS software. Various scenarios were developed under different criteria weights and nearly 100 alternative locations have been identified. The results obtained in this study provide guidance for decision makers who want to open a new pharmacy or make similar facility investments.

Keywords: Geographical information systems, pharmacy site selection, spatial data.

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Coefficient Estimates for a subclass of univalent functions defined by Ruscheweyh Operator

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Abstract

Making use of a Ruscheweyh operator, we introduce a new subclasses of the Janowski type close-to-convex functions and determine estimates the coefficient bounds for this class. Furthermore, we investigate the special cases and consequences for this new subclass.

Keywords: Univalent Function, Subordination, Close-to-Convex Function, Ruscheweyh Operator

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A space-fractional reaction-diffusion system with applications in neuroprosthetics

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Abstract

Diffusion within porous media, such as biological tissues, exhibits departures from conventional Fick's diffusion laws, often resulting in the manifestation of space-fractional diffusion phenomena. The paper considers a simple case of a reaction-diffusion system with two spatial compartments - a proximal one of finite width having a source; and a distal one, which extends to infinity where the source is not present but first-order decay of the diffusing species takes place. The system models the foreign body reaction around an implanted electrode. The model was first proposed in [1] and further studied in [2]. Microscopic heterogeneities inside the tissue were modeled by a space-fractional diffusion term – a Riesz Laplacian of the concentration. This could allow for a more flexible approach when estimating transport parameters from real data. The steady-state of the system is solved in terms of Hankel and Mellin transforms, resulting in a Fox H-function. This analytical solution reduces in the integer-order case to modified Bessel functions of first and second kinds. Methods for numerical evaluation of the Hankel transform, representing the solution, are demonstrated and compared.

Keywords: Hankel transform, Mellin transform, Riesz Laplacian, Fox H-function, Bessel function

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Effect of Polypropylene Fiber Aspect Ratio and Use Rate on Drying-Shrinkage Behavior of Lightweight Concrete

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Abstract

In this study, the effect of polypropylene fiber aspect ratio and usage rate on the drying-shrinkage behavior of lightweight concrete was investigated. For this purpose, three different polypropylene fibers with lengths of 3, 6 and 12 mm and slenderness ratios of 100, 200 and 400, respectively, were used. 10 different lightweight concrete mixtures were prepared by adding fiber at the rate of 0.25%, 0.50% and 0.75% of the total volume to the fiber-free control mixture. In all mixtures, water/cement ratio, cement amount and slump value were kept constant as 0.46, 300 kg/m3 and 40±20 mm, respectively. The produced samples were cured in water in accordance with the standard until the test day. 28-day drying-shrinkage values of the prepared mixtures were measured. According to the test results, it was understood that the drying-shrinkage amount of all fibrous mixtures was lower than the control mixture. In this context, it was observed that the amount of drying shrinkage decreases by 10% to 56% with the addition of fiber to lightweight concrete mixtures. It was observed that when more than 0.50% fiber is used, the positive effect on the drying shrinkage behavior of the mixtures decreases slightly as the fiber length increases. In this context, it was determined that in mixtures containing 0.75% fiber, the drying shrinkage of the mixtures increased by 70% as the fiber length increased from 3 mm to 12 mm. This situation is thought to be due to the formation of an inhomogeneous and void matrix as a result of the increased possibility of fibers getting stuck together due to increasing fiber length and usage rate. It was understood that the optimum fiber usage rate in terms of drying-shrinkage behavior was 0.50%.

Keywords: Polypropylene fiber, lightweight concrete, fiber length, fiber usage rate, drying-shrinkage

Effect of Polypropylene Fiber Aspect Ratio and Use Rate on The Wear Resistance of Lightweight Facade Concrete

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Abstract

It is known that lightweight concrete is generally used in the production of facade panels. In this context, it is aimed to improve the wear resistance of facade concrete against environmental influences. For this purpose, the effect of slenderness and usage rate of polypropylene fibers on the wear resistance of lightweight concrete mixtures was examined. Within the scope of the study, polypropylene fiber with lengths of 3 mm, 6 mm and 12 mm and aspect ratios of 100, 200 and 400, respectively, was used. A total of 10 different lightweight concrete mixtures were prepared by adding fiber at the rates of 0.25%, 0.50% and 0.75% to the fiber-free lightweight concrete control mixture. In all mixtures, water/cement ratio, cement amount and slump value were kept constant as 0.46, 300 kg/m3 and 40±20 mm, respectively. The samples were cured in water in accordance with the standards and 28-day wear-related weight loss values were measured. According to the test results, it was understood that the abrasion resistance of all fibrous mixtures was higher than the control mixture. It has been determined that the abrasion resistance of the mixtures increases with increasing fiber length in mixtures containing 0.25% fiber. However, with the increase in fiber usage rate, the opposite of this behavior was observed. In this context, it has been determined that weight losses due to wear increase by 4% by increasing the fiber length from 3 mm to 12 mm in lightweight concrete mixtures with a fiber usage rate of 0.75%. The results showed that optimal balancing of fiber length and usage rate could increase wear resistance by ensuring effective integration of polypropylene fibers into the concrete matrix. In terms of wear resistance, the lightweight concrete mixture with 12 mm polypropylene fibers with a usage rate of 0.25% showed the best performance.

Keywords: Polypropylene fiber, lightweight concrete, fiber length, fiber usage rate, wear resistance

Rebalancing of multi-manned assembly lines with model variability

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Abstract

In recent years, due to the evolving market and increasing specialized demands, there is a notable surge in competition among companies. Complex model assembly lines, as compared to simple assembly lines, are better equipped to respond to customized customer demands. While numerous studies have been conducted on assembly line balancing in the literature, research specifically addressing the type-E mixed-model assembly line balancing problem is quite limited. In type-E problems, unlike others, the goal is to minimize both cycle time and the number of stations simultaneously, aiming for maximum line efficiency. This study proposes a solution in the form of a mixed- integer mathematical model. Also, a heuristic algorithm is developed for solving large-scale problems. In the developed model, lower and upper limit values for cycle time, denoted as $Cmin$ and $Cmax$ are provided to offer flexibility to the decision-maker. Additionally, in real-life scenarios, when rebalancing the line, completely reassigning jobs to different stations and the significant changes it brings about are undesirable.

Therefore, a new constraint group is added to the model for line rebalancing problems, limiting the number of changes. The proposed model that has been tested with datasets of varying dimensions and case study is capable of rebalancing type-E mixed-model assembly lines, offering the decision-maker alternative solutions under different conditions. According to the results obtained, the heuristic algorithm can achieve over 97% line efficiency in reasonable time for all the problems considered, including large scale problems.

Keywords: Mixed-model assembly line, rebalancing, line efficiency, optimization, type-E, mixed-integer programming, multimanned operation.

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Optimization of Grinding Conditions during the Clinker Grinding Stage

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Abstract

Grinding processes are characterized by intensive energy consumption. Therefore, it is extremely important to choose a mill and optimize the grinding conditions in the selected mill to ensure energy efficiency in the grinding process [1-3]. Approximately one-third of the total energy required for cement production is consumed in the clinker grinding stage [4,5]. From this point of view, even a small increase in grinding efficiency can provide economic and environmental benefits. Parameters such as the type and dimensions of the grinding media, mill speed, power, feed size, and amount significantly impact the grinding performance in terms of product size and energy consumption. In the literature review, it was observed that many experimental studies were carried out on the effect of parameters such as ball and feed size, mill speed, and ball shape on grinding efficiency and product properties [2-3, 6-7]. However, it was found that there is a lack of literature on the effect of different ball sizes, feed sizes, and mill speeds on grinding efficiency. In this context, within the scope of this study, nine spherical balls ranging in size from 15-65 mm were used in different proportions, and cement was produced with three different ball distributions, three different feeding amounts, and three different mill speeds. The effects of the examined grinding conditions on the grinding efficiency and product properties were investigated based on the Blaine fineness values of the produced cements at certain cycles and the energy spent for the target Blaine fineness value. In addition, these parameters were examined with the help of the Taguchi method and ANOVA. By creating linear and quadratic regressions, an attempt was made to provide both financial and time benefits.

Keywords: Grinding efficiency, ball size, feed rate, mill speed, ANOVA, Taguchi

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Evaluation of the Performance of Amine-Based Grinding Aids

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Abstract

The cement industry is known to cause significant environmental damage in terms of energy, raw material consumption and CO_2 emissions [1,2]. CO_2 emissions from cement production account for 5-7% of global CO_2 emissions [3]. Approximately 1.2 tonnes of raw materials and 130 kWh of energy are consumed to produce 1 tonne of cement, resulting in the emission of approximately 1 tonne of CO_2 [1,4]. Approximately 60% of the energy used in cement production is consumed in the clinker grinding process. A significant portion of the energy consumed during the grinding stage is dissipated as heat, noise and vibration [5]. Grinding Aids (GA) are used in the clinker grinding stage to ensure energy efficiency and reduce harmful gas emissions to the environment [6,7]. GAs are adsorbed on the surfaces of grains with the help of highly polar functional groups (-OH, -NH2, -COOR, -SO3, etc.) [8]. Adsorbed GAs neutralises the electrical charges on the surface and prevents the clinker cracks from closing, the grains from aggregating and coating the mill surface and/or balls [8]. This ensures grinding efficiency. Due to the complexity of the appropriate selection criteria, the selection of performance-efficient GAs is extremely difficult. In this research, varying proportions of the commonly utilized compounds triethanolamine (TEA) and triisopropanolamine (TIPA) were mixed, and their impact on the Blaine fineness of cements manufactured under identical conditions was examined. Furthermore, apart from the control cement generated following 6000 grinding cycles devoid of GAs, 6000 grinding cycles were conducted with the following compositions: 100% TEA, 100% TIPA, 25% TEA 75% TIPA, 50% TEA 50% TIPA, and 75% TEA 25% TIPA. The Blaine fineness values of the cements obtained from the grinding were compared. Thus, the effect of using different proportions of GAs on the Blaine fineness of the cement produced at the same number of revolutions was investigated.

Keywords: Grinding efficiency, grinding aids, TEA, TIPA, Blaine fineness

Acknowledgments

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Study on Generalized (3+1)-Dimensional Variable Coefficient Nonlinear Wave Equation

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Abstract

Rogue waves (RW) are huge waves that appear suddenly and unexpectedly in the ocean. These giant waves are often disproportionate in size to the surrounding sea conditions and can pose serious dangers to sailors and ships.

In recent years, advances in technology and the use of observing tools such as radars, underwater sensors and satellites have improved the ability to monitor and measure RW [1,2,3,4,5]. This has allowed the ocean industry and researchers to better understand the potential impact of RW and take precautions.

RW solutions of the mathematical model have important applications in the ocean industry in areas such as ship design, safety measures, and sailor training [6,7,8,9,10,11]. These models are used for the assessment of RW probabilities, the strengthening of ship structures, and the improvement of maritime safety.

Non-linear evolution equations include terms or parameters corresponding to external and intrinsic effects such as ocean currents, wind effects, wavelengths, and wave interactions. These terms are related to the generation mechanism of RW, why some waves become larger than others. Although we have mentioned that RWs have always been related to oceans and maritime, they are encountered in many fields such as optics, plasma, etc.

In this work, RW solutions of the generalized $(3+1)$-dimensional variable-coefficient nonlinear wave equation [12] are obtained by ansatz-based methods. The obtained results will play an important role in marine research for new models and preparation against natural disasters.

Keywords: Rogue Wave, Analytical solutions, Ansatz-based methods.

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Measuring The Effect of Certain Basic, Social and Academic Activities on Success Using Modern Techniques

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Abstract

The aim of the research is to model the exam success status of high school students using fuzzy logic. The scope of this study includes examining the relationship between students' math exam results and variables such as daily study times, play times, homework times, and sleep times. The method used is a fuzzy logic approach called ANFIS (Adaptive Neuro-Fuzzy Inference System), developed by Jang and Sun (1995). This method uses a neural network learning method to adjust the parameters of the system by combining fuzzy logic and artificial neural networks [1].

Among the significant findings, it was determined that the ANFIS model has an 80% success rate in predicting high school students' exam performances. These results indicate that ANFIS could be an effective tool in determining academic performance of high school students. However, it is recommended to consider more data and variables to improve the accuracy of the model [1].

The significance of the research lies in presenting a new approach to predicting student success in education by using the combination of fuzzy logic and artificial neural networks. This study could serve as a useful tool for decision-makers in education to determine and improve student performance. As a result, the use of the ANFIS model can enhance data-driven decision-making processes in education and help improve students' achievements [2].

Keywords: Mathematics Achievement, Fuzzy Logic, Education

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Multi Objective Manta Ray Foraging Optimizer for a Home Health Care Routing Problem

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Abstract

Home health care services offer the most important conditions for customers to receive more economical and better quality service at home under sterile conditions [1-2]. Vehicle routing and scheduling are important in the successful performance of home health care services. The time period during which the patient will be served, the quality of the service provided by health professionals and the travel costs that will occur depending on the route are important in planning process. Assuming that patients' treatment times are known in advance, patients request a variety of services and teams can provide services of varying quality depending on their level of service proficiency.

It is possible to examine current life problems in a multi-objective way to reach realistic solutions. In the literature, it has been seen in home health care studies that the problem is combined mostly with weighted objective functions [3]. In scalarization, weights are chosen in proportion to the relative importance of the objective to find a single solution that satisfies the subjective preferences of a decision maker. However, it can be required to achieve the complete pareto front instead of a single solution in real world problems.

In this study, in addition to team competencies, maximum travel limits have been determined for vehicles and teams. Pareto solutions were obtained with Multi Objective Manta Ray Foraging Optimizer [4]. Multi Objective Manta Ray Foraging Algorithm is a population-based algorithm that mimics foraging strategies of manta rays such as chain foraging, cyclone foraging, and somersault foraging. The integration of a fixed-sized external archive preserves the elitist concept by preserving the optimal Pareto set throughout the optimization process. Algorithm is coded on MATLAB R2021a and simulations are performed for different test instances to achieve the pareto solutions. The results obtained with Multi Objective Manta Ray Foraging Algorithm is compared with the outcomes from Non-dominated Sorting Genetic Algorithm and Multi Objective Particle Swarm Optimization to prove the accuracy of proposed approach.

Keywords: Home health care, routing, Multi Objective Manta Ray Foraging Optimizer

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Classification of Bifurcation Type in COVID-19 Pandemic Models Using Deep Learning

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Abstract

There have been many recent studies based on the COVID-19 data to construct alternative ordinary differential equation (ODE) models from simple 3D nonlinear compartmental models to more complex 6D models e.g. SEIQRD (Susceptible, Exposed, Infected, Quarantined, Recovered and Death) structure [1]. Based on the parameterisation of the pandemic models, fitting observational data, many of them were studied using the bifurcation analysis for chosen systems of ODEs. Especially such models may have many complex factors like higher order or fractional order dynamics, time delays, and measurement noise which make the bifurcation analysis of such complex dynamical systems extremely difficult. For simple nonlinear systems identifying the fixed points and studying their behaviour as one or more parameters change are considered as the fundamental step of bifurcation analysis. For 3D and higher dimensional systems, it's often difficult to find the fixed points for noisy, delayed, fractional order systems [2] since their behaviour are not the sole function of the right-hand side (RHS) of the nonlinear state space models. On the contrary, for such complex nonlinear systems, generating bifurcation diagrams from the time domain numerical simulation of the state variables are much easier solution, albeit being computationally demanding to study a wide range of parametric variations, parametric granularity vs. sparsity, and longer simulations. Bifurcation diagrams confirmed with the Lyapunov exponents, phase portraits and power spectrum can reveal different types of bifurcation, especially period doubling to chaos [3]-[5]. The aim is to classify the pandemic systems' behaviour based on different parameter effects on the bifurcation type e.g. saddle-node, pitchfork, Hopf, transcritical, especially for the fractional order ODEs (FODEs) in commensurate and incommensurate forms [6], delay differential equations (DDEs) and stochastic systems with noise.

Keywords: Pandemic model, nonlinear dynamics, bifurcation diagram, chaotic systems, classification

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The Comparison of Success Performances of Machine Learning Techniques: An Application on BIST

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Abstract

In this study, for the purpose of regression analysis, it is aimed to examine the changes in the sensitivity and success performances of data mining algorithms depending on the data size, which are frequently used in the literature. In this regard, an examination will be made on the financial ratios affecting the profitability of the energy companies in the BIST Index. Data mining is the process of discovering understandable, interesting and new patterns as well as explanatory, understandable and predictive models from large-scale data [1]. In the study, it is planned to use artificial neural network regression methods selected from XGBOOST, Catboost and Deep learning algorithms as data mining algorithms. The XGBOOST Method is a method with high predictive performance that provides superior performance in gradient boosting, classification, regression and ranking methods [2]. CatBoost method, one of the gradient boosting methods, was introduced by [3]. Studies conducted in many disciplines show that the CatBoost method is successful in classification and regression methods [4]. Artificial Neural Networks provide effective success in many areas such as rating the financial situations of businesses and rating the financial and political situations of countries [5].

Keywords: BIST, Energy Companies, Machine Learning, XGBOOST, Catboost

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A Strategic Approach for Sustainable Logistics: Environmental Performance Evaluation of Logistics Companies Using Grey Relational Analysis

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Abstract

This study presents an innovative methodology for measuring the environmental sustainability performance of companies operating within the logistics sector. Utilizing data from Global Reporting Initiative (GRI) sustainability reports, it evaluates the environmental performance of these companies through the application of Grey Relational Analysis (GRA). Grey Relational Analysis approach, one of the multi-criteria decision-making methods serves as a significant tool for analyzing uncertain and multidimensional environmental data, objectively comparing and ranking companies based on various performance criteria. In this context, the analysis identifies leading companies in terms of environmental sustainability within the sector and provides valuable data for the development of sustainable operational strategies. Furthermore, this research is considered a new methodological approach to measuring and improving environmental sustainability performance in the logistics sector. Consequently, the study offers a comprehensive analysis and strategic approach to evaluating and enhancing the environmental sustainability performance of logistics companies. This approach emphasizes the importance of sustainable logistics management and aims to increase awareness and practices related to environmental sustainability within the industry.

Keywords: Sustainable logistics, environmental performance, grey relational analysis

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Integrating K-Nearest Hyperbox Expansion Rule with Improved Online Learning Algorithm for General Fuzzy Min–Max Neural Networks

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Abstract

In the digitalizing world, the amount of data generated every day reaches astronomical levels. This deluge of data contains potential insights that can enable to make more informed and effective decisions. Machine learning and artificial intelligence technologies are critical due to their ability to extract meaningful information from these vast datasets and make predictions. Hyperbox-based learning algorithms categorize as a specific subset within the vast array of machine learning approaches. Improved online learning algorithm for general fuzzy min–max neural networks (IOL_GFMM) is among the algorithms that utilize hyperboxes for learning purposes.

This paper proposes an improved classifier method using an improved online learning algorithm for general fuzzy min–max neural networks (IOL_GFMM) with K-nearest hyperbox expansion rule. The aim of this study is to decrease the training time for the IOL_GFMM without reducing on classification accuracy. For this purpose, instead of evaluating all boxes belonging to the same class in the expansion process, the K-nearest neighbor boxes have been evaluated. It marks the first attempt at integrating the IOL_GFMM with the K-nearest hyperbox expansion rule. The proposed method has been tested with frequently used datasets in the literature. The results indicate that the training time has increased up to ten times without a decrease in classification accuracy. Particularly with large datasets, the effectiveness of the proposed method increases as the number of neighbor boxes increases.

Keywords: hyper-box, general fuzzy min-max, classification, k-nearest neighbors, machine learning

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Time-efficient Fractal-Fractional Image Compression Based on the Hybridity between the Chaotic System and Deep Learning Algorithms

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Abstract

The fractal image encoding and decoding method with preference to an image compression system is a more viable option owing to its capacity for high achievement with regard to compression ratio and resolution independence in any scale. Fractal image embodies two major phases: the encoding, where the numerical data are obtained from the statistically self-similar input image to construct the iterated function systems (IFS), and the decoding process, when the IFS data are decoded for reverting a fractal image as an attractor via the fractal inverse theorem. Yet, the popularity of fractal encoders in light of partition iterative function systems tumbles into nearly out of favor due to their massive time of encoding. Thefore, the existing process is yet further correctable. Accordingly, the current paper demonstrates a better redeemable aspect based on on the analyses conducted by introducing artificial intelligent tools to handle this problem effectively. Thus, in this study, we propose a new fractal-fractional image compression algorithm by utilizing the convolutional neural network with a chaotic activation function, which is due to its advantages in fast search and relevant matching. The chaotic properties of the newly designed chaotic activation function can enable the learning to be faster and to have better performance in comparison with the classical convolutional neural network (CNN). This mechanism also helps one to quickly obtain the best solution for fractal image compression by searching through and encoding both the domain-corresponding classification set and the sub-blocks of the range block classification set. Consequently, the experimental results obtained prove that the proposed algorithm is outstanding in terms of encoded speed, accuracy, and high compression ratio. Therefore, this intelligent segmentation algorithm for fractal image compression outperforms similar algorithms in terms of these related metrics and computational means.

Keywords: Fractal Image; Iterated Function System (IFS); Partition Iterative Function Systems; Fractal-Fractional Image Compression; Fractal Inverse Theorem; Fractal Encoders; Encoding; Decoding; Fractal-Fractional Algorithms; Deep Learning, Convolutional Neural Network (CNN); Range Block Classification Set; Hybridity; Chaotic Activation Function; Chaotic Systems.

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Demystifying Fractional Order Chaotic Respiratory Disease System with XAI

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Abstract

The current study delves into the intricate association between meteorological conditions and ~~the~~ incidence of Upper Respiratory Tract Infections (URTIs), leveraging the advanced capabilities of the CatBoost machine learning algorithm in conjunction with a Fractional Order Chaotic System and cutting-edge Explainable Artificial Intelligence (XAI) techniques. By analyzing comprehensive meteorological and health data collected from the Pamukova District (Marmara Region, Turkey), this research paper employs the SHapley Additive exPlanations (SHAP) values to elucidate the model's predictions, emphasizing the consequential effects of mean temperature, humidity, and atmospheric pressure over a 5-day period on the occurrence of URTIs [1, 2]. The findings obtained by the related analyses demonstrate that mean temperature holds a dominant influence on URTI predictions, with SHAP values peaking at 5.6, thus underscoring its critical role as a predictive marker for increased URTI cases. Similarly, the mean humidity is identified as a pivotal factor, manifesting a maximum SHAP value of 3.2, which signifies its substantial impact on the prevalence of URTIs. In contrast, mean pressure exhibits a wide array of SHAP values, indicating a multifaceted and somewhat indirect correlation with URTI incidences [3].

Integral to our approach is the incorporation of a fractional-order system that meticulously accounts for the history of data, thereby offering a nuanced understanding of the temporal dynamics influencing URTI trends. This aspect of our methodology not only enriches the predictive model with a deeper temporal context but also aligns with the foundational principles of chaotic systems as described by Lorenz, enhancing the robustness and accuracy of our predictions [1].

The predictive prowess of our model is evidenced by an accuracy rate of 75.21%, complemented by precision and recall metrics of 0.75 and 0.5217, respectively. Such metrics highlight the feasibility and effectiveness of our integrated approach in forecasting URTI occurrences with considerable reliability. The implications of our study are far-reaching for the domain of public health, accentuating the imperative to integrate extended weather data within disease prediction frameworks and to inform efficient and timely targeted preventive measures and strategies.

Keywords: Explainable AI (XAI); Upper Respiratory Tract Infections; Weather Data; Fractional Order Systems; Disease Prediction; Forecasting; SHapley Additive exPlanations (SHAP) values; CatBoost. Chaotic Systems; Temporal Dynamics

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Explaining Fractional Order Chaotic Lung Cancer Treatment with Artificial Intelligence

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Abstract

The complexity of lung cancer treatment presents a formidable challenge in oncology, which necessitates innovative and personalized approaches that transcend conventional therapeutic modalities. Accordingly, this study introduces a groundbreaking integrative approach by synergizing a fractional-order mathematical model with surgical and immunotherapeutic interventions to meticulously explore their collective influence on tumor growth and immune response dynamics [1]. At the core of our methodology is the strategic incorporation of Explainable Artificial Intelligence (XAI) techniques which significantly enhance the transparency and interpretability of the model's decision-making process [2]. By employing SHapley Additive exPlanations (SHAP) values, we provide a quantitative analysis illustrating the pivotal impact of individual parameters on the model's predictive outcomes. Specifically, our analysis identifies 'delta', 'epsilon_1', and 'mu' as critical parameters exerting a substantial influence on tumor progression, as evidenced by their high SHAP values [3]. In contrast, parameters such as 'phi_2' and 'phi_3' are delineated to have a comparatively marginal impact, indicated by their lower SHAP values.

By further substantiating the efficacy of our proposed combined therapeutic strategy, the model's simulations reveal a significant enhancement in patient outcomes which markedly surpass the results achievable through singular treatment modalities. A detailed sensitivity analysis underscores the critical role of cancer stem cell dynamics, particularly emphasizing the rates of division (k5) and differentiation (k13), in determining the effectiveness of treatment interventions. Beyond offering a robust mathematical foundation for understanding the intricacies of lung cancer dynamics, our research paper can provide facilitating processes for clinicians to formulate personalized as well as evidence-based treatment strategies. By harnessing the interpretive power of XAI, clinicians are equipped with a potent tool to inform and refine clinical decision-making processes in the end.

The innovative amalgamation of surgery, immunotherapy, and control theory, augmented by the analytical prowess of XAI, represents a paradigm shift towards precision oncology. For these reasons, the current research paper illuminates new pathways for cancer treatment while also setting a precedent for the integration of advanced computational models in the management of cancer, paving the way for more effective, timely as well as tailored therapeutic interventions.

Keywords: Explainable AI (XAI) techniques; Fractional Order Chaotic Systems; Mathematical Oncology; Sensitivity Analysis; Cancer Stem Cell Dynamics; Differentiation; Lung Cancer.

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WASAR Counter: Machine Learning Based Water Sport Activity Recognition for the Repetitive Action Counting

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Abstract

Human Activity Recognition (HAR) using time series data plays a critical role in various domains such as healthcare, security, and sports [1]. This paper presents a comprehensive study which aims at enhancing HAR through the utilization of advanced deep learning techniques to distinguish different water sport activities.

The in-house data (a total of 891 paddle and other sport activities sessions) will be provided by "WaterSpeed.app". This data is collected from an Apple Watch during the water sport activities. The water sport activities are paddle, kayaking, dragonboat, surfski, canoe, outrigging and rowing. In each session of data there 12 different features including accelerometers, gyroscopes, row, roll, pitch, and yaw. Firstly, the data will be labelled, and the feature extraction will be applied. Then, Turi Create (which is a deep learning model, specialized for time based human activity recognition) will be used to classify the water sport activities.

The accuracy, F1 and precision scores will be reported to understand the evaluation of the time-based series for human activity recognition.

The research investigates the efficacy of different deep learning algorithms in accurately classifying water sport activities such as paddling, kayaking, dragon boat, etc. from time series data. Through experimentation and analysis, the findings will contribute to advancing the state-of-the-art in Water Sport Activity Recognition, providing valuable insights for the development of robust and accurate activity recognition systems with reporting the paddle movement counts in the Apple Watch applications. Future research directions may focus on exploring advanced deep learning architectures and integrating wind-based water sport activities such as wind surfing.

Keywords: Human activity recognition, water sport activities, machine learning, time series data

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Minimization of Manufacturing Cost in Mixed-model Robotic Assembly Lines

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Abstract

Since cobots are more flexible than robots, they can be used in different areas of production and can work at the same workstation with the operator. Thanks to these features, the use of cobots in production is becoming increasingly widespread. Assembly lines are mass production systems that have an important concept in production. In these lines, to produce a final product, components are assembled sequentially into an incomplete product, depending on a certain task order [1]. With the use of operators and cobots together on assembly lines, the structure of assembly line balancing problems becomes more complex and new problem areas emerge.

In this study, a mixed model robotic assembly line balancing problem is addressed. In the problem, the cost of assembly line is minimized. As cost items, workstation opening cost, cobot cost and operator cost are also considered [2]. Since cobots and operators are heterogeneous, the unit cost of each type of cobot and operator varies. One operator and one cobot can work together at the same workstation and perform tasks in parallel. Tasks cannot be divided and are assigned to resources in accordance with the common precedence diagram. Not all types of resources can perform every task due to their capabilities. A numerical example is solved under various cycle time scenarios and the results are interpreted to examine the effects of problem-specific features on the objective function. When the results are examined, it is seen that the presented mathematical model gives quality solutions for small-sized data sets.

Keywords: Assembly Line Balancing, Mixed Model, Mixed Integer Linear Programming, Cobots.

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A New Total Data Fitting Method (TDFM)

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Abstract

Data fitting analyses hold significant importance in various fields, particularly in engineering, geographic information systems, graphic design, and related areas. This method enables the creation of mathematical models of real-world objects or phenomena. These studies facilitate a better understanding, analysis, and utilization of available data. Additionally, surface fitting ensures accuracy and precision in data-based predictions and simulations. Consequently, these studies serve as critical tools for extracting meaningful information from complex datasets and enhancing decision-making processes.

In this study, a novel approach to surface fitting methods has been developed, particularly for two-dimensional data sets. This new method involves clustering the data sets and constructing differantiable model functions based on either the centroids of the clusters or the minimum and maximum values within the clusters. An examination of various clustering algorithms used in the literature was conducted, along with an evaluation of their effects on the model construction process. The study extensively investigates the impact of clustering methods on deriving models and emphasizes the potential for enhancing existing algorithms.

The newly developed Total Data Fitting Method (TDFM) was tested using education data modeled using fuzzy logic [1]. Additionally, it is emphasized that for global optimization problems, the differentiability of the objective function is crucial for testing new optimization methods. The applicability of the objective function ddifferantiable from the model with existing global optimization techniques in the literature [2] was also tested.

The results obtained indicate that the developed method could serve as a novel, effective, and practical tool in data fitting studies. It is anticipated that this method could provide high-confidence predictions for unmeasured data values even with a limited number of measured data sets.

Keywords: Data Fitting, Clustering, Fuzzy Logic, Global Optimization Techniques

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Drone Routing Problem for Patrolling Forest Areas

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Abstract

Forest fires are gaining more attention due to the escalating impact of factors that endanger nature. These factors include habitat destruction, ozone layer depletion, smoking, volcanic activities, spontaneous combustion, lightning, wind, high temperatures, dry conditions and global warming. The causes of forest fires can be categorized into two main types: those caused by human activity and those arising naturally. Preventing forest fires is of utmost importance for safeguarding natural ecosystems, ensuring the continuation of life, and providing a healthy environment for future generations. Various methods are employed to mitigate forest fires, including observation towers, unmanned aerial vehicles, satellite imagery, and fire detectors. Swiftly detecting and intervening in fires at their inception prevents their escalation and mitigates adverse impacts. In practical scenarios, drones are employed for forest surveillance. In addition, on the drone routing problem have increased in recent years. In the realm of literature, fire prevention through forest patrols is a well-explored topic. ([1], [2], [3]). The susceptibility of forest areas to fires can differ based on various factors, including regional climate, topography, humidity levels, vegetation type, tree species and density. Researchers [4], and [5] have investigated the assessment of fire sensitivity. In this research, the problem of monitoring fire sensitive areas with drones is discussed. However, due to the intricate constraints, the mathematical model cannot swiftly attain an optimal solution. Matheuristic algorithms, which blend mathematical and heuristic techniques, yield high-quality outcomes in routing problems [6]. Specifically, we propose a novel matheuristic algorithm to solve the small, mediuam and large scale data.

Keywords: Drone routing problem, forest fire, matheuristic algorithm, fire detection

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Natural and Mixed Convection Phenomena under Lorentz Forces: Application of the SUPS Finite Element Formulation

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Abstract

Stabilized finite element simulations of unsteady natural and mixed heat convection phenomena in square enclosures under strong magnetic effects applied perpendicular to the walls are the subject of this presentation. The classical Galerkin finite element method (GFEM) for convection-dominated flow simulation is well known for yielding nonphysical oscillations. Thus, the streamline-upwind/Petrov–Galerkin (SUPG) [1,2] and pressure-stabilizing/Petrov–Galerkin (PSPG) [3,4] formulations are employed to stabilize the GFEM in order to handle such flows that occur at high Hartmann and Rayleigh numbers. The backward Euler formula is used to carry out temporal discretizations. The Newton–Raphson (N–R) method is used at each time step to linearize the nonlinear systems, and the sparse lower-upper (LU) decomposition is used to solve the linearized systems directly. The flow solvers are in-house developed, tested on a broad range of numerical experiments involving various thermal boundary conditions, and executed in parallel. Numerical simulations reveal that the proposed formulation operates successfully at high Hartmann and Rayleigh numbers without exhibiting any notable localized or globally scattered numerical instabilities.

Keywords: Natural convection, mixed convection, finite elements, SUPS

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Optimization of Fleet Search

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Abstract

Unmanned Aerial Vehicles (UAVs) play a vital role in enhancing the capabilities of military forces and organizations involved in operations like search and rescue. They can easily perform tasks that are challenging and unsafe for conventional (manned) aircraft, such as exploring or destroying chemical, biological, and nuclear facilities or highly defended combat platforms on land or at sea. Especially in military operations conducted in challenging terrains, there are numerous roles or tasks that UAVs can perform. Among these, intelligence, surveillance/reconnaissance missions for potential targets are prominent.

The effective planning of resources with high technological capabilities is as important as developing and deploying them. In this study, we assume a network of regions that possibly have enemy vessels, where each region has a probability of having vessel(s) and a difficulty of search. A homogeneous UAV fleet searches this network of regions to maximize the sum of cumulative detection probabilities obtained over a limited operation time. The regions are assumed to remain fixed at least during the period in which the planning of location and routing and its execution take place. The search for detection in each region follows the assumptions of random search, where the time to detection is a random variable of exponential distribution with a certain mean (Wagner & Mylander, 1999).

A mathematical model based on the formulation of prize collecting location and routing problem (PCLRP) introduced by Yakıcı (2016) is extended and developed to solve the aforementioned problem. The suggested model attempts to find optimal base station(s) among candidate locations, optimal routing for each UAV in the fleet, and also optimal duration of search in each region simultaneously.

Keywords: Unmanned aerial vehicles, search and detection, optimization

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An application of the SUPG/PSPG finite element formulation for simulating natural convection heat transfer inside nanoliquid-filled 2D cavities

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Abstract

We examine heat transfer via natural convection inside square cavities filled with nanofluids from a computational perspective. It is assumed that the cavities are square-shaped and mounted with heat sinks and/or sources on different parts of the boundaries. Pure water is the base fluid, and the nanoparticles under consideration are Cu, CuO, and Al_2O_3. The governing equations are based on the Navier–Stokes equations of incompressible flows. Several numerical instabilities can arise in the numerical simulations of incompressible flows for high Rayleigh (Ra) numbers when using classical numerical tools, such as the Galerkin finite element method (GFEM). Therefore, stabilized formulations are needed. In this regard, we employ the streamline–upwind/Petrov–Galerkin (SUPG) [1] and pressure-stabilizing/Petrov–Galerkin (PSPG) [2], along with the least-squares incompressibility constraint (LSIC). The numerical results obtained and the comparisons with reported research ([3]–[5]) show that the proposed formulation performs pretty well without any numerical instabilities.

Keywords: Natural convection, finite element method, SUPS

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Uniqueness and Stability of Solutions for a Fractional Initial Value Problem

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Abstract

In this talk, we deal with a class of nonlinear fractional differential equations, with initial conditions, involving the Riemann-Liouville fractional derivative of order $\alpha \in (1, 2)$. The main objectives are to obtain conditions for the existence and uniqueness of solutions (within appropriate spaces), and to analyze the stabilities of Ulam-Hyers and Ulam-Hyers-Rassias types. Motivated by the results obtained in [1]-[5], in this talk we present different conditions for the existence and uniqueness of solutions based on the analysis of an associated class of fractional integral equations and distinct fixed-point arguments. Examples are also included to illustrate the theory. This is a joint work with L.P. Castro[1] .

Keywords: fractional differential equations; Riemann–Liouville derivative; fixed point theory; Ulam–Hyers stability; Ulam–Hyers–Rassias stability

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The mathematical aspect of transfer learning parameters in pretrained models for lung cancer classification

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Abstract

Lung cancer is a leading cause of global cancer-related deaths, often ranking among the top three most diagnosed cancers alongside breast and colorectal cancers, with late-stage diagnoses contributing to its high mortality rate. Variations in incidence and mortality rates are influenced by factors like tobacco use, exposure to toxins, and advancements in screening and treatment methods. [1]. Early detection of lung cancer is crucial as it improves treatment outcomes and reduces the risk of metastasis, leading to better patient survival rates. Moreover, it enables the use of less invasive treatment options, enhancing patient well-being and reducing complications associated with aggressive therapies. Artificial intelligence (AI)-enabled medical imaging systems play a pivotal role in detecting anomalies in lung X-rays or CT scans indicative of tumor presence [2,3,4]. Similarly, genetic analysis algorithms contribute to more precise diagnosis and treatment selection by identifying specific mutations associated with lung cancer. In our study, we spotlight the utility of deep learning algorithms such as ResNet-18 [5], AlexNet [6], and Inception-V3 [7] in discerning between three highly aggressive lung cancer subtypes: adenocarcinoma, neuroendocrine tumors, and squamous cell carcinoma. Leveraging pre-trained convolutional neural network (CNN) models, our investigation involved testing on a dataset comprising 12000 high-resolution images focused on lung cancer cases. The accuracy results are highly gratifying, with rates of 94.5%, 96.4% and 99.3%, for AlexNet, InceptionV3 and ResNet18 respectively.

Keywords: Deep learning, pretrained models, transfer learning, lung cancer, ResNet-18.

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A Study of Scattering Theory of Eigenparameter-Dependent Impulsive Sturm-Liouville Equation With Matrix Coefficients

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Abstract

In this study, we set an eigenparameter-dependent impulsive boundary value problem for matrix valued Sturm-Liouville equation on the semi axis. The main purpose of this work is to examine the properties of scattering solutions and scattering function of this problem [1-4]. Firstly, we obtain Jost solution and Jost function of the operator corresponding to the impulsive boundary value problem [5,6]. Then, we find scattering function by using Jost function and we investigate scattering function's properties. We also get resolvent operator, Green function and the sets of eigenvalues and spectral singularities of this operator [7]. Finally, we present an example to demonstrate the application of our results. The novelty in this study is that it is the first study related to the impulsive Sturm-Liouville problem with matrix coefficients whose boundary conditions depend on spectral parameter.

Keywords: Jost function, Jost solution, impulsive condition, resolvent operator, scattering matrix, Sturm-Liouville equation

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Incorporating 3D Printing Technology and Component Dimension Considerations into Advanced Manufacturing Strategies for Disassembly Line and Routing Problem

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Abstract

Additive manufacturing, also known as 3D printing, involves transforming a 3D CAD model into a physical part through layer-by-layer material combination. This technology has become increasingly vital and is expected to play a larger role in the future, particularly with the advent of Industry 4.0. With global consumption on the rise, there is a substantial increase in electronic waste generated by discarded devices. One effective approach is the disassembly of End-of-Life (EOL) products, which involves carefully disassembling these items to recover usable components and materials. This not only reduces waste but also promotes recycling efforts, contributing to a more circular and eco-friendly economy. Also, the Vehicle Routing Problem (VRP) plays a crucial role in managing the delivery of components generated from the disassembly process. The variation in component sizes resulting from product disassembly directly affects distribution operations. Optimizing distribution operations leads to significant savings in both cost and time. This study explores the impact of additive manufacturing on the integrated disassembly-routing problem. Initially, EOL products are disassembled into components at disassembly centers equipped with 3D printers. These components are then distributed to demand centers. 3D printers are engineered to fulfill demand center requirements by producing intact components instead of faulty or broken ones from the production line. A mathematical model is proposed to address this problem, followed by through analysis and result evaluation. Through rigorous analysis and comprehensive result evaluation, this study seeks to provide valuable insights and practical solutions for enhancing the efficiency and sustainability of supply chain operations in the era of additive manufacturing and Industry 4.0.

Keywords: Additive manufacturing, vehicle routing problem, disassembly, reverse supply chain

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Mathematical Foundations and Applications of Genetic Algorithms in Defense Industry: Practices and Analyses

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Abstract

This study investigates the applications of genetic algorithms in the defense industry along with their mathematical foundations. Genetic algorithms are metaheuristic algorithms inspired by biological evolution processes such as natural selection and genetic crossover, utilized to solve complex optimization problems. In the defense industry, various problems such as route planning for aircraft, deployment of military units, logistics, and supply chain optimization can be effectively addressed using genetic algorithms. This study elucidates the mathematical foundations of genetic algorithms and examines their practical applications in the defense industry. Particularly, it delves into the mathematical models of various genetic algorithm operators, namely selection, crossover, and mutation, in detail. Subsequently, the focus shifts to how genetic algorithms are applied to real-world problems in the defense industry. The study analyzes the role and effectiveness of genetic algorithms in the defense industry, providing guidance for researchers and practitioners in this field. Furthermore, it discusses the successes of genetic algorithms in the defense industry and their potential future applications. Ultimately, this study is expected to provide insights and understanding for researchers and industry professionals seeking solutions to complex optimization problems in the defense sector.

Keywords: Genetic Algorithms, Defense Industry, Mathematical Foundations

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Deep Learning Models Designed for Solar Power Forecasting

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Abstract

According to the World Energy Outlook 2023 report published by the International Energy Agency (IEA), the global population is expected to increase by approximately 1.7 billion by 2050 [1]. In order to encounter the ever-increasing energy demand; It emphasizes that the effort to be completed to ensure the reliability of production, storage and transportation should be improved correctly. Nowadays, countries that rely on renewable energy sources, especially in the context of sustainable energy, put forward different forecasting mechanisms for the power plants that will be established or have been installed. Calculations completed not only for these energy resources, which are known to be uncertain and variable, but also to encounter energy supply and demand, are gradually increasing today [2]. Through the expansion of technology, many machine learning methods have begun to be used to make these calculations accurately and to ensure that the predictions are reliable. In particular, real-life data sets that consist of a series of data sets collected over time are known as time series. The purpose of time series forecasting is to find values for the future using historical data. In particular, researchers have found that deep learning models such as LSTM, GRU, and CNN are better at remembering complex and long-term dependencies on data. Ultimately, attention mechanisms inspired by human cognitive processes have become the focus of popular consideration in deep learning. The highest impetus of this study is to make the prediction mechanisms required for Solar Energy Systems comprehensive and economical with the help of deep learning algorithms in order to proliferation the use of solar energy, one of the renewable energy sources. In this context, future time predictions were made using actual solar energy system production data. The results achieved were compared with the help of altered statistical calculations and graphs, and the model that made the best prediction was discovered. This work was supported by Balıkesir University Research Grant No.:2024/007

Keywords: Renewable Energy, Solar Power Systems, Deep Learning

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A New Two-Step Smoothing Newton-Type Algorithm to Solve Non-Lipschitz Absolute Value Equations

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Abstract

This study focuses on solving the system of Non-Lipschitz Absolute Value Equations (NAVE) of the form $Ax + B|x|^p = b$ where A, B are $n \times n$ type real matrices, b is an $n-$dimensional real vector and $0 < p \leq 1$. The current form of NAVE is described as a non-Lipschitz and non-smooth system of non-linear equations. In order to solve this problem, firstly, a new smoothing function is developed for NAVE, and the NAVE is turned into a system of parametrized smooth equations. Following that, two distinct versions of Traub's method are modified for NAVE, depending on the smoothing technique. The numerical experiments are carried out on some well-known and randomly created test problems, and the numerical results are reported. Finally, a comparison with various approaches is provided to demonstrate the efficiency of the proposed algorithm.

Keywords: Non-Lipschitz absolute value equation, smoothing function, Traub's Method

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Parallel Implementation of Late Acceptance Hill-Climbing Algorithm

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Abstract

Optimization of combinatorial problems has been a central focus in numerous domains, ranging from logistics to manufacturing and beyond. In the last decade, the Late Acceptance Hill-Climbing Algorithm (LAHC) has attracted considerable interest due to its simplicity and efficiency in finding high-quality solutions in these problems [1]. This paper presents a thorough investigation focusing on the parallel execution of LAHC, specifically designed to address the Uncapacitated Facility Location Problem (UFLP) [2].

The proposed approach exploits the capabilities of parallel computing by initiating multiple threads, each of which starts its exploration from a different solution within the search space. To enable effective exploration, each thread maintains its individual historical record, preserving previously encountered solutions. This parallel implementation allows simultaneous exploration of the solution space, potentially speeding up the search process. Our analysis focuses on examining algorithm behavior under different parameters. We study the impact of varying history list sizes and thread counts on the performance of the algorithm. Through extensive experimentation, we evaluate the effectiveness of our parallel LAHC implementation in resolving UFLP instances of varying sizes in ORLIB [3].

Experimental results demonstrate the superiority of parallel LAHC over its sequential counterpart. Parallel LAHC consistently outperforms sequential LAHC and produces significantly better solutions across a range of UFLP instances. Our evaluation shows that parallel LAHC achieves up to a 10x speedup over its sequential counterpart on instances with 100 facilities and 1000 customers. This remarkable performance improvement underscores the effectiveness of parallel computing in tackling large-scale combinatorial optimization problems. In summary, our research provides valuable insights into the parallel use of LAHC for UFLP, highlighting its efficiency and scalability. By utilizing parallel computing resources and carefully tuning algorithmic parameters, we demonstrate a promising strategy for tackling complex optimization challenges in practical scenarios.

Keywords: combinatorial optimization, parallel late acceptance hill-climbing, uncapacitated facility location problem.

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Solvability of a System of Difference Equations

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Abstract

In this paper, we study the following three dimensional system of difference equations

$$\begin{cases} x_n = \dfrac{y_{n-4}z_{n-5}x_{n-6}}{y_{n-1}z_{n-2}(\alpha + \beta x_{n-3}y_{n-4}z_{n-5}x_{n-6})}, \\ y_n = \dfrac{z_{n-4}x_{n-5}y_{n-6}}{z_{n-1}x_{n-2}(\gamma + \theta y_{n-3}z_{n-4}x_{n-5}y_{n-6})}, \\ z_n = \dfrac{x_{n-4}y_{n-5}z_{n-6}}{x_{n-1}y_{n-2}(\eta + \zeta z_{n-3}x_{n-4}y_{n-5}z_{n-6})}, \end{cases} \qquad n \in \mathbb{N}_0,$$

where the initial values x_{-p}, y_{-p}, z_{-p}, for $p = \overline{1,6}$, and the parameters $\alpha, \beta, \gamma, \theta, \eta, \zeta$ are real numbers. Firstly, we examine the solutions of the mentioned system depending on whether the parameters are equal to zero or non-zero. In addition, the solutions of the aforementioned system are obtained in closed form. Finally, we also describe the forbidden set of solutions of the system of difference equations.

Keywords: difference equations, solution, forbidden set

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A Best Worst Method based Vehicle Routing Model for Medical Waste Management

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Abstract

Medical waste refers to infectious waste generated by businesses dealing with medical services. Medical waste logistics includes the collection, temporary storage, transportation and disposal of medical waste activities without harming the environment [1,2]. In the field of public health, waste collected regularly from private clinics, health centers, veterinary clinics, pharmacies and the homes of dialysis patients is tried to be rendered harmless to the environment. Management of the medical waste recycling process prevents many potential health risks, including virus transmission. It is mandatory to properly collect and dispose of medical wastes that may pose a risk to the environment [3]. In the process of collecting medical waste, it is useful to utilize the vehicle routing problem that evaluates the safety scores of health centers, and thus the urban environment and human health can be protected.

In this study, a vehicle routing problem related to the medical waste collection process from hospitals to disposal centers is discussed. First of all, the safety scores of hospitals are calculated with Best Worst Method which is a multi-criteria decision making method developed by Rezaei [4,5]. In selecting the criteria, studies in the literature have been used. This study also proposes a new mathematical model with safety scores and distances, giving priority to hospitals with low safety scores for the process of collecting medical waste from hospitals. The mathematical model was coded in GAMS software, and the results were interpreted on the basis of the objective function, using different weight sets for the results. The computational experiments demonstrate that shortest distance tours and high security collection are provided.

Keywords: Waste Management, Best Worst Method, Vehicle Routing Problem

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End of Day Process Optimization Through Multi-Mode Resource Constrained Project Scheduling - A Banking Case Study

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Abstract

An End of Day process is a batch job that consists of a list of programs, where tasks are automatically executed at times determined by a scheduler. Execution of these tasks requires the usage of multiple resources and must comply with certain prerequisite relations. Since End of Day process is executed on a regular basis, efficient allocation of resources to carry out tasks on time is of the utmost importance; since it enables a company to minimize the time required to complete all tasks, and maximize customer satisfaction by completing orders on time. This paper presents a case study in a Turkish bank. The goal of the project is to reduce the duration of the End of Day process by optimizing the schedule and the resource allocation of tasks with respect to execution constraints. The problem is discretized and modelled as a Multi-Mode Resource Constrained Project Scheduling Problem (MRCPSP) [1]. This paper provides a flow-based mixed integer programming formulation for the MRCPSP, which is then solved to optimality using commercial solvers for theoretical benchmark purposes; and a simulated annealing based heuristic approximation algorithm for implementation purposes. The main contributions of this paper are the flow-based mixed integer programming formulation of the MRCPSP, and the analysis conducted on the bank's End of Day process. Furthermore, it is shown that in addition to optimization and improvement, the scheduler in this paper can also be used to assess the importance of scheduling and crashing tasks, along with the sufficiency of the infrastructure for optimizing the End of Day process.

Keywords: Multi-mode resource constrained project scheduling; thread allocation; simulated annealing; End of Day process optimization; banking case study

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Analysis of integer and fractional order cobweb models: Comparative case study with machine learning algorithms

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Abstract

In this study, we bring different types of dynamic cobweb models into the spotlight and present some results about them. Price fluctuations in economic markets have long been of interest to scientists and policy-makers and cobweb models have taken remarkable attention from scholars since price fluctuations in economic markets can be described by the cobweb theory. [1,2,3,6] Specifically, the cobweb model is the first theoretical framework which is employed to clarify the ambiguities in the dynamics of agricultural prices. On the other hand, the utilization of intelligent systems which provide machine learning and artificial intelligence tools has become a hot topic in the applied sciences in the last decade. [4] As it is well-known, this discipline uses algorithms and their constructions to learn from data. [5] As the major task of this research, we aim to establish a linkage between cobweb theory and machine learning algorithms by using a data set of real agricultural prices.

Keywords: Fractional Order Cobweb Model, Machine Learning Algorithms, Artificial Intelligence

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Single Server Scheduling Problem with Stochastic Service Times

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Abstract

In this paper we consider the parallel machine scheduling problem with a single server. In this problem, each job has to be processed on one of the identical machines and before each processing, the machine needs to a setup operation by the server. If more than one machine needs the server at the same time, only one of them can be serviced and the others have to wait. In such a situation, it is critical to schedule the server, that is, to determine the order in which it will serve the machines. There are many studies in the literature that address this problem, but most of them assume that the problem parameters are deterministic. In studies that consider the stochastic nature of the problem, the case where the processing times of the jobs are stochastic is usually considered. However, in many different production sectors, the service time of the server performing the setup process may vary due to many factors such as the wear or breakdown of the equipment used, the number of workers assigned, or different performances of the workers. Moreover, since the machines share the server, an unforeseen change can cause significant amount of waits in all machines, so it is more realistic to consider the service time of the server as stochastic in the problem. In this paper, the single-server scheduling problem with stochastic service time in the identical parallel machines is considered for the first time. A two-stage stochastic programming model is developed to solve the problem. The performance of the proposed solution approach is demonstrated using randomly generated test problems. The contribution of stochastic treatment of the service time is also demonstrated by comparing it with the deterministic treatment of this parameter value.

Keywords: identical parallel machine scheduling, single server, stochastic server service time.

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Wind Energy Forecasting with Different Machine Learning Methods

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Abstract

While global energy demand continuous to grow, the use of fossil fuels increases greenhouse gas emissions in the atmosphere, leading to problems such as climate change and environmental degradation. Therefore, there is an increasing need to turn to environmentally friendly and renewable energy sources. Renewable resources such as wind energy have significant potential for use on land and water. However, due to the inherently stochastic and unpredictable nature of wind, short-term forecasts are of great importance for the efficient and reliable utilization of wind energy resources. These forecasts play a critical role for decision makers in energy markets, helping to manage the variability and randomness of wind power.

In this study, different machine learning methods (such as artificial neural networks, support vector machines) and different ensemble learning methods (such as XGBOOST, random forest) were tested using various different types of wind turbines to estimate the wind energy potential. In the model proposed within the scope of this study, the output powers of different types of wind turbines were used in the training phase and the reliability of the model was tested. The results of the study provide important insights that will inform light on decision-making processes for more effective and efficient use of wind energy in electricity generation.

Keywords: Renewable Energy, Wind Power, Wind Power Plant, Machine Learning

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PSO for Radar and Sensor Network Optimization: Mathematical Modeling and Supported Studies with Simulations

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Abstract

Radar and sensor network optimization plays a crucial role in enhancing the efficiency and effectiveness of defense systems. In recent years, metaheuristic algorithms have gained significant attention for addressing the complex optimization problems inherent in this domain. Among these algorithms, Particle Swarm Optimization (PSO) has emerged as a powerful tool for optimizing radar and sensor network configurations. This study explores the application of PSO in radar and sensor network optimization, focusing on its mathematical modeling and supported studies with simulations. By employing PSO, researchers aim to achieve optimal sensor placement, route planning, and resource allocation to maximize detection capabilities while minimizing resource utilization. Through mathematical modeling and simulation-supported studies, this abstract delves into the methodologies employed, challenges encountered, and promising results obtained in the realm of radar and sensor network optimization. Furthermore, it highlights the potential of PSO as a versatile optimization technique for addressing real-world defense challenges, paving the way for future advancements in this critical field.

Keywords: Radar Optimization, Sensor Network, Particle Swarm Optimization (PSO), Mathematical Modeling, Simulation Studies

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A comprehensive computational approach for a model of the dynamics of acute inflammatory response

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Abstract

In this study, we propose an algorithm using a collocation approach to investigate a dynamicmodel of the acute inflammatory response. Analytical results regarding the linear stability ofthe system around its equilibria are detailed. Previous work by Kumar et al. (2004), Reynoldset al. (2006), and Day et al. (2006) introduced a model to elucidate the dynamics of the acuteinflammatory response during infection. Our research involves deriving and numericallysolving the model under given initial conditions using a numerical method. This methodtransforms the problem into matrix equations, allowing the acquisition of point-by-pointsolutions within the specified interval using collocation points. In addition, we consider thestability analysis of the dynamical system in terms of positive equilibrium. Furthermore, wepresent an error analysis, numerical solution simulations and bifurcation analysis results tounderline the effectiveness and practicality of the method and to elucidate the behaviour ofthe model.

Keywords: Dynamical system, Taylor series, bifurcation analysis.

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Bypass – Blood Flow Simulation for Coronary Artery Disease via Openfoam

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Abstract

This work presents a comprehensive computational fluid dynamics study using OpenFOAM to simulate a blood flow - bypass model that includes varying degrees of stenosis, bypass angles, and diameters. Examining blood - vascular flows with CFD simulations can be a helpful resource in choosing treatment strategies for some important disease scenarios. For example, coronary artery disease (CAD) is a common, life-threatening condition that affects roughly 5-8% of the world's population. Bypass graft surgery is a common treatment for CAD that aims to restore blood flow [1,2]. However, the success of such procedures largely depends on the design and optimization of the bypass graft.

Therefore, in this study, blood flow simulations were performed with 50%, 70%, and 90% stenosis degrees representing different levels of arterial occlusion. Additionally, how bypass angles of 15° and 30° and graft diameters ranging from 1 to 2 times the bypass inlet diameter affected blood flow were examined. By systematically changing the parameters, the effects of stenosis severity, bypass angle and diameter on blood flow were compared. Thus, the performance of different bypass configurations can be evaluated through simulations and an additional decision mechanism can be created in choosing the most appropriate bypass scenario.

Simulations were performed using OpenFOAM [3], an open source computational fluid dynamics (CFD) software that can accurately model blood flow in complex geometries. IcoFoam solver was used to generate blood flow.

Keywords: Computational Fluid Dynamics, Blood Flow, Bypass Model

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Solution Approaches for Airport Taxiway Planning Problem

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Abstract

In recent years, demand for air transportation has been increasing rapidly and airports have difficulties in meeting this demand with their existing capacities. Flight delays are some of the most common problems faced by air traffic managers. Planning and managing flights by providing the necessary security measures becomes even more important at this stage. Departure, arrival, and parking processes are interconnected with the taxiing process, which refers to the ground movements of the aircraft between the runway and the gates. The taxiing planning is an important process for the passenger to reach his/her destination faster, for the airline to save fuel and increase customer satisfaction, and for the airport operator to ensure safe flight traffic. The aim of this study is to determine the most appropriate taxi routes, taxi routes based on appropriate gate assignments and taxi routes based on appropriate runway assignments, and to manage flight operations safely and efficiently according to these routes, taking into account the needs and desires of all stakeholders (Passengers, Airline and Airport Operators) that will benefit from the improvement of the taxiing process. So, we propose a mixed integer programming model to deal with taxiway planning. Practical constraints of the taxiway conflict and gate assignment are considered. Because of the NP-hard nature of the problem, the proposed mathematical model may not find feasible solutions for large-size problems. Thus, a genetic algorithm is developed to solve large-size problems. We used randomly generated test problems to demonstrate the performance of the proposed methods. Experimental results showed that genetic algorithm outperforms the mathematical model in both solution quality and solution time.

Keywords: Taxiway Optimization, Runway Assignment, Gate Assignment

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On Non-viscous Regularization of the 3D Davey-Stewartson System

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Abstract

The (3 + 1) dimensions Davey–Stewartson (DS) system arises from the three-dimensional modulation of an electron-acoustic wave in a collisionless, unmagnetized plasma using the multiple-scale asymptotic expansion method [1]. The DS system in the elliptic-elliptic case is given by

$$\begin{aligned} i\,u_t + u_{xx} + u_{yy} + u_{zz} &= a\,|u|^2 u + b_1\,u\,v_x\,, \\ v_{xx} + v_{yy} + v_{zz} &= -\,b_2\,(|u|^2)_x\,, \end{aligned} \qquad (1)$$

where u is a complex and v is a real function of $(t; x, y, z) \in \mathbb{R}_+ \times \mathbb{R}^3$. The commonly known DS system is a reduction of equation (1) to two spatial dimensions. Inspired by the α -model of turbulence, non-viscous regularizations of the 2D DS system were discussed in [2]. Some of the local and global existence results for solutions of system (1) with the initial condition $u(0, x, y, z) = u_0(x, y, z) \in H^s(\mathbb{R}^3)$ were established in [3, 4]. Conditions for the solutions to the 3D DS system that develop a finite-time singularity were obtained in [5]. The objective of this talk is to introduce a non-viscous regularization system for equation (1) in scenarios where the existence of finite-time blow-up solutions.

Keywords: Davey-Stewartson system, NLS-type equation, Non-viscous regularization

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Thermal Performance Improvement of an Internally Finned Tube by Optimizing the Shape of the Fins

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Abstract

In the present research, the numerical investigation focused on optimizing the geometry of fins to enhance the thermal performance of a three-dimensional internally finned tube. The computational domain was computed using the computational fluid dynamics (CFD) technique. The study examined laminar flow with Reynolds number ranging from 50 to 150. The tube has a diameter of 0.0272 m and a length of 0.3 m, and the fins have a thickness of 0.004 m and a height of 0.004 m. The fluid used in the simulations was water with a constant temperature of 293 K and the wall temperature of the tube and fins was fixed at 323 K and 333 K. The performance of the tube's heat transfer and its fluid behavior were studied at different fin configurations. The tube was simulated without and with fins for comparison. In the computational domain, the values of pressure drop and velocity were obtained. The average outlet temperature was utilized to analyze the thermal behavior of the three-dimensional internally finned tubes in the fully developed region. The results clearly show that the Reynolds number, the number of fins, and the fin arrangement directly influence the transfer performance. The average outlet temperature of the internally finned tube exhibited an increase in comparison to the smooth tube due to the increase in Reynolds number and the number of fins. As the Reynolds number and number of fins increase, the pressure drop also increases. This study provides a detailed analysis of the thermal and hydraulic performances of internally finned tubes and its results can help design internally finned tube heat exchangers with high efficiency.

Keywords: computational fluid dynamics, three-dimensional internally finned tube, heat exchanger

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A Multi-Objective Vehicle Routing Model to Minimize Maximum Travel Time of the Longest Tour Under Stochastic Travel Times Between Nodes

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Abstract

Vehicle Routing Problem is one of the fundamental problems in the literature with practical applications in transportation, distribution, and logistics. It is a combinatorial optimization and integer programming problem that search the answer of the question asking which routes should be used by the given number of vehicles to visit each customer only once without exceeding truck capacity and returning back to stating point with minimum cost. In other words, the problem mainly focuses on minimizing total transportation cost (or total travel distance) while (i) all sets of tours start and end at the same node (commonly the depot node), (ii) each considered customer node is visited only once, and (iii) capacity requirement of all customers of each route does not exceed the capacity of the used vehicle for this route [1]. In the modified model of vehicle routing problem presented in this study, a multi-objective integer linear programming model is designed to minimize maximum travel time of the longest tour. Since travel times between nodes are not deterministic values, the stochastic mathematical modelling approach is used. Moreover, unlike the traditional model, the required number of vehicles is calculated by the model. Thus, the model does not take a predetermined parameter value for the number of vehicles to use. The model is also checked in a real-life situation that comes from a factory's personnel transportation case. The solutions that stand on the Pareto-frontier are evaluated. The case not only validates the proposed model but also shows that solving the problem using the proposed approach gives better solutions than traditional approaches.

Keywords: Vehicle Routing Problem, minimax optimization, stochastic modeling, multi-objective modelling

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Solar PV cell parameters optimization using improved whale optimization algorithm

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Abstract

In order to meet the increasing energy demand, interest in alternative and clean energy sources is constantly increasing [1]. At the beginning of these sources, solar energy stands out as an unlimited and environmentally friendly source. Photovoltaic (PV) systems are mostly used to generate electrical energy from solar energy systems [2, 3]. PV modules are composed of solar cells connected in series/parallel. The efficient operation of the PV module is directly dependent on solar radiation and efficient power conversion [2]. These important characteristics of PV modules are affected by many physical parameters such as weather, location, module placement angle and air temperature. Modelling the electrical equivalent circuits of PV modules is an important factor to achieve efficient power conversion and performance. Different models have been proposed to model the electrical characteristics of PV modules. Among these, single diode model and the two diodes model. The single diode model is a useful and relatively low complexity model used to model the behaviour of the PV module. The two diode model is more complex than the single diode model, although it gives more accurate results. In both models, the nonliner characteristics need to be obtained more accurately. Optimization algorithms are very successful methods to solve this problem [4]. In this study, a new method is proposed to obtain PV cells. The proposed optimization algorithm is the improved whale optimization (IWOA) algorithm as an improved version of the whale optimization (WOA) [5] algorithm. The effectiveness of the proposed method is tested on single and dual diode PV system models. The results obtained show that the proposed method gives successful results against other classical methods in obtaining the optimum parameters.

Keywords: Optimization, PV cell, solar energy, whale optimization algorithm, WOA

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New Global Optimization Algorithms for Solving Economic Load Dispatch Problems

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Abstract

The purpose of this study is to address economic load dispatch problems in combined heat and power systems when the first derivatives of objective function are unavailable. To achieve this goal, we propose two new algorithms that are inspired by two existing approaches: an Auxiliary Function Algorithm and a Particle Swarm Optimization method. To assess the efficiency of the two proposed methods, we first conduct numerical experiments on several standard test problems and compare our findings to those obtained from existing global optimization algorithms in the literature. Following that, various economic load dispatch problems are resolved with the new codes and other global optimization approaches, and the results are compared. The numerical results verify the effectiveness of the two new algorithms.

Keywords: Global optimization, economic dispatch , auxiliary function, particle swarm optimization, smoothing techniques

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Performance comparison of oppositional metaheuristics for global optimization

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Abstract

In the rapidly evolving field of computational intelligence, metaheuristic algorithms have emerged as powerful tools for solving complex global optimization problems. This study presents a comprehensive performance comparison of three advanced metaheuristic optimization algorithms: rime optimization algorithm (RIME) [1], Mountain Gazelle Optimizer (MGO) [2], and Electric Eel Algorithm (EEA) [3]. These algorithms, inspired by distinct natural phenomena and biological behaviors, represent the cutting edge in algorithmic design for global optimization. Aiming to enhance the exploration and exploitation capabilities of these algorithms, this study incorporates three different opposition-based learning (OBL) [4-5] approaches. Opposition-based learning, a concept rooted in simultaneously considering an opposite estimate, has been shown to significantly improve the convergence speed and accuracy of metaheuristic algorithms. By integrating OBL into RIME, MGO, and EEA, we investigate how these enhanced algorithms perform against a suite of benchmark functions that are well-known in the literature for their complexity and multi-modality. The performance evaluation is conducted based on CEC2020 problem suite and several criteria, including convergence speed, solution accuracy, and robustness across multiple runs have been used to evaluate the performance of the algorithms.

Keywords: Global optimization**,** Metaheuristics, Opposition-based learning

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Comparison of Modified Karnik-Mendel Algoritm Based Interval Type-2 ANFIS and Type-1 ANFIS Controllers

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Abstract

Interval Type-2 Adaptive Neuro-Fuzzy Inference System (IT2-ANFIS) based Neuro-Fuzzy Control (NFC) is tested in this paper which is the first paper of the Modified Karnik Mendel Algorithm (M-KMA) based ANFIS control structure in the open literature. The Fuzzy Logic System (FLS) is a very effective method to model nonlinear and not precisely defined systems. So, the FLS is widely used in engineering and industry [1]. Determining the antecedent and consequent parameters of FLS is still a research area and the ANFIS is the most used structure in the literature. The ANFIS has two training stages as antecedent and consequent parameters training and two training methods as Least Square Estimation (LSE) and Gradient Descent (GD). In this paper, only consequent parameters training has been implemented because of the online training that only one input value has been considered in every step and GD is used concerning its advantages [2]. The type-1 FLS antecedent and consequent Membership Functions (MF) are accurate so it is impossible to represent uncertainties. So, Type-2 FLS and Interval Type-2 FLS are proposed in the literature to overcome uncertainties. The Interval Type-2 FLS can not be calculated directly and so, the Interval Type-2 FLS to Type-1 FLS reduction methods are used [3-7]. Karnik-Mendel Algorithm (KMA) that is one of the reduction methods is modified by Öztürk to implement ANFIS to Type-2 FLS and named as M-KMA [8]. The M-KMA-based Interval Type-2 NFC is implemented to nonlinear control problems and the results are compared to Type-1 NFC. The results show that the Interval Type-2 NFC is superior to Type-1 NFC at settling time and error.

Keywords: Modified Karnik Mendel Algorithm, Interval Type-2 Fuzzy Logic System, ANFIS

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Pell-Lucas Collocation Method for High-Order Linear Differential Equations

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Abstract

The Pell-Lucas collocation method can be applied to various high-order linear differential equations encountered in physics, engineering, and applied mathematics. It is particularly useful when the differential equation has complex boundary conditions and the equation is a nonlinear or functional differential equation. The Pell-Lucas collocation method is a numerical technique used to solve high-order linear differential equations. It uses Pell-Lucas polynomials as basis functions to approximate the solution of the differential equation. This method leverages the orthogonal properties and recurrence relations of Pell-Lucas polynomials, which can provide efficient and accurate solutions for such problems.

In this study, an approximate method is presented for the solutions of higher order linear ordinary differential equations with variable coefficients under given conditions. Solutions were obtained in terms of Pell-Lucas functions. Additionally, some examples are given to demonstrate the validity and applicability of the method. The numerical results is compared with some methods in the literature.

Keywords: Pell-Lucas collocation method, Pell-Lucas, High-order linear differential equation.

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On the Existence of Optimal Solutions for the Mayer Problem with Differential Inclusions

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Abstract

This paper deals with the existence of optimal solutions for the Mayer problem with differential inclusions. Differential inclusions play a significant role as a tool in the study of various dynamic processes and optimal control problems [1-6]. As is well known, there might not be a solution to an optimal control problem. A.F. Filippov assumed the velocity set to be convex, which allowed him to derive his well-known existence theorem in [7]. Furthermore, R.V. Gamkrelidze's work in [8] further improved this convexity-based method. We give our existing results to minimize overall solutions to given differential inclusion defined on a fixed time interval and satisfying boundary conditions, a functional depending on the final position. To achieve this, we make use of a result on the existence of continuous maps from the set of solutions to a differential inclusion with Lipschitzian right-hand side to the space of absolutely continuous functions.

Keywords: Differential inclusions, existence solutions

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Mathematical Modeling and Analysis of Virus Dynamics: Integrating Immune Responses and Transmission Modes

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Abstract

In the past decade, the field of mathematical biology has seen the emergence of various mathematical models addressing viral infections, notable among them being COVID-19, Human Immunodeficiency Virus (HIV), and Chikungunya virus [1]-[3]. These models have become instrumental in enhancing our understanding of disease dynamics while also proving critical in the evaluation of control strategies [4]. As the prevalence of infectious diseases continues to impact global health, these mathematical models serve as invaluable tools, offering insights that guide the formulation and assessment of effective control measures. Their significance extends beyond theoretical frameworks, providing a practical foundation for shaping strategies to mitigate the spread and impact of viral infections on a broader scale.

In this study, we introduce a virus dynamics model incorporating Cytotoxic T Lymphocyte (CTL) and antibody immune responses, offering a comprehensive exploration of the intricate interplay between the immune system and viral infection. The model accounts for two categories of infected cells: latently infected cells and actively infected cells responsible for virus production. Both virus-to-cell and cell-to-cell transmissions are integrated into the model, providing a more nuanced representation of infection dynamics. Ensuring the biological feasibility of our proposed model, we rigorously establish the nonnegativity and boundedness of its solutions. To delve further into the system's behavior, we derive five threshold parameters, crucial for determining the existence and stability of steady states. Our exploration extends to the global stability analysis of these steady states through the construction of suitable Lyapunov functions.

To validate the robustness of our theoretical findings, we conduct numerical simulations. These simulations serve as a crucial step in confirming the efficacy and applicability of our proposed model under various conditions. The combination of analytical proofs and numerical simulations enhances the reliability and significance of our research findings.

Keywords: Viral infection, Adaptive immune response, Global stability

Acknowledgements

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Determination of Temperature Distribution of FG Dry Cylinder Liner

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Abstract

The cylindrical-shaped part placed inside the internal combustion engines cylinder, which forms a surface resistant to wear caused by the piston and ring, is defined as the cylinder liner. In an internal combustion engine, if the cylinder wall temperature value is closer to the combustion gas temperature values, the thermal losses will be less, ideally. However, while high cylinder wall temperature has a positive effect on HC emissions, it has an increasing effect on NOx emissions. In gasoline engines, part temperatures must be kept below a certain level because in-cylinder excessive temperature causes uncontrolled explosions, which is known as knocking in the engine. However, the overcooled parts will cause undesirable compressor leaks, the temperature of these parts should not be reduced excessively. Thermal stresses due to temperature gradient along the radial or longitudinal axis of the cylinder liner can lead to cracking, crack propagation, and deformation. These deformations may cause compression leaks, resulting in a decrease in efficiency. For such reasons, it is crucial to predict the cylinder liner wall temperature in advance. In this study, the two-dimensional temperature distribution of a functionally graded dry cylinder liner is determined numerically by using the pseudospectral Chebyshev method. It is assumed that the material properties vary along the longitudinal direction as linearly. The governing equation of the functionally graded dry cylinder liner is obtained as a second-order partial differential equation. An analytical solution of such equations is possible for homogeneous material with simple boundary conditions. The validation of the method is provided by comparing numerical and analytical results that are obtained from the temperature distribution of a dry cylinder liner, which is made of homogeneous material, under constant temperature boundary conditions.

Keywords: Dry Cylinder Liner, Functionaly Graded Materia, Pseudospectral Chebyshev Method

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New Exact Travelling Wave Solutions for (2+1)-dimensional Date-Jimbo-Kashiwara-Miwa Equation

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Abstract

In this study, we investigate (2+1)-dimensional Date-Jimbo-Kashiwara-Miwa (DJKW) equation to obtain exact and novel solutions via the generalized unified method (GUM). The mathematical form of the DJKW equation as second formulas for Kadomtsev-Petviashvili hierarchy is given as follows:

$$u_{xxxxy} + 4u_{xxy}u_x + 2u_{xxx}u_y + 6u_{xy}u_{xx} - \alpha u_{yyy} - 2\beta u_{xxt} = 0.$$

Recently, some of the nonlinear phenomena mostly described the DJKW equation have been becoming very significant in applied sciences and attracted attention of many researchers as a research topic because of its applications in in plasma physics, fluid mechanics, and other fields. Particularly, the DJKW equation arises in the wave propagation problems when modelling the long water waves with frequency dispersion and weakly nonlinear restoring forces. Considering applications of the DJKW equation on real world problems, finding exact solution can be helpful to understand the mechanism of the complicated physical problems modelled by the DJKW equation.

Keywords: Date-Jimbo-Kashiwara-Miwa equation, The Generalized Unified Method, Exact Solution Method

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The Forecasting of Arrival Calls to Call Centers Using Artificial Neural Networks Method: An Application for the Electiricity Distribution Company

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Abstract

Call centers are organizations that employ thousands of representatives and have complex and intricate problems. Two issues are important when planning processes, especially in call centers. First, call centers are labor intensive, so there must be enough employees and shifts must be planned. Secondly, factors such as waiting time in call centers and the number of answered calls are very important for customer satisfaction [1]. It can be said that there are two factors affecting each other, where accurate shift planning serves to minimize waiting times by ensuring that calls are answered on time. It will help to predict the number of incoming calls to facilitate shift planning and to quickly adapt to changing situations. In this study, the number of calls received by the call center of the electricity distribution company was forecast. Artificial neural networks-Multilayer perceptron (ANN-MLP) method was used to forecast the number of calls. In the literature, time series methods are generally used for demand forecasting studies for the number of calls arrival to call centers [2] [3]. In this study, the MLP application was implemented with different inputs, focusing on causality. ANN-MLP can be applied to many problems and high-performance solutions can be produced. The ANN create rules that link inputs to outputs, and the most effective outcomes are achieved through feedback during this process [4]. As inputs, seasonality (at different scales), planned maintenance, weather conditions (e.g., rainy, snowly, windly) inputs were considered by consulting the officials of the retail electricity distribution company serving the Eastern Anatolia region in Turkey. In addition, the regions of arrival calls, regional populations and special days were included in the model as input variables. The developed multilayer perceptron (MLP) model facilitated the anticipation and interpretation of call volumes under diverse scenarios. Performance evaluation of the model was based on metrics such as Mean Absolute Percentage Error (MAPE) and the coefficient of determination (R^2). The MAPE and R^2 values were considered as performance criteria in the evaluation of the model. As a result of the study, the most appropriate ANN-MLP network structure was obtained and, the development of the forecasting model suitable for application within the call centers of electricity distribution companies.

Keywords: Artificial neural network, forecasting, call center

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Optimizing Energy Consumption of Electrical Vehicles with Smart Driving Systems

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Abstract

Smart transportation systems are information technology-based systems aimed at increasing efficiency in transportation by facilitating coordination between passengers, vehicles, and roads. In these systems, decisions are made regarding how, where, and in what manner infrared, wireless network, or mobile technologies along with sensors will be implemented. Thus, policies that ensure citizen safety, low emissions, environmental friendliness, and ease of passenger and freight transportation can be established. The main goal is to design a smart transportation system that is real-time, integrated, efficient, safe, innovative, continuously evolving, and environmentally friendly. Despite all the technological advancements, one of the biggest challenges of smart transportation systems is the ineffective management of vehicle traffic. Traffic lights, which are an essential part of urban roads, improve traffic conditions while also limiting vehicle speeds and increasing energy consumption. In this study, a mathematical model has been developed to optimize the energy consumption of electric vehicles based on pre-planned routes and considering both traffic signals and road conditions. The validity of the model has been tested based on various scenarios, and optimal speed profiles have been determined for small-scale problems.

Keywords: Electrical vehicles, energy consumption, traffic lights, smart driving

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A discretization-free deep neural network-based approach for advection-dispersion-reaction processes

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Abstract

This study aims to show the potential of artificial intelligence methodologies to forecast complex behaviors in physical systems, particularly those described by partial differential equations with nonlinear dispersive elements. The current advection-dispersion-reaction equation is one of the key formulas used to depict natural processes with distinct characteristics [1]. It is composed of a first-order advection component, a third-order dispersion term, and a nonlinear response term. The analytical and computational approaches used to explain real-world processes have recently shown themselves to be inadequate for satisfying the growing need to understand life as it truly is [2,3]. Employing deep learning techniques alongside physics-informed neural networks, this investigation thoroughly explores the eqouation which has been elaborately discussed. Initial and boundary conditions are added as constraints when the neural networks are trained by minimizing the loss function [4-6]. In comparison to the existing results, the approach has produced qualitatively correct kink and anti-kink solutions, with losses often remaining around 0.01 [7]. It has also outperformed several traditional discretization-based methods.

Keywords: Advection-dispersion-reaction model, physics-informed deep neural networks, kink waves, solitary waves.

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Masking of Measurements Obtained from Photovoltaic System with an Incommensurate Fractional-order Chaotic System

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Abstract

In the pursuit of enhancing data security and privacy in photovoltaic (PV) systems, this study explores the application of an incommensurate fractional-order chaotic system (IFOCS) for masking measurements obtained from such systems. The utilization of chaotic systems offers a promising avenue due to their deterministic yet seemingly random behavior, which can obscure sensitive information effectively [1]. This paper presents a new approach wherein measurements from PV systems are subjected to masking through an IFOCS. The random signals to be used in the masking method are derived from a hidden attractor in IFOCS [2]. Classical sliding mode control system-based chaotic synchronization method is utilized to encrypt and decrypt sensor measurements [3]. The chaotic nature of this system introduces complexity and unpredictability, rendering the original measurements unintelligible to unauthorized users [4]. The proposed method not only safeguards sensitive data but also ensures system robustness against potential cyber threats [5]. Through numerical simulations and comparative analyses, the efficacy and resilience of the proposed masking technique are demonstrated, highlighting its potential applicability in enhancing the security posture of PV systems.

Keywords: chaos, synchronization, PV system, fractional-order

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Fuzzy VIKORSort method for supplier segmentation

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Abstract

The strategic segmentation of suppliers has become pivotal for companies seeking to streamline their supply chain operations and achieve a competitive edge. This study introduces an integrated approach to supplier segmentation through the use of the fuzzy AHP [1] and fuzzy version of the classical VIKORSort [2] methods. The VIKORSort [2] method is the extension of the VIKOR method [3], developed to cope with multiple criteria sorting problems. The proposed methodology leverages the fuzzy VIKORSort technique, which provides a more robust and systematic framework for supplier segmentation. To demonstrate the efficacy of the proposed approach, a case study has been provided. Furthermore, the comparisons with the TOPSIS-Sort [4-5] have been made. The proposed model contributes to the literature on supply chain management by highlighting the applicability of the fuzzy VIKORSort method for supplier segmentation. The methodology offers a pragmatic tool for supply chain practitioners aiming to enhance their supplier management strategies in the face of complex and dynamically changing market conditions.

Keywords: Supply chain management**,** supplier segmentation, fuzzy VIKORSort

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Worker Assignment and Training Problem Based on Competency Levels

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Abstract

Assigning workers to tasks can pose a significant challenge due to the varying competencies required for each task and the differing competency levels among workers. The objective of this project is to assign worker tasks fairly and improve operational efficiency by worker training simultaneously. The deficiencies found in the manual assignment methods have been determined to be insufficient for assigning worker tasks in an efficient manner, which could result in a delay in project completion, a decrease in the quality of work, and ultimately, dissatisfied customers. It is noteworthy that working in the same position continuously for long periods, especially during a demanding and heavy work period, can have negative effects on workers and effectiveness. Therefore, it is essential to increase the number of competent workers by training who can perform difficult jobs and to introduce a more regular rotation schedule for workers in these positions. In this study, we develop a mathematical model aimed at assigning workers to tasks based on their optimal competency levels. Additionally, we propose a training strategy to enhance workers' competency levels for various tasks in a long-term planning horizon, e.g., 6 months. The proposed mathematical model offers a systematic approach to worker assignment, training, and rotation. This comprehensive framework ensures not only efficient worker assignment but also fosters a healthier work environment by preventing worker burnout and promoting skill development among workers. By implementing this approach, organizations can achieve higher productivity, improved worker satisfaction, and an efficient assignment that ensures optimal workplace performance and enhanced customer satisfaction. We tested the proposed framework within a work environment with 70 workers, and compared preliminary results with the company's schedule, which yielded promising outcomes.

Keywords: Worker Assignment, Worker Training, Worker Rotation, Mathematical Modelling

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Smart Grid Solutions for Managing High-Power Demands and Uncertainties in Electric Vehicle Charging Infrastructure

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Abstract

The power demands of Electric Vehicles (EVs) are considerably high, especially with fast-charging capabilities. Additionally, there is uncertainty regarding which charging station an EV will use and when. Balancing the power in electrical grids is challenging, and the existing infrastructure limitations, coupled with uncertain high-power demands, may lead to imbalances, faults, and potential blackouts. Therefore, it is crucial to develop smart systems for rapidly growing but infrastructure-limited and imbalanced grids, involving predictions, optimizations, simulations, and designs. This study initially provides a perspective considering the current situation, highlighting potential issues, and subsequently offers assessments for problem forecasting and solutions, taking into account short, medium, and long-term scenarios.

Keywords: Electric Vehicles (EVs), Smart Grid Systems, Power Demand Management, Infrastructure Optimization, Charging Station Uncertainties

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Stability and sensitivity analysis of a Leslie type prey-predator system with Allee effect

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Abstract

The dynamic behavior of a broad continuous-time Leslie type prey-predator system [1] with the Allee effect will be presented. First, the local stability conditions of the positive equilibrium point of this system are determined. Next, the conditions of existence for Hopf bifurcation arising from this positive equilibrium point are investigated. This bifurcation is demonstrated through Hopf bifurcation theory and normal form theory [2] by using the Allee constant as a bifurcation parameter. It is observed that the system exhibits multiple Hopf bifurcations. Subsequently, we focus on a sensitivity analysis to ascertain the robustness of the model to the parameter values that are correlated with the critical bifurcation parameters directly related to the Allee constant. Finally, we discuss the impact of the Allee effect on the dynamics of both prey and predator populations via numerical simulations. Moreover, the FAST approach was used to examine the sensitivity of the prey-predator system to all parameter values [3]. The findings highlight the importance of the Allee effect in maintaining the intricate balance between prey and predator populations and the importance of considering complex ecological interactions in order to accurately model and understand these systems.

Keywords: Stability analysis, Hopf bifurcation, Periodic solutions, Allee effect, Sensitivity analysis

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Pathogenicity Prediction of CHEK1 and CHEK2 Genes Using Artificial Intelligence-supported in Silico

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Abstract

CHEK-1 and CHEK-2 genes harbour non-synonymous single nucleotide variant (nsSNP) variations associated with breast cancer. Variants are classified as pathogenic (associated with cancer risk) or non-pathogenic (not associated with cancer risk). However, a significant portion of tests yield variants of uncertain significance (VUS), whose impact on cancer is unclear. The use of rapidly evolving in silico techniques, supported by artificial intelligence (AI) has increased in clinical research to predict disease treatments. Polymorphism phenotyping-2 (PolyPhen-2) evaluates data based on multiple parameters and provides results as "benign", "probably damaging" or "possibly damaging." At the same time, Sorts Intolerant From Tolerant (SIFT) identifies possible amino acid changes in the sequence by comparing the data with similar sequences. It classifies them as "tolerated" or "intolerant." The National Center for Biotechnology Information (NCBI) provides extensive data, including the ClinVar database, which reveals relationships between human variations and phenotypes. Another AI tool, GeneMANIA, is used to study gene interactions. This study, aimed to benefit genetic engineering and cancer research by performing computational analyses of nsSNPs in the CHEK1 and CHEK-2 genes, which affect breast cancer, along with variants of unknown clinical significance using AI-supported in silico techniques. In the method, nsSNPs in the CHEK1 and CHEK2 genes, along with variations of unknown clinical significance (VUS), were retrieved from the ClinVar database by selecting 'single nucleotide variant,' 'missense,' and 'uncertain significance' in the search field, and the data were downloaded as a txt file, with a copy of the data imported into an excel file. The obtained data of nsSNPs and VUS in the CHEK-1 and CHEK-2 genes were analyzed using PolyPhen-2 and SIFT in silico tools by inputting a vcf file, and the relationships of CHEK-1 and CHEK-2 genes with other genes were examined using the GeneMANIA tool.

Keywords: CHEK1, CHEK2, AI-supported in silico

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Exploiting a Multifrequency Duffing-Mathieu Oscillator to Explore the Effect of Driving Force Strength on Hydrodynamic Sensitivity of a Micro-cantilever

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Abstract

This current work presents a new conceptual model to investigate the hydrodynamic sensitivity of a micro-cantilever with the consideration of drıvıng force strength. A nonlinear dynamic model of an oscillating micro-cantilever is constructed based on a forced and damped Duffing-Mathieu oscillator including the bimodal-frequency excitation scheme. Duffing-Mathieu equations are solved by using diverse theoretical methods for different applications [1-5]. In the present work, the effect of excitation force magnitude on time-domain responses of the micro-cantilever in sugar solutions with different concentrations is explored for single- and bimodal-frequency excitations. The simulation result indicates that the amplitude of 0.55 nm at the first eigenmode is acquired in 55% sugar solution under the driving force strength of 400 nN in the single-frequency operation. Besides, effective hydrodynamic forces acting on the one-side area of the vibrating micro-cantilever are determined considering Sader's hydrodynamic functions. Magnitudes of hydrodynamic forces remarkably change on the time domain as the excitation force varies for the first two flexural modes. To illustrate, the viscous loads at the second eigenmode appear in the range of 20-2000 nN as the driving force strength ranges from 100 nN to 400 nN. Obviously, the Duffing and Mathieu functions in the proposed model have also significant influences on time-domain responses and effective hydrodynamic forces. Correspondingly, the displacements of the micro-cantilever and effective viscous loads at the first two eigenmodes are obtained for different nonlinearity degrees of mechanical systems. Micro-cantilever responses strongly depend on excitation frequency and amplitude in Mathieu functions. It is worth mentioning that as the parameter of excitation amplitude is varied from 1 to 12, the amplitude at the first eigenmode decreases from 600 pm to 500 pm. Therefore, the multimodal nonlinear dynamic model enables to evaluate the influence of driving force strength on nonlinear behaviours of the micro-cantilever at higher mode in a viscous environment.

Keywords: Duffing-Mathieu oscillator, hydrodynamic sensitivity, bimodal-frequency excitation of micro-cantilever

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Investigating the Energy Saving Potential of University Buildings in Terms of Energy Management: A Case Study

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Abstract

Due to the ever-increasing energy demand, one of the most important factors when designing livable spaces and environments will be energy efficiency. Approximately one third of the total final energy consumption worldwide originates from the building sector (residential, commercial, public buildings, etc.). One of these, university campuses, can be considered small settlements due to their large number of users, size and number of buildings. For this reason, university campuses, which include office buildings, student dormitories, cafeterias, health centers, sports facilities, laboratories, and educational buildings, have a significant share in energy consumption with their continuous energy needs. Determining the energy saving potential of an existing building can be possible through an approach that evaluates energy consumption data based on the characteristics of the building or obtained from energy meters. This study includes a sample study on energy management, which is a systematic method for efficient use of energy. Within the scope of the application, the aim is to analyze the current energy consumption of an educational building within the campus by using energy consumption data and to reveal the energy consumption trends and reasons of the building with the collected information. In addition, it is aimed to minimize energy consumption by taking into account issues such as determining boiler efficiency, lighting efficiency and insulation suitability in terms of CO2 emissions. This study reveals a preliminary study for a more comprehensive and sustainable energy management modelling. Energy consumption models thus created can aid future building planning, provide useful information about the most likely energy consumption for similar buildings, or predict energy consumption under different conditions. It can also be used in future building designs and applications to see the effects of possible energy-saving measures and find the most appropriate way to reduce energy expenditures.

Keywords: Sustainable Energy Management, Energy Consumption in Buildings, Energy Efficiency

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Comparison of Fractional Order Sliding Mode Controllers on Robot Manipulator

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Abstract

This paper aims to propose new fractional order sliding mode control (SMC) approaches, which give better results compared to previously presented fractional order-based SMC approaches in the open literature. So, in this study, the mentioned methods are implemented to a 2-degree of freedom (2-DOF) robot manipulator that some fractional order-based SMC approaches were tested on this dynamical system in the literature [1-3]. The sliding mode controller is a robust control method that is simple and can cope with dynamical uncertainties [4] and parametric modifications, so it is used widely in many areas such as robotic and aerial vehicles [5]. The fractional order SMC studies are common in the literature because the derivatives are very important in SMC structure. In this study, a classical SMC has been implemented in the 2-DOF robot manipulator to determine SMC coefficients. The SMC coefficients are held persistently for all simulations for a fair comparison. The Caputo fractional order method is used in this study because of its advantages in the computation of derivatives [6,7]. The Caputo fractional derivative results are compared with integer derivatives separately and afterwards combined with the SMC structure. All fractional order-based SMC approaches are subjected to the Lyapunov test. The stability of the fractional-based SMC algorithms is proved by using Lyapunov stability analysis. The results of the approaches are analyzed to see the advantages and disadvantages of the methods and the best one is chosen for real applications.

Keywords: Sliding mode control, Caputo fractional order operator, Lyapunov test

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A new approach for training achievement based on course materials

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Abstract

Evaluating the effectiveness of training programs and curricula is of critical importance in educational sciences as well as in other disciplines. An effective education must achieve program or training goals by creating desired changes in knowledge, skills and attitudes of participants. In engineering education, the level of achievement of learning outcomes is usually achieved through approaches such as assignments, exams and projects. In this paper, we propose a new approach for measuring learning achievement in engineering education. The proposed approach is designed in two stages, based on natural language processing and multi-criteria decision-making methods. First, a neural network-based natural language processing application is applied to digitize course materials. In the second stage, a multi-criteria decision-making method was applied to determine the level of achieving the planned outcomes. In multi-criteria decision-making applications, factors such as the level of inclusion of learning outcomes in training materials obtained from different algorithms and the grammatical accuracy of course materials were weighted with the Level Based Weight Assessment (LBWA) method. Afterwards, the learning outcomes planned based on the course materials and the impact of the course materials were ranked with the fuzzy COmplex PRoportional ASsessment (COPRAS) method. As a result, a system that will provide support to educators has been proposed by evaluating the level of achievement of learning outcomes based on course materials.

Keywords: Fuzzy COPRAS, Level Based Weight Assessment, Natural language processing, Training achievement

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Forecasting of Energy Production in Solar-PV Plant Using Artificial Neural Networks Techniques

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Abstract

Interest in renewable energy is increasing day by day to reduce the effects of global warming and climate change. Considering the targets set by the Paris climate agreement for countries, generating electricity from renewable energy has increased significantly, especially in the last decade [1]. Recently, it has been observed that energy production using solar energy has become widespread, as developments in solar photovoltaic (PV) technology provide significant cost advantages in energy production costs. Solar power production (SPP) using photovoltaics is one of the most effective ways of solar energy utilization. SPP poses a future challenge for electricity sector actors responsible for the coordination and distribution of electricity, given its direct dependence on climatic and meteorological conditions [2]. For this reason, in order to predict solar energy production reliably, it is necessary to develop models that allow future predictions. Also, Accurate prediction for SPP is also important for providing high-quality electricity to end-consumers [3]. For companies that produce electricity from SPP, estimating the energy to be produced is important in terms of planning the amount to be produced and sold. This article uses artificial neural network (ANN) method to predict solar energy production generated by SPP. ANN is widely used in machine learning and AI applications for tasks like classification, regression, pattern recognition, and more. Training an ANN involves adjusting the connection weights between neurons based on example inputs and their corresponding desired outputs, typically using algorithms like backpropagation [4-5]. With the help of ANN, future energy production can be predicted by using parameters related to SPP production. Our tool uses an ANN that we developed using MATLAB® software. This research not only contributes to the academic literature by applying machine learning techniques to SPP, one of the renewable energy methods, but also provides practical implications for investors and policy makers to make more accurate forecasting and planning.

Keywords: Renewable energy, solar power production, artificial neural networks

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Set Distance Based Lipschitz Classification and Metric Modelling

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Abstract

In this presentation, we aim to introduce a new classification technique that is based on metric distances which is used to obtain a new machine learning algorithm using the properties of the given dataset. To obtain such a classification and metric modelling, we use Lipschitz functions defined on set based distances. The fundamental property of Lipschitz functions lies in their capacity to control the rate of change within a metric space. Specifically, a Lipschitz function ensures that the difference in function values between any two points within the space is bounded by a constant multiple of the distance between those points. Thus, we propose a Lipschitz continuous function to be used in classification, which surpasses Support Vector Machine and K-Nearest Neighbour algorithms in accuracy rate.

Theoretical background of this work relies on Cobzaş, Miculescu, and Nicolae's work [1], especially the theoretical use of McShane & Whitney extensions. By using these theoretical foundations, this work intends to achieve competitively accurate classifiers as in the pivotal work of von Luxburg and Bousquet [2]. In addition to the work of von Luxburg and Bousquet [2], our classification technique provides a more stable and accurate algorithm with further optimised Lipschitz constant.

Another use of Lipschitz functions and their extensions is to create insightful sorting algorithms as showcased in Erdoğan, Ferrer-Sapena, Jiménez-Fernández, and Sánchez-Pérez [3] and also in Ferrer-Sapena et al. [4]. By treating the data points of a given dataset as elements of a metric space and constructing a Lipschitz function from the given index, extension of the Lipschitz function will correspond to a sorting algorithm.

Keywords: Lipschitz Extensions, Classification, Set Based Distance, Machine Learning,

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Efficient Scheduling and Setup Time Minimization in Panel Line Production

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Abstract

In the furniture industry, efficient panel line production is critical for timely order fulfilment and customer satisfaction. This study addresses the challenges faced by a furniture manufacturer, in scheduling its panel line production processes. Through a comprehensive analysis of the current system, it was identified that manual planning of the panel line led to inefficiencies and delivery delays. Two identical parallel machine scheduling problems involving the sequence-dependent setup processes are examined. To mitigate these issues, a mathematical model was developed based on the relevant literature findings. The variations in glue types and bobbins for different product categories cause to setup complexities. The proposed model focuses on minimizing setup times by considering parameters such as processing times, shift schedules, and setup times for bobbin and glue changes. Constraints are incorporated to facilitate the efficient assignment of orders to panel lines, accounting for sequence dependencies and resource limitations. Additionally, the model aims to reduce setup times and maximize panel line capacity utilization by scheduling similar tasks consecutively. By implementing the developed model, the company aims to enhance operational efficiency and customer satisfaction through timely order deliveries. Future research directions include adapting the model to more complex production scenarios. The proposed mathematical model offers a systematic approach to panel line planning and can also be implemented in other industries.

Keywords: Setup time minimization, mathematical modeling, panel line scheduling.

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Prediction of Seismic Performance of Coastal and Port Structures via LSTM-Based Transfer Function Retrieval Approach

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Abstract

Modeling and predicting the seismic performance of structures are of critical importance before a catastrophic event happens. Among many different techniques, one possible approach is to use ambient vibration data during regular service time of the structure [1, 2]. Although there are some applications of such an analysis on land-based structures, their applications on coastal and port structures are not well-studied. In this paper, we investigate the possible usage of the long short-term memory (LSTM) deep learning network for the prediction of the earthquake performance of a quay wall using ambient vibration data and an LSTM-based transfer function retrieval approach. With this motivation, we analyze an empirical data set reported in [4]. We discuss the seismic prediction performance, usage areas, and potential research areas related to our findings.

Keywords: Seismic analysis, earthquake vibration, deep learning, transfer function, LSTM network.

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The ARIMA Predictions and Spectral Analysis of the 30 October 2020 İzmir-Samos Tsunami

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Abstract

Tsunamis are natural disasters that have extremely devastating effects on coastal areas [1]. There is a wide variety of studies in the literature regarding the analysis and prediction of tsunami parameters [2-4]. In this study, we investigate the hydrodynamic characteristics of the 30 October 2020 İzmir-Samos (Aegean) Tsunami utilizing some artificial intelligence time series analysis tools. To be more specific, we introduce the feasible application and utilization of the Autoregressive Integrated Moving Average (ARIMA) model [5-6] for the predictability and spectral (FFT) analysis of tsunami time series data. This study's data collection was obtained from the UNESCO data portal for different stations. Daily data from October 30, 2020, at 0:00 a.m. to October 31, 2020, at 0:00 a.m. UTC are sourced from the various stations previously stated. It is important to note that the stations' sample times vary from one another. Next, we examine the application and limitations of the ARIMA method for Fourier spectrum and tsunami time series prediction. In particular, we examine the predictability of the dynamics of offshore sea surface elevation, as well as its spectrum frequency and amplitude properties, potential for success in predictions, and improvement of the early forecast time scales that are accurate. We analyze the effects of training data and different data-obtaining types. The study's prediction error in terms of the coefficient of determination (R^2) and the root-mean-square error (RMSE) are presented. It is shown that the prediction success can vary depending on the data obtaining type and size of the training data. There is also a discussion of our results' applications and uses as well as potential future study areas.

Keywords: İzmir-Samos (Aegean) tsunami, artificial intelligence, ARIMA, spectral and time series analysis and prediction

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The Predictability of Oceanic Circulations via FFT-ANFIS Spectral Adaptive Fuzzy Network

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Abstract

Oceanic currents and circulations are vital components of the marines on Earth for their physical and biological existence [1-6]. In the literature, many different data processing techniques are proposed and employed for their analysis [2-6]. In this paper, we examine the predictability of oceanic circulations using spectral fuzzy logic. More specifically, we propose the possible implementation and usage of the Adaptive Neuro-Fuzzy Inference System (ANFIS) fuzzy network [7-8] approach for the spectral (FFT) analysis of oceanic circulation data. The data set investigated in this study was acquired by the National Oceanic and Atmospheric Administration (NOAA) between November 2002 and February 2003 in Massachusetts Bay, US. We show that the current speed time series and its spectrum in 2D horizontal directions, namely u and v, can be successfully predicted using the FFT-ANFIS approach. We present prediction error in terms of the coefficient of determination (R^2) and the root-mean-square error (RMSE). The effect of the training data set on the prediction error and the spectral properties of predictions are also analyzed. We show that depending on the temporal and spatial resolution of the data, the prediction times and distances can vary. Depending on their resolution in some cases, they can be very beneficial for the early prediction of the ocean current parameters. Our results can find many important applications including but not limited to predicting the statistics and characteristics of tidal energy variation and controlling the current-induced vibrations of structures in the marine environment.

Keywords: Oceanic circulations, fuzzy network, FFT, ANFIS

Acknowledgments

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Construction of new finite differences to approximate the modified Helmholtz type equations

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Abstract

The present study introduces a new finite difference method addressing boundary value problems represented by modified Helmholtz type equations. In particular, we consider the MHD flow problems, of which the governing equations, coupled in velocity and induced magnetic field, can be transformed into two decoupled modified Helmholtz equations. The new FDM improves on the standard FDM by minimizing truncation errors in the finite difference formulas for approximating derivative terms [1, 2]. In this sense, the new FDM is considered to be numerically exact due to its lack of truncation error. First, the new finite difference formulas are developed to approximate the first-order derivatives in mixed-type boundary conditions and the second-order derivatives in the modified Helmholtz equations in one and two dimensions. These formulas are then utilized to discretize the MHD flow equations in their reduced Helmholtz form. The numerical simulations are carried out to validate the new FDM computer codes and to compare the outcomes of the new and standard finite difference schemes. Although both of the FDMs construct linear systems with comparable structures, it is observed that the new FDM, even with a coarse mesh, produces solutions that are more accurate than the findings of the standard FDM. Furthermore, to accurately capture the characteristics of the velocity field and the induced magnetic field at high values of problem physical parameters, a finer mesh is needed in both new and standard FDMs.

Keywords: New FDM, modified-Helmholtz equation, MHD flow

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Resonant Tunnel Vibration Frequency and Magnitude Identification by LSTM Deep Learning Network

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Abstract

Identification of vibration characteristics of engineering structures is critically important to investigate, assess, and mitigate the effects of vibrations and resonance. One of those structures is the tunnels. In this paper, we model the vibration dynamics of an elastic tunnel using Flügge equations of the elastic theory [1, 2]. We consider various load cases such as the harmonic point load and train-induced axle loads and model vibrations induced by these loads using the vibration model discussed in [1, 2]. Then, we examine the usage of the long short-term memory (LSTM) artificial intelligence (AI) network [3, 4] for the identification of the resonant tunnel vibration spectrum. We show that the LSTM AI network can be used to identify resonant frequencies and vibration levels. We discuss our findings, their usage, potential extensions, and future research areas related to our findings.

Keywords: Tunnel vibration, Flügge theory of elasticity, LSTM artificial intelligence network, resonant frequency.

Acknowledgments

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Analysis of Vortex Dynamics by LSTM Deep Learning Network

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Abstract

Wakes and vortices can be observed in fluid flows around, especially around bluff bodies. Such a phenomenon is known as the vortex shedding. It is possible to model these vortices and the dynamics of vortex shedding using numerical techniques. In some of the numerical approaches, the Navier-Stokes equations are used as the governing equations. However, some reduced dynamic equations such as the complex Ginzburg-Landau (GL) equation are another frequently used model for these purposes [1, 2, 3]. In this paper, we solve the GL equation using a spectral scheme employing FFT routines and Runge-Kutta time integrator to simulate the dynamics of von Kármán vortices around a cylinder. Then, we examine the usage of the long short-term memory (LSTM) artificial intelligence (AI) network [4, 5] for the identification of the dynamics of those vortices. We show that the LSTM AI network can be used to identify and predict vortex time series, and resonant frequencies. We discuss and comment on our findings and their potential usage areas. Possible future research areas are also discussed.

Keywords: Vortex dynamics, Ginzburg-Landau Equation, LSTM artificial intelligence network, resonant frequency.

Acknowledgments

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Analysis and Modeling of Dam Break Problems by Fractional Dynamic Equations

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Abstract

Dam failures can have a catastrophic impact on the surrounding environment. Thus, the study of the hydrodynamical effects of dam failure is of critical importance. Although the majority of work on the dam-break problem employs the shallow water approximation where shallow water equations are used [1, 2], there are some studies involving some dynamic equations such as St.Venant and Korteweg-de-Vries (KdV) [1] equations. In this paper, we investigate the possible usage of fractional dynamic equations for the analysis and modeling of dam break hydrodynamics. We investigate the usage of the fractional KdV and Schrödinger equations [3] for this aim. We compare our findings with empirical data and discuss the possible usage and limitations of our results.

Keywords: Dam break problem, KdV equation, Schrödinger equation, fractional dynamic equations.

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DRBEM Solutions of MHD Flow in a Rectangular Duct with Variably Conducting Walls

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Abstract

The two-dimensional laminar, fully developed magnetohydrodynamic (MHD) flow of a viscous and incompressible fluid is considered in a long pipe of rectangular cross section under the effect of a vertically applied magnetic field [1]. The imposed magnetic field is uniform and the induced magnetic field is neglected due to the small magnetic Reynolds number, however, the electric potential is also solved from the divergence of Ohm's law. The governing non-dimensional coupled momentum and electric potential equation (divergence of current density) are solved by using the dual reciprocity boundary element method (DRBEM) with the fundamental solution of Laplace's equation i.e $u = \frac{\ln(r)}{2\pi}$ [2]. The normal derivatives in the equations and in the boundary conditions are computed by using the coordinate matrix of DRBEM. The no-slip velocity condition is imposed for the flow on the walls. However, the Dirichlet, Neumann and mixed type boundary conditions are used for the electric potential depending on the physics of the problem. The influences of the Hartmann number *Ha* and the wall conductance ratio c on the flow have been examined. The results show that, the Hartmann number controls the thickness of the boundary layers, however, the wall conductivity ratios determine the structure of the flow. While $c = 0$ ($\frac{\partial \phi}{\partial n} = 0$) the flow has a parabolic shape and with a conducting metal on the boundary ($c = 0.1$) flow has M-shape. The wall conductance ratios c on the four walls can also be chosen differently resulting in distorted M-shapes on the flow. Thus, the conductivity ratio on the walls affects the flow behavior significantly [3].

Keywords: DRBEM, MHD duct flow, variable wall conductivity

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The Prediction of Pier Dynamics Using LSTM Deep Learning Network-based SAP2000 Analysis

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Abstract

Marine structures are continuously subjected to dynamic loads such as waves, currents, wind, earthquakes, and ship impact. Prediction and modeling of accurate dynamics is a must and have become the research subject over decades [1, 2, 3]. Although some analytical techniques may also be used, due to the complexity of the problem numerical approach is generally employed. One of the numerical tools used for this purpose is the SAP2000 software. In this paper, we examine the usage of the long short-term memory deep learning technique [4, 5] for the prediction of dynamics of piers under various loads including waves, currents, and earthquakes. These dynamics are modeled using the SAP2000 software. We examine the predictability of dynamics under various load cases using the LSTM network using a realistic pier model. We discuss our findings, their usage, and potential research areas related to our findings.

Keywords: Marine structural dynamics, deep learning, LSTM network, SAP2000 software.

Acknowledgments

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Optimal Multiple Testing Procedure for Imputation of Single Cell RNA Sequence Data

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Abstract

Single-Cell RNA-Seq provides transcriptional profiling of thousands of individual cells. This level of throughput analysis enables researchers to understand at the single-cell level what genes are expressed, in what quantities, and how they differ across thousands of cells within a heterogeneous sample. On the other hand, scRNA-seq often fails to capture expressed genes, leading to the prominent dropout problem. These dropouts cause many problems in down-stream analysis, such as significant increase of noises, power loss in differential expression analysis and obscuring of gene-to-gene or cell-to-cell relationship. Particularly, MAGIC (Markov affinity-based graph imputation of cells) is a method for addressing computational diffculties to reduce technical noise in single-cell data, including under-sampling of mRNA molecules, often termed "dropout" which can severely obscure important gene-gene relationships. Accordingly, this algorithm shares information across similar cells via data diffusion so that the cell count matrix can be denoised and missing transcripts can be filled. In this study, we combine MAGIC subsampling algorithm with multiple testing approach, namely knockoff filtering, to control false discoveries of principle components of MAGIC, resulting in reduction of noise in single cell RNA sequence data [2, 4]. Hereby, we evaluate our proposal strategy in single cell epithelial-to-mesenchymal transition data set and compare the gain in accuracy.

Keywords: Single cell data, subsampling, multiple testing

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Adaptive Conformal Quantile Regression Neural Networks With Survival Data

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Abstract

Conformal prediction is a popular, modern technique for providing valid predictive inference for arbitrary machine learning models. Its validity relies on the assumptions of exchangeability of the data and symmetry of the applied algorithm as a function of the data. But it requires fully observed outcomes and is not directly applicable to samples with censored outcomes. On the other side, Quantile Regression Neural Network (QRNN) is a hybrid method which is based on quantile regression. This robust regression can model data with non-homogeneous variance with neural network approach that can capture nonlinear patterns in the data. In the neural network part, QRNN uses the feed forward neural network which is the most commonly used neural network types. In this study, we propose conformal inference with QRNN to make improvement in right-censored outcomes within the setting of Type-I censoring. This setting assumes that the censoring time is observed for every unit while the outcome is only observed for uncensored units. Hereby, our strategy is to generate a covariate-dependent lower prediction bound, which is one-sided, on the uncensored survival time which is presented by Cox proportional hazard model. We compute accuracy values of conformal QRNN for survival data with different numbers of parameters and numbers of observations.

Keywords: Conformal inference, quantile regression neural networks, survival data

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Forward-Backward Dynamic Mode Decomposition with Control

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Abstract

In this study, we improved and investigated the Forward-Backward Dynamic Mode Decomposition with Control (fbDMDc) algorithm. The fbDMDc method aims to analyze noise-corrupted data. Dynamic Mod Decomposition (DMD) [1] and Dynamic Mode Decomposition with Control (DMDc) [2] methods are data-driven methods that do not require knowledge of the underlying governing equations but only snapshots in time of observables and actuation (external forces). In these methods, data sets are obtained from historical, simulation, and experimental works. DMD is limited in extracting accurate dynamical features from noise-corrupted data, as described in depth in [3] by Scott et al. They show that DMD is a biased method for noisy data sets. They remove this bias without needing to know the noise characteristics with the forward-backward dynamic mode decomposition (fbDMD) algorithm [3]. In the same way, we aim to decrease bias in the DMDc algorithm with the fbDMDc algorithm. DMD and DMDc use the Singular Value Decomposition (SVD) reduction technique. Forward-backward DMDc (fbDMDc) algorithm is given below:

1. Storage state measurements X, X' and control measurements Υ as in the following

$$X = \begin{bmatrix} \uparrow \uparrow & & \uparrow \\ x_1 x_2 & \dots\dots & x_{m-1} \\ \downarrow \downarrow & & \downarrow \end{bmatrix} \quad X' = \begin{bmatrix} \uparrow \uparrow & & \uparrow \\ x_2 x_3 & \dots\dots & x_m \\ \downarrow \downarrow & & \downarrow \end{bmatrix} \quad \Upsilon = \begin{bmatrix} \uparrow \uparrow & & \uparrow \\ u_1 u_2 & \dots\dots & u_{m-1} \\ \downarrow \downarrow & & \downarrow \end{bmatrix}, \quad X' = [A \quad B]\begin{bmatrix} X \\ \Upsilon \end{bmatrix} = G\Omega$$

2. Compute the singular value decomposition of Ω with truncation value p: $\Omega \approx \tilde{U}\tilde{\Sigma}\tilde{V}^*$
3. Compute the singular value decomposition of X' with truncation value r: $X' \approx \hat{U}\hat{\Sigma}\hat{V}^*$
4. Compute the matrix A_f and $\tilde{B}$:$A_f = \hat{U}^*\bar{A}\,\hat{U}^* = \hat{U}^*X'\,\tilde{V}\tilde{\Sigma}^{-1}\tilde{U}^*{}_1\hat{U}$, $\tilde{B} = \hat{U}^*\bar{B} = \hat{U}^*X'\,\tilde{V}\tilde{\Sigma}^{-1}$, $\tilde{U} = [\tilde{U}^*{}_1 \quad \tilde{U}^*{}_2]^T$
5. Compute the matrix A_b: with interchanging the matrix X X' in 2.,3.and 4. step
6. Compute the matrix $\tilde{A}$: $\tilde{A} = \sqrt{A_f A_b}$

Keywords: Dynamic mode decomposition, control, forward-backward, machine learning, noise

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Fractional Investigation of an Asymmetric Model for Two-Dimensional Harmonic Oscillator

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Abstract

A two-dimensional asymmetric harmonic oscillator is a physical system where the restoring force is proportional to the displacement from the equilibrium position and the motion is confined to two dimensions [1-3]. In this paper, the fractional dynamics of an asymmetric model two-dimensional oscillator is investigated. The corresponding fractional Euler-Lagrange equation of the system is derived being a system of two-coupled fractional differential equations having the form:

$$ {}_tD_b^{\alpha}\,{}_aD_t^{\alpha} x - x - \mu sinh\varepsilon y = 0, \quad (1)$$
$$ {}_tD_b^{\alpha}\,{}_aD_t^{\alpha} y - y - \mu\varepsilon x cosh\varepsilon y = 0. \quad (2)$$

The numerical results of the system are obtained using the fractional predictor-corrector method and simulated concerning the different values of the model parameters as μ, and ε and the order of the fractional derivative in use. Finally, many plots have been introduced and discussed via the fractional order.

Keywords: Fractional Euler-Lagrange formulation, asymmetric harmonic oscillator, numerical approximation.

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Modern Regression Tools for the Dynamics of Complex Networks – A Comparative Study Based on a Real-World Application

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Abstract

New insights for developing mathematical tools and models are essential to provide for a better understanding of the underlying dynamics of complex systems, whose components are highly correlated and consist of unknown effects of additional parameters. Such complex phenomena appear in real-world problems of the fields like system biology, medicine, engineering, biochemistry, nanotechnology, finance, education, environment and so on, where the gene-environment regulatory networks is a subclass of them whose dynamics are mathematically represented by a network matrix.

The entries of the network matrix represent the network relations and they can be in the form of polynomial, trigonometric, exponential, logarithmic, hyperbolic and spline functions containing unknown parameters to be identified [1-4]. In this study, we consider choosing spline-based entries to define the network structure and implement conic multivariate adaptive regression spline (CMARS) technique on a real-world data from system biology for the inference of such complex regulatory networks. The performance of the model is investigated in comparison with the results obtained from multivariate adaptive regression spline (MARS) modeling approach.

Keywords: Mathematical modelling, complex systems, spline regression.

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A Multi-Objective Replenishment and Vehicle Routing Problem for Disaster Container

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Abstract

There has been an increase in the number of disasters in recent years both in the World and in Turkey due to reasons such as global warming and destruction of natural resources. Therefore, disaster management has become a subject that has gained more importance in recent years for both academia and government institutions. There has been an increase in the number of studies carried out and the state has also implemented its newly developed. Disaster stations (containers) placed in some cities of Turkey are also a new practice. [1] and [2] dealt with the problem of disaster container location selection. [3] dealt with the location problem of non-perishable products such as tents, blankets. Vehicle routing problem about the disaster station have also been studied by [4] and [5]. The containers contain humanitarian aid materials to be used after the disaster, such as medicine, canned food, medical aid materials, shovels, and lamps. While some of the materials are non-perishable, some are perishable products and have a certain shelf life. For this reason, perishable products in containers need to be renewed at regular intervals. In this study, pre-disaster vehicle routing problem is studied for disaster containers. The objective function of this study is to maximize the profit from resale of perishable products and to minimize routing costs. The trade-off between the objectives is also observed through the analyzes made in the multi-objective problem. The best solution of the NP-hard vehicle routing problem can be obtained for small-sized samples. For this reason, a heuristic method has been developed to solve large-scale problems.

Keywords: Disaster container, Vehicle Routing Problem, Multi objective problem

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Fuzzy Neural Network on Linguistic Variable by using WABL Defuzzification

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Abstract

Neural network is widely used methodology in artificial intelligence [1-5]. An artificial neural network is a mathematical model to solve non-linear problem structures. In non-linear problem structures, neural networks perform good learning ability, and robustness. In real life, the data collected from human includes imprecise information. Fuzzy logic gives an flexible approach to make the computations with the words. The combination of fuzzy systems and neural networks has been around since the 1990s [1-3] until today [6]. This structure is called as fuzzy neural networks (FNNs) such as adaptive-network-based fuzzy inference systems [7], dynamic fuzzy neural networks [8], Recurrent Fuzzy Neural Network [9], etc. In linguistic datasets, linguistic variables are defined as a fuzzy variable. It is necassary a defuzzification operator which number gives the average numerical equivalent of this number. WABL (Weighted Averaging Based on Levels) Defuzzification operator carries more information within itself [10]. It means that it can be called as an universal defuzzification operator. In this study, fuzzy feed-forward algorithm is selected [11] and a novel fuzzy feed-forward neural network is proposed. This novel approach aims to solve a classification problem on linguistic dataset. Each linguistic variable is defined by using trapezoidal fuzzy numbers. WABL defuzzification operator is performed and fuzzy feed-forward neural network is constructed. An experimental work is performed on well-known three datasets (iris, glass, wine). The results are supported by statistical analysis.

Keywords: Fuzzy neural network, WABL defuzzification, Linguistic variable.

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Deterministic Kalman Observer for Multimachine Power Systems

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Abstract

In this study, we discuss an observer-based control approach aimed at stabilizing power systems. Employing a multimachine power system model, we develop an observer tailored to this model. Notably, our observer design is decentralized, leveraging locally available measurements from synchronous generator units. We present the proposed model in this decentralized framework. Subsequently, through observer-controller design, we implement a deterministic observer for the power system model. This facilitates the retraction of state information across subsystems, employing control theory principles to utilize only measurement-based subsystem states and outputs. The design of the deterministic observer relies on full-state measurements from the power system model, with observer convergence analysis utilized to ensure power system stabilization. Furthermore, we address a state feedback problem by proposing the design of a Kalman observer. Our primary aim in this work is to explore the effective observer-based control within the context of state feedback design, guaranteeing the stabilization of multimachine power systems. We conduct an analysis of decentralized stability within multimachine power systems, demonstrating their amenability to stabilization through a deterministic observer. Additionally, we introduce the stability characteristics of the Extended Kalman Filter, which can serve as a deterministic observer for nonlinear power systems.

Keywords: Decentralized stability, deterministic observer, state-feedback control

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Loading Optimization of Shrinkage Products for Airline Companies

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Abstract

Food and beverages are loaded on planes to be sold in flight. A group of products known as "shrinkage products" are gone to waste in case they may be off. This situation is called shrinkage, and such products are referred to as shrinkage products. There is a need to load right amount of shrinkage products for flights to prevent waste without reducing sales and customer satisfaction. There are different approaches to the problem: unsupervised machine learning using KPIs[1], Mixed Integer Programming with Markov Chain and multiple regression model[2], multiple linear regression models[3], neural networks[4]. Proposed solution generates a graph with customer nodes(created with a similarity metric on customer features), with flight features as global variables of graph. Dataset is flight id based and contains flight data, stock out data, cabin crew performance data, product load data and customer data. Customer features are total travel time, earned points, lifetime, average travel duration, gender, residency, communication channel and age. Lifetime, average travel duration are generated features. Age is also categorized. Flight features are flight duration, ground duration, local global time difference, delay time, capacity, bundle sales, preorder sales, airplane type, is weekend, month, flight type(domestic, international), departure continent, arrival continent, categorical time of day. Ground duration, departure continent, arrival continent, categorical time of day are generated features. Total demand for a product group is calculated summing sale count and stock out count. There are 8 product groups including sandwiches and menus to predict total demand. Customer graph was generated with cosine similarity and 0.9 threshold. GNN model is trained for multiple output regression problem to predict demand per food category. GCNConv with two layers and 16 hidden channels returned best results with metrics mae: 1.15, mse: 4.19, r2: 0.74.

Keywords: GNN, demand forecasting, shrinkage products, in-flight food demand.

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Generation of Discontinuous Unpredictable Motions by Quasi-linear Systems with Regular Moments of Impulses

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Abstract

This study is concerned with unpredictable solutions in a class of quasi-linear impulsive systems. The system under investigation possesses a term periodic in t, and it is with regular moments of impulses. It is rigorously proved that the system admits discontinuous unpredictable solutions in the case that a perturbation generated by an unpredictable sequence is implemented. Asymptotic stability of the unpredictable solution is also discussed. The theoretical results are supported by an appropriate illustrative example.

Keywords: Discontinuous unpredictable solutions, unpredictable sequences, impulsive systems, regular impulse moments

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Optimizing Power Systems for High-Sharing Renewable Integration with Security-Constrained Linear OPF

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Abstract

Power system optimization relies on a set of coupled optimal power flow (OPF) techniques utilizing various variables and constraints. This includes addressing constraints over these variables. The resulting challenge is known as the security-constrained optimal power flow (SCOPF) problem, which aims to minimize the objective function (total operation cost) not only for the base (no contingency) case but also for a range of post-contingency scenarios. However, due to supply scarcity, demand fluctuations, increased integration of Renewable Energy Sources (RESs), and the presence of contingencies and stochastic production in the power system, computational complexity has significantly increased for large-scale SCOPF. In this study, we propose a power network optimization approach under SCOPF. We optimize generator dispatch, including renewables, using security-constrained linear OPF to prevent branch overloads during outages. Additionally, we determine an optimal mix of new generation resources, incorporating energy storage systems to enhance grid stability.

Keywords: SCOPF, OPF, Network contingencies

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Architecting and Evaluating a RAG based Question Answering System for SQuAD Dataset

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Abstract

Large language models have gained great popularity in recent years and have started to be used in various applications in the field of natural language processing [1], [2]. The main advantage of these models is that they have high-level language comprehension abilities[3]. However, since they are designed to understand general knowledge, they may have difficulty achieving the desired success in specialized subjects. RAG (Retriever-Augmented Generation) technique has been developed to close this gap. RAG focuses on improving the accuracy and reliability of large language models by using information and data from external sources[4], [5]. In this study, a question-answering system was designed using the RAG technique on the SQuAD 2.0 dataset. This dataset contains two different types of questions, the answer of which is included in the context and the answer is not included in the context. The aim is to determine the most appropriate parameter configuration to increase RAG performance with the questions whose answers are included in the content. For this purpose, a series of experiments were conducted with different independent variables. As a result of the experiments, it was determined that "chunk_size" and "search type" parameters were the independent variables that most affected RAG performance, depending on the characteristics of the dataset used. System performance was evaluated by comparing LLM-generated responses with reference responses included in the dataset. This evaluation was performed automatically using an LLM-supported evaluation model and used the answer correctness metric[4]. As a result of different experiments, accuracy rates between 78% and 82% were obtained. Questions with answers not included in the context were used to test the LLM's tendency to produce hallucinations. This shows that the model produces unrealistic or incorrect answers. Different "prompts" were identified in the research, and it was observed that LLM did not create hallucinations when a correct "prompt" was used. However, when the "prompt" was not used, LLM was observed to answer questions not included in the dataset and produce hallucinations.

Keywords: Large Language Models, retriever-augmented generation, squad 2.0

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Numerical analysis of porosity values for different IP classes and verification with experimental studies

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Abstract

This paper presents air resistance for computational fluid dynamics by analysis and experiments. Transformers are essential equipment in every aspect of energy needs in the world. In this context, the production of transformers has been increasing in recent years. However, although these transformers are electrical machines that operate with 99% efficiency, even a 1% excess loss causes heating. As a solution to these problems, the size of the transformer can be increased, but this also increases the cost. Optimum design of transformers is very important to compete with other manufacturers globally. As a result, to heat is aspect that must be considered in the design stage.

In dry-type transformers without a cabin, in a ventilated room, the heat required to be removed can easily be taken away from the transformer, and it is possible to calculate this with empirical formulas. However, dry-type transformers with cabin, different air resistances are used in the calculation method of the heat expelled from the cabin. It is not possible to calculate these resistances with empirical formulas. Additionally, it is necessary to receive thermal and CFD support from 3D finite element programs. In order to calculate this, thermal and CFD support from 3D finite element programs is required. To calculate the air resistance, porous sections are produced according to IP protection classes. Moreover, the air passing through these sections encounters different resistances in each protection class. Therefore, air resistanece (viscous resistance) must be calculated according to the protection class of the cabin. As a result, the dimensions of the cabin must be changed.

In this study, the porosity ratio of IP21, IP31, IP23, IP54 protection classes is examined, and air resistance is analyzed. There are different porosity values for each protection class, and this study is necessary to define them within the CFD model. At the end of this study, the viscous resistance coefficient of air for different IP classes are presented.

Keywords: porous, CFD, protection classes, air resistance, dry-type transformer

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Natural Convection in a Nanofluid Filled Inclined Cavity Beneath the Influence of a Partial Magnetic Field

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Abstract

Magnetohydrodynamic (MHD) flow combined with other multi-physical situations has a wide range of applications in various engineering systems, electronics, biology, and medical science. The present study contributes to understanding the thermal convection of a Al_2O_3/water nanofluid flow in a differentially heated inclined square enclosure under the impact of the partially active magnetic field. The influence of a partial magnetic field on the inclined chamber has been extensively investigated using different positions and effective widths [1]. The square enclosure is inclined with the horizontal axis and rotated counterclockwise direction. The nanofluid flow is steady, incompressible, two-dimensional, and Newtonian, and the fluid and nanofluid properties are considered in thermal equilibrium with the same velocity field [2]. The Boussinesq approximation is adopted to describe the buoyancy force and magnetic field. The coupled transport equations have been solved utilizing the dual reciprocity boundary element method (DRBEM), which is an efficient numerical approach of the boundary integral method discretizing only the boundary of the computational domain, resulting in a small-sized algebraic system of equations that can be solved in a relatively small amount of computer space so at a low cost. Effects of the Rayleigh number, Hartmann number, position and width of the magnetic field, cavity angle, and the solid volume fraction of nanofluid on flow and thermal patterns have been scrutinized. The results have been visualized via streamlines, isotherms, and average Nusselt number plots. The investigation reveals that the partial magnetic field with square enclosure inclination has significantly affected heat transport characteristics. In addition, changing the position and width of the magnetic field, the inclination angle of the cavity, and other parameters can drastically manipulate the thermal transport in a multi-physical situation.

Keywords: MHD, DRBEM, nanofluid, inclined cavity

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Determination of Optimal Design Parameters for Hybrid PV/T Wall Application in Buildings Using The Response Surface Method

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Abstract

PV/T wall technologies in buildings stand out as an important application in generating energy in buildings. Another prominent feature of this application is its ease. PV/T hybrid walls are a building energy saving application that attracts attention thanks to the feature of producing both electricity and hot water for the building. PV/T wall application applied to these buildings has a high potential for use, especially in rural areas. The PV/T wall consists of elements such as insulation material, copper tubes, solar cells, covering glass, absorber layer feature and air layer [1,2]. Meteorological parameters such as temperature, solar radiation and wind speed are also effective in the efficiency of these building hybrid PV/T walls [3]. Accordingly, the type of insulation material inside the PV/T hybrid wall, the thickness of the insulation material inside, solar cell type, covering glass emissivity, copper tubes thickness, absorber layer feature, air layer thickness, air speed passing through the air layer, outdoor temperature, outdoor environment. The most important factors affecting PV/T hybrid wall efficiency are solar radiation value and outdoor wind speed [1-3]. In the study, a widely used method was used to find the mathematical relationship between these eleven factors (input variables) affecting the PV/T hydrid wall on the external walls of buildings and the measured response variable (performance criterion), and subsequently to find the optimum factor values that will ensure maximum PV/T hybrid wall efficiency. Response Surface Methodology (RSM), an experimental design and optimization technique, was used. Experiments were designed using "Face Centered Design" in modeling, and mathematical modeling was made with full quadratic regression models using the obtained data. Experimental design, mathematical modeling, statistical analysis of the models and optimization studies were all carried out using the MINITAB statistical analysis program. To test whether the number of factors used in the resulting mathematical models was sufficient and the significance of the model, R2 and ANOVA results were examined, respectively. The results obtained show that the R2 value is quite high, which means that the factors used in the modeling are sufficient to explain the PV/T hybrid wall efficiency. According to the results of the ANOVA analysis performed at the 95% confidence level, the P-value obtained with MINITAB is lower than the 5% significance level (Type I error) and the model is significant [4,5].

Key words: PV/T efficiency, RSM, PV/T design parameters, building energy supply

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On Optimal Inventory Management of Substitutable Products with Fixed Shelf-Lives

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Abstract

Effectiveness and efficiency in grocery retailing are paramount, especially amidst the increasing food waste and loss around the globe, in addition to ramping price inflation and scarcity of production resources. Consumers look for both nutritious and affordable foods. Hence, optimizing inventory policies tailored to specific product characteristics becomes imperative, particularly for perishable products, such as milk. In this study, we investigate a retailing-inventory control problem in which we focus on two substitutable products distinguished by their remaining shelf life, as consumers perceive. We model this problem from a retailer's perspective to maximize profit and availability while considering consumer preferences and perishability of the items. We leverage optimization techniques to find closed-form solutions for the retailer's optimal ordering time and selling price. Furthermore, we explore potential applications of this model across diverse sectors, including services and manufacturing. Numerous extensions are possible, including stochasticity in demand and lead time, integrating logistics and collaboration between suppliers and retailers, multi-criteria variations of the objective function, ways to revalorize leftover food items at the retailer's location, and implications of our analytical model on sustainable consumption and production.

Keywords: Inventory control, Pricing, Optimization, Perishable products, Sustainability.

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Enhancing Classification Accuracy with Interval-Valued Fuzzy Sets in the OWA Distance-Based CxK-Nearest Neighbor Approach

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Abstract

Classification problems are a fundamental concept that we rely on for decision-making in our daily lives. One of the widely recognized and efficient techniques in supervised classification, artificial intelligence, pattern recognition, etc. is the k-nearest neighbors' classifier [1-6]. The words play a role reveal the data structure in the decision process. With this, the data collected from the real life includes ambiguous information. With this, the data collected from the real life includes ambiguous information. Fuzzy sets deal with such kind of information in [2]. In artificial intelligence, there are many algorithms such as fuzzy ID3 algorithm, fuzzy K-NN, etc. produced by the combination of many fuzzy logic and classical machine learning algorithms [3-5] for the classification. The OWA-CKNN Algorithm, proposed in [4], is a supervised learning algorithm that adjusts CxK points using the OWA-Distance combination. OWA-Distance is computed to determine the distance between new data and the set of K-nearest neighbors. This approach offers flexibility by adjusting weights, like inter-cluster distance methods such as single, complete, and average linkage approaches. In fuzzy K-NN is adapted into interval-valued fuzzy numbers in [5]. In this study, interval-valued fuzzy numbers are integrated into the OWA-CKNN Algorithm. A fuzzy metric for interval-valued fuzzy numbers is employed as a distance metric [6]. A comparative experimental study is conducted, comparing the performance of Fuzzy K-NN, Weighted Fuzzy K-NN, and the F-OWA-CKNN algorithm. The classification accuracy is evaluated on three well-known datasets (Iris, Glass, Wine) using nonparametric statistical procedures. The results indicate the strong performance of the F-OWA-CKNN algorithm.

Keywords: Fuzzy OWA Distance-Based CxK-NN Algorithm, Interval-valued fuzzy sets, Supervised learning.

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MHD Slip Flow in a Wavy Channel Subjected to an Inclined Magnetic Field

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Abstract

In the present study, the influences of boundary slip and magnetic field inclination angle on MHD flow in a wavy channel are investigated. Fully developed fluid flow is studied on the 2D cross-section of the channel [1]. The top wall consists of cosine waves and the other walls are straight. Top and bottom walls are perfectly conducting and side walls are insulated [2]. The 2D axial flow is mathematically modeled in terms of time-dependent Navier-Stokes and magnetic induction equations. Numerically stable solutions of coupled MHD equations are obtained by utilizing the dual reciprocity boundary elements method for space discretization and the central difference method for time discretization [3]. A grid independence test is carried out. No-slip, top wall slip, side wall slip, and all wall slip flow configurations are analyzed for various values of Hartmann number, inclination angle of the external magnetic field, undulation number, and amplitude of the top wavy wall. Numerical results in the steady state show that the fastest flow occurs when all walls are slipping and it is followed by top wall slip, side wall slip, and no-slip flow configurations in descending order. Flow vortices align in the direction of the applied magnetic field. An increase in the Hartmann number decelerates the flow and shifts the vortices through the side walls. Dense velocity variations are observed in front of the recesses of the wavy wall, especially in the no-slip and the side wall slip cases. As the undulation number ascends induced field lines close their path within the pockets of the wavy wall and this behavior is enhanced with an increase in the amplitude of the top wall.

Keywords: MHD, slip flow, stability, wavy channel, inclined magnetic field.

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Classification of Bandung Regency Wells Based on Mineral Elements using Cluster Analysis of K-Means, K-Medians, and K-Medoids

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Abstract

Wells are a source of water that is used to meet daily needs. The good quality of well water depends on the mineral element in it. The aim of this research is to identify the optimal cluster analysis method and evaluate the quality of well water based on drinking water quality standards. Cluster analysis is a statistical method used to group data by maximizing the similarity of data in a cluster and minimizing the similarity of data with other clusters. Using this method, the characteristics in each cluster can be classified. This research was conducted on 6 mineral elements (i.e. As, Cd, Fe, Mn, Pb, and Zn) in well water spread across 160 observation point locations in Bandung Regency. These data are classified using K-Means, K-Medians, and K-Medoids with Euclidean and Manhattan distance metrics respectively. Each cluster analysis method is evaluated to determine the optimal number of clusters (k) using the criterion function with the Elbow method. Then, to determine the best cluster analysis method, three cluster validation was carried out, one of them using the Silhouete Coefficient. The two best cluster methods were obtained, i.e. K-Means Euclidean and K-Medians Manhattan. Verification of the results regarding water conditions is carried out by comparing the limits of water quality standards at the centroid so that each elements can be explained. This research obtain K-Medians Manhattan at $k = 9$, while K-Means Euclidean at $k = 19$. These clusters have a range of well water quality levels from 1 to 4, with the higher the level the better. K-Medians Manhattan tend to group at a high level of well water quality, with level 1 found in Ciparay and Majalaya districts, while level 4 is dominant in Baleendah and Pacet districts. Meanwhile, K-Means Euclidean tend to group at low levels of well water quality, with level 1 dominant in Rancaekek district, while level 4 is dominant in Pacet district. In grouping, there is a unique cluster, namely in K-Medians Manhattan, safe Mn element is dominant in Baleendah district and dangerous Cd element is found at 2 observation locations at Soreang and Pacet districts. Meanwhile, for K-Means Euclidean, safe Mn element is dominant in Pacet district. The results of this research can be an important basis for managing water resources and protecting public health.

Keywords: Bandung regency, wells, cluster analysis, k-means, k-medians, k-medoids

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A Highly Accurate Family of Stable and Convergent Numerical Solvers Based on Daftardar-Gejji and Jafari Decomposition Technique for Systems of Nonlinear Equations

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Abstract

This study introduces a family of root-solvers for systems of nonlinear equations, leveraging the Daftardar-Gejji and Jafari Decomposition Technique coupled with the midpoint quadrature rule. Despite the existing application of these root solvers to single-variable equations, their extension to systems of nonlinear equations marks a pioneering advancement. Through meticulous derivation, this work not only expands the utility of these root solvers but also presents a comprehensive analysis of their stability and semilocal convergence; two areas of study missing in the existing literature. The convergence of the proposed solvers is rigorously established using Taylor series expansions and the Banach Fixed Point Theorem, providing a solid theoretical foundation for semilocal convergence guarantees. Additionally, a detailed stability analysis further underscores the robustness of these solvers in various computational scenarios. The practical efficacy and applicability of the developed methods are demonstrated through the resolution of five real-world application problems, underscoring their potential in addressing complex nonlinear systems. This research fills a significant gap in the literature by offering a thorough investigation into the stability and convergence of these root solvers when applied to nonlinear systems, setting the stage for further explorations and applications in the field.

Keywords: Nonlinear equations, Root-solver, Convergence and Stability, Numerical simulations.

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Investigating the Effects of Morphological Changes of Red Blood Cells on Flow Characteristics in Capillaries Numerically

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Abstract

Understanding flow characteristics in capillaries plays a vital role in evaluating the whole human circulatory system. According to the well-known phenomenon, namely Fahreaus-Lindqrist effect, red blood cells (RBC) migrate from near wall regions to the core region of capillaries, and a Cell Free Layer (CFL) forms within the near wall region. On the other hand, some types of anemia, i.e., microcytic hypochromic anemia, sickle cell anemia, megaloblastic anemia and erythroblastosis fetalis can damage RBCs, and can cause morphological changes which can affect flow characteristics. Therefore, in this preliminary study, effect of morphological changes of RBCs due to anemia on flow field in capillaries was investigated numerically, considering change in size and volume fraction of RBCs in a capillary, which is geometrically resembled by a microchannel with sudden expansion. Multiphase Euler-Euler approach was employed where blood is modeled as a suspension of plasma and RBC particles, which are in liquid and solid phases, respectively. Modified Carreau-Yasuda viscosity model was used to take account of non-Newtonian behavior of blood. RBCs were modeled as rigid spheres of various diameter. Results obtained through the numerical calculations show that RBC volume fraction near the wall region decreases with cell diameter. This effect is more pronounced especially for relatively lower bulk volume fraction of RBCs, leading to even vanishing concentration of RBCs in the flow separation region near the sudden expansion, where augmenting of cells causes that to decrease to 50% of mean volume fraction at high hematocrit rates. Consequently, morphological changes of RBCs due to anemic diseases effect cell distribution in capillaries, hence mass transfer between cells and capillary wall.

Keywords: Blood flow in capillaries, multiphase blood flow, granular flow, computational fluid dynamics

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Super Domination Number of Middle Graphs

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Abstract

Graph theory plays a crucial role in mathematics due to its practical applications. The vertices determine the solution to mathematical problems, resulting in faster and more efficient results. This paper focuses on the super dominating set problem, which is a variant of the dominating set problem that has recently gained significant attention [1-3]. For a given simple graph G = (V, E), a dominating set of G is a subset S ⊆ V such that every vertex in V \ S is adjacent to at least one vertex in S. The dominating set problem is the problem of finding a minimum size dominating set, and its corresponding minimum size gives the domination number of G. A dominating set S is called a super dominating set of G if for every vertex u ∈ $\bar{S}$=V \ S, there exists a v ∈ S such that N(v)∩ $\bar{S}$= {u}. The super domination number of a graph G, denoted by $\gamma_{sp}(G)$, is the minimum cardinality of a super dominating set [4].

The middle graph M(G) of a graph is obtained from G by inserting a new vertex into every edge of G and joining these new vertices by edges that lie on adjacent edges of G [5]. In this study the super domination number of middle graphs are examined. Some bounds for the super domination number are obtained and the general results for the super domination number of middle graphs of some graph families are derived.

Keywords: Domination number, super dominating set, super domination number, middle graph

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Vibration Analysis FGM Plate: A Hybrid Analytical and Machine Learning Approach

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Abstract

This study investigates the free vibration characteristics of functionally graded material (FGM) plates through both analytical solutions and machine learning (ML) approaches. Starting with deriving equilibrium equations for FGM plates via Hamilton's principle, we accurately determine their natural frequencies under various conditions. Subsequently, we employ an Artificial Neural Network (ANN) model, trained on an extensive dataset from previous research, to predict these vibrational frequencies [1]. The ANN's predictions are meticulously compared with our analytical findings and corroborated against existing studies, showcasing the model's high level of precision and computational efficiency. Notably, the research reveals that the ANN model can significantly streamline the analysis process, handling complex patterns in data that traditional methods find challenging. This blend of analytical rigor and ML innovation offers a novel pathway for enhancing the structural analysis and design of FGM plates, potentially revolutionizing material science and engineering practices. The precision with which the ANN model predicts the natural frequencies across a diverse range of FGM plates underscores the power of data-driven approaches in engineering analysis. The integration of ML not only augments the accuracy of traditional methods but also introduces a level of adaptability and scalability previously unattainable. Our findings suggest that the convergence of computational mechanics and artificial intelligence holds immense promise for the future of material design and optimization, offering a more holistic understanding of the dynamic properties of FGM plates. Furthermore, this study sets a precedent for the application of ML in complex engineering problems, encouraging further exploration into hybrid methodologies that can bridge the gap between theoretical analysis and practical engineering solutions [2]. Through this innovative approach, we aim to contribute to the advancement of FGM technology, paving the way for the development of more resilient and efficient structural components.

Keywords: FGM Plates, Artificial Neural Network, Plate Vibration

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Thermal Performance Analysis for Walls in Buildings with Analytical Quadrupoles Method

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Abstract

The most important building envelope component of buildings in terms of energy saving is the exterior walls with the highest surface area. In order to determine the energy saving potential of the external wall, the properties of the wall materials to absorb, store and recover heat are very important. These properties of external walls with multiple layers show their thermal performance. The study used the quadrupole method for analytical solutions to determine the thermal performance of multilayer walls. The outer surfaces of the multilayer walls were assumed to be exposed to solar-air temperature and the indoor temperature was assumed to be constant. Fourier and Laplace transforms were applied for temperature changes in multilayer walls depending on these temperatures. Analytical calculations were made with the heat transfer transformation matrix, which includes the heat flux and temperatures in all layers of the external walls. For multi-layered walls, the transformation matrix of each layer from the outer side to the inner side is expressed in quadrupole terms. The quadrupole terms of each layer depend on wall of thickness, thermal conductivity, thermal diffusivity and angular frequency. For each layer of the outer wall, wall of thickness, thermal conductivity, thermal resistance, thermal diffusivity and angular frequency and thermal wavelength are determined. Fourier and Laplace variables are based on replacing time with jω. Here $j = -1$ is the complex argument and ω is the angular frequency [1-5]. For January, which is the coldest month in terms of time, one-month outdoor temperature, wall surface solar absorptivity and solar-air temperature determined based on solar radiation coming from four different directions south, north, east/west were used. Calculations were made for the exterior walls of a building in Balikesir province. Thermal performance of the external wall without insulation and with different insulation thicknesses in four different directions, south, north-east/west, was investigated.

Keywords: External wall layers, insulation thickness, quadrupole method, thermal performance, heat transfer matrix

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The Evaluation of Handwritten Examination Papers Utilizing Artificial Intelligence Methods

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Abstract

The evaluation of examination papers is a significant task in many educational institutions, requiring considerable effort, time, and expertise to be reported within a limited timeframe [1]. Therefore, various studies have been conducted on examination papers in different languages in the literature [2]. This study aims to address the challenges encountered in evaluating examination papers and to automatically read and assess handwritten Turkish examination papers. The first phase of the proposed approach is to obtain characters from examination papers. The difficulties in deciphering handwritten examination papers include the abundance of characters, overlapping letters, and the inherent variability in individuals' handwriting, even within different instances of the same individual's writing. The handwritten short-answer assessment system acquires characters on paper using Optical Character Recognition (OCR) methods [3]. In this study, the characters in handwritten Turkish are obtained using Tesseract OCR. Tesseract, encompassing machine learning and deep learning algorithms, is augmented by the OpenCV library to enhance text detection rates on examination papers [4]. In the second phase, keywords or sentence patterns of both given and correct answers are obtained via natural language processing methods. Finally, the similarity between the given and the correct answers is calculated to mark the examination papers. Thereby, an assessments system is ensured that free from ambiguity for both academics and students, expediting the process of receiving grades through swift interaction.

Keywords: Natural language processing; Handwriting recognition, Image processing; Exam evaluation

Acknowledgements

This study is derived from the project titled "Evaluation of Handwritten Examination Paper Using Image Processing and Multi-Criteria Decision-Making Methods" supported by TÜBİTAK 2209-A Program. Besides, Adem Erik is supported by TÜBİTAK 2211 program. The authors would like to thank the Scientific and Technological Research Council of Turkey (TÜBİTAK) for their support.

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Traveling Salesman Problem Using Metaheuristic : An Optimization Of The Formula 1 2024 Race Calendar

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Abstract

The Traveling Salesman Problem (TSP) is a fundamental problem in the sector of logistics and supply chain that aims to find the shortest route for a salesman who has to deliver goods by visiting several cities and get back to the first city, the TSP at its core, has countless real-world applications, including route optimization, vehicle routing and finding the near-optimal solutions for such problems can significantly improve operational efficiency and reduce costs for businesses that are involved in transportations and logistics. This research aims to discover and evaluate the efficiency of using the genetic algorithm to optimize the Formula One 2024 race calendar by minimizing the total travel distance of the whole season. This research aims to evaluate various metaheuristic methods, with a specific focus on utilizing the genetic algorithm to optimize the Formula One 2024 race calendar.

Keywords: Traveling salesman problem (TSP), Formula One, Metaheuristic Algorithms, Genetic Algorithm, Crossover, Mutation Rate, Chromosome, Gene, Population,

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Designing Order Picking Systems Used in Logistics Warehouses with Mathematical Modeling and Artificial Intelligence Methods

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Abstract

The ongoing differentiation of customer expectations and behavior complicates the management of orders for companies today. Customers' orders for small quantities and high variety of products have become more frequent and, at the same time, customers demand timely delivery of orders. Therefore, for companies, the process of picking small quantities of diverse orders becomes a labor-intensive and costly task. There are articles in literature classified under the category of studies related with order picking problem that considered grouping, sorting and routing process optimization by using heuristic and metaheuristic algorithms [1-3]. On the other hand, by integrating a mathematical model and fuzzy logic method, it is possible to design a system of order picking operations to formulate the order picking plan and batch processing sequence [4]. In this research, a mathematical model and artificial intelligence methods are used to design order picking systems that assist in preparing an order picking plan and formulating the picking order of the batches that constitute the orders to achieve an efficient order picking process by reducing the order picking distance. In the order picking plan, small orders are usually batched so that two or more orders can be picked at the same time, and the orders are taken in batches to common picking locations. Then, the order picker can be allocated to each batch depending on the delivery priority of the order. To present the results obtained by using the proposed order picking systems, a logistics warehouse case study is provided. The optimized order picking system that organizes both the order picking operation and the labor utilization is selected among the alternatives.

Keywords: Order picking, order batching, artificial intelligence

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Finite Difference/Finite Element Solution of 2-Dimensional Damped Wave Type Convection-Diffusion Equation

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Abstract

Convection-diffusion equations describe how substances move within a medium, influenced by both fluid flow and molecular diffusion. These equations find widespread use across various fields in science and engineering. In [1], novel approaches and analyses are suggested to improve the efficiency, stability, and precision of the finite element method employed for solving time-dependent convection-diffusion equations.

The type of wave equation known as the Damped Wave Equation is commonly used in physics and engineering to model how waves decrease or damped over time. The critical role that damping plays in controlling oscillations in moving fields has made it a fundamental concept in physics and engineering. A general form of the equation was analyzed in [2]. Our research analyzed a more effective numerical solution for the 2-dimensional damped wave type convection-diffusion equation

$$u_{tt} + u_t - \varepsilon \Delta u + a \nabla u = f \quad u = u(x, y)$$

using the Finite Difference/Finite Element Method, which addresses an advanced mathematical model and algorithm. The finite element method has been used to discretize the spatial variable of the 2-dimensional damped wave type convection-diffusion equation. The temporal variable of the aforesaid equation has been discretized using the finite difference method.

The application of this method enhances the accuracy and computational efficiency of damped wave-type equations. The study presents a Finite Element approach developed for constant-coefficient and time-dependent equations. The results demonstrate the method's potential to model transport-diffusion processes more realistically and effectively. This work represents a significant advancement in the solution of damped wave equations, particularly in the fields of engineering and applied physics. The obtained numerical results using the Finite Difference/Finite Element Method hybrid numerical scheme are displayed in the figures.

Keywords: Finite element method, finite difference method, damped wave-type convection-diffusion equation,

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New insights into epidemiology: Theoretical and numerical investigation of piecewise differential equations

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Abstract

This study delves into the theoretical and numerical applications of piecewise differential equations, a powerful mathematical tool used for modeling different processes happening over varying time periods. Through this new strategy, our aim is to provide a different perspective on different models of HIV infection, in which horizontal and vertical transmission begin to occur simultaneously when an infected newborn is introduced into a population after a certain period of time. The investigation of this piecewise differential equation includes exploring concepts like equilibrium points, reproduction number, and piecewise Lyapunov function for stability. We investigate the scenarios in which these new models utilize fractional derivatives and study the emerging patterns. Also, we present the derivation of the Lagrange polynomial method for solving piecewise differential equations for vertical and horizontal transmissions. Finally, we depict the numerical simulations to visually showcase the different behaviors displayed by this innovative model in a range of scenarios.

Keywords: Piecewise differential equations, fractional derivative and integral, reproduction number, Lyapunov function, numerical scheme.

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The Imbalanced Data Problem: Investigating Factors Affecting Financial Freedom Using Data Mining Techniques with SMOTE Method

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Abstract

The differences in the distribution of classes in the dataset lead to an imbalanced data problem. The study aims to demonstrate the effect of imbalanced data problems on XGBOOST and Support Vector Machines (SVM) methods and to compare these methods. The study tackled a five-class classification problem using the financial freedom index to accomplish this. Initially, both methods were applied to the imbalanced dataset, revealing the imbalance. To address this issue, we employed the Synthetic Minority Oversampling Technique (SMOTE) to create a balanced dataset and then reapplied the two methods. The classification was performed using two methods (XGBOOST and Support Vector Machines) with the financial freedom index. Firstly, the methods were applied to the imbalanced dataset, and the imbalanced data problem was detected. Then, a balanced dataset was created using the Synthetic Minority Oversampling Technique (SMOTE), and these two methods were applied again to this dataset. The results indicate that after addressing the imbalanced data issue, the XGBoost algorithm outperformed the Support Vector Machines method. Additionally, the success rate of the XGBoost algorithm improved significantly more than that of the Support Vector Machines method after using the SMOTE technique.

Keywords: Financial Freedom, XGBOOST, Support Vector Machines, SMOTE

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