ICOMAA 2026

9th International Hybrid Conference on Mathematical Advances and Applications

6–8 May 2026

Istanbul / Türkiye

Abstract Book

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Yildiz Technical University, Istanbul, Türkiye

Editors

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Prof. Dr. Murat KIRISCI

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ABSTRACT BOOK

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FOREWORDS

Dear Conference Participant,

Welcome to the International Hybrid Conference on Mathematical Development and Applications (ICOMAA-26) we are organizing the ninth. First of all, I would like to start my words by reminding one of G. H. Hardy's words:

"Mathematics, more than any other art or science, is a young man's game."

This phrase he expressed in his book “A Mathematician's Apology” is quite meaningful. Because Newton discovered his biggest ideas, fluxions and the law of gravitation, when he was just 24 years old. He found the 'elliptic orbit' at 37 years old. Also, Galois(at twenty-one), Abel(twenty-seven), Ramanujan(thirty-three), and Riemann(at forty) had passed away in their youth.

That's why we thought we should continue this series of conferences that brings together exciting and productive young mathematicians. So, we aim to bring together scientists and young researchers from all over the world and their work on the fields of mathematics and applications of mathematics, to exchange ideas, to collaborate and to add new ideas to mathematics in a discussion environment. With this interaction, functional analysis, approach theory, differential equations and partial differential equations and the results of applications in the field of Mathematics are discussed with our valuable academics, and in mathematical developments both science and young researchers are opened. We are happy to host many prominent experts from different countries who will present the state-of-the-art in real analysis, complex analysis, harmonic and non-harmonic analysis, operator theory and spectral analysis, applied analysis.

I would like to express my gratitude to those who see and appreciate our efforts and innovative steps that we have made to improve our conference every year, to our dear invited speakers and to all our participants. I owe a debt of gratitude to the Scientific committee, organizing committee, local organizing committee and for their efforts throughout this conference series.

The conference brings together a total of 146 attendees, consisting of 138 regular participants (69 from Türkiye and 69 from abroad) and 8 invited speakers (2 from Türkiye and 6 from abroad), representing 16 countries (Algeria, Azerbaijan, Bangladesh, Canada, Czech Republic, France, India, Japan, Kazakhstan, Kosova, Mexico, Pakistan, Saudi Arabia, Türkiye, U.S.A., Yemen). **Since more than 50% of our total participants participated from abroad, this shows that the conference successfully meets the criteria of being international.**

It is also an aim of the conference to encourage opportunities for collaboration and networking between senior academics and graduate students to advance their new perspective. Additional emphasis on ICOMAA-26 applies to other areas of science, such as natural sciences, economics, computer science, and various engineering sciences, as well as applications in related fields. The articles submitted to this conference will be addressed on the conference web sites and, in the journals, listed below:

- Romanian Journal of Mathematics and Computer Science,
- Miskolc Mathematical Notes,
- Türkiye Mathematical Sciences
- Special Issue "Symmetries of Difference Equations, Special Functions and Orthogonal Polynomials II",
- Sigma Journal of Engineering and Natural Sciences,
- Istanbul Commerce University Journal of Science,
- Journal of Nonlinear Sciences and Applications,
- Symmetry,
- Mathematical and Computer Modelling of Dynamical Systems,
- Journal of Inequalities and Special Functions.

This booklet contains the titles and abstracts of almost all invited and contributed talks at the **9th International Hybrid Conference on Mathematical Development and Applications**. Only some abstracts were not available at the time of printing the booklet. They will be made available on the conference website https://2026.icomaas.com when the organizers receive them.

We wish everyone a fruitful conference and pleasant memories throughout the online conference.

Prof. Dr. Yusuf ZEREN
On Behalf of Organizing Committee
Chairman

It was a big excitement moment when Prof. Dr. Yusuf ZEREN discussed with me on the issue of "9th International Hybrid Conference on Mathematical Development and Applications" (ICOMAA-2026) in Yıldız Technical University, Istanbul. It is a great pleasure that this conference is going to take place now. As one of the organizers of the conference, I am delighted with all the delegates, distinguished mathematicians, speakers and young researchers in this international event. It is expected that delegates and participants will benefit from this conference experience and the legacy of information dissemination will continue.
I wish all of you to have a nice and enjoyable participation in the conference.

Prof. Dr. Necip ŞİMŞEK

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INVITED TALKS

Graph Realizations and New Combinatorial Formulae

Ismail Naci Cangül[1]

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Abstract

A set D of positive integers is called as a degree sequence when its elements correspond to the vertex degrees of some graph. Then D is said to be realizable. Omega invariant is a recently defined and intensively studied graph invariant which can be utilized in many combinatorial, graph theoretical, topological, algebraic problems in Graph Theory and also in many application areas of graphs. In this presentation, we shall first present some open problems on realizability and give some results on the number of realizations of a given degree sequence. Recent results on omega invariant will be used in combinatorial and topological calculations. Especially, this problem has combinatorial applications for molecular graphs. Some new results on several open combinatorial and algebraic problems will be presented. In particular, the open problem that whether the realizations of a given realizable set of positive integers are connected or not is solved.

Keywords: *degree sequence, realizability, omega invariant*

Degree-Based Prodeg Indices and Entropy Linking Graph Theory and Cheminformatics with QSPR Modeling

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Abstract

Degree-based topological indices provide powerful mathematical tools for describing the structural features of graphs and molecular networks. In this talk, we present a unified study of Prodeg-type indices and entropy measures as a bridge between graph theory and cheminformatics. The work focuses on several degree-power descriptors, including inverse, misbalance, and higher-order Prodeg indices, together with their corresponding coindices and Shannon entropy formulations. These descriptors are designed to capture important structural information such as branching, degree heterogeneity, molecular compactness, and connectivity patterns. From the theoretical side, we derive exact formulas for important graph families, establish sharp bounds in terms of graph order, size, and extremal degrees, and investigate the behavior of the proposed indices under standard graph operations. The entropy-based approach further converts degree-power information into normalized information-theoretic descriptors, allowing a deeper understanding of structural irregularity in graphs. From the applied side, the proposed descriptors are evaluated in QSPR modeling for molecular datasets, showing their potential to predict physicochemical and biological properties. The results indicate that Prodeg-type indices offer interpretable and mathematically rigorous descriptors that can complement classical topological indices and cheminformatics features. Overall, this study highlights the value of degree-based Prodeg indices and entropy measures as a unified framework linking sharp graph-theoretical results with practical applications in molecular modeling and cheminformatics..

Keywords: *Prodeg indices; degree-based indices; graph entropy; topological descriptors; molecular graphs; cheminformatics; QSPR modeling.*

On Martínez-Kaabar fractal-fractional Double Laplace Transformation

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Abstract

An extended version of the Martinez-Kaabar fractal-fractional calculus theory is investigated in this talk, to the integral transformations and employed in solving some fractal-fractional partial integro-differential equations. Specifically, a new concept of double Laplace transformation, named as the Martinez-Kaabar fractal-fractional double Laplace transformation, is formulated, which involves the Martinez-Kaabar double integral operator into the ordinary double Laplace transformation. The proposed Laplace transformation method is constructed and employed in solving various types of non-integer partial integro-differential equations exhibiting a fractal effect. Finally, several examples are provided to validate the results obtained.

Nonlinear Dynamics and Hyperchaos in a Modified memristor-based Chua's Circuit and its Generalized Discrete System

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Abstract

A modified hyperchaotic memristor-based Chua's circuit and its generalized discrete model are proposed. The dynamics of the continuous system is investigated using stability theory, phase portraits, Lyapunov exponents, and bifurcation diagrams. The proposed circuit model is shown to possess a line of equilibrium and exhibits rich dynamics, including the coexistence of regular and chaotic attractors, and mixed-mode oscillations. Moreover, a generalized discrete version of the proposed system is formulated, and its dynamics is explored. A new stability test useful for locating certain stable regions in three parameter planes is proposed, based on the Jury criterion. The presence of an exact periodic solution is numerically highlighted, and the occurrence of chaotic behavior is confirmed computing the largest Lyapunov exponent and using the 0−1 test.

Existence of Solutions to Dirichlet Problems for Second Order Degenerate Elliptic Operators with Rough Low-Order Terms

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Abstract

In this talk I discuss joint work with D. Cruz-Uribe (University of Alabama), Y. Zeren (YTU, Istanbul), S. Cetin, and F. Elif-Dal concerning the existence of solutions to Dirichlet problems for second order degenerate elliptic linear operators X with general rough low order terms of the form

$$Xu = -\frac{1}{v} Div(Q\nabla u) + HRu + S'Gu + Fu$$

Where v is a weight, R, S are rough first order vectorfields and $H,\ G,\ F$ are measurable functions.

Formalizing Network Topology Matrices in Higher-Order Logic

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Abstract

Network topology matrices constitute fundamental algebraic structures for representing and analyzing graph-based models arising in various domains such as applied mathematics and engineering. In particular, topological matrices, such as adjacency, incidence and Laplacian matrices, encode essential structural and dynamical properties of networked systems in a compact and systematic form. Despite their widespread usage, the mathematical analysis of these matrices is traditionally carried out using paper-and-pencil and simulation-based approaches, which may lack rigor and formal guarantees.

In this work, we present a comprehensive higher-order logic formalization of network topology matrices using the Isabelle/HOL theorem prover. We formally define major classes of topology matrices associated with directed graphs, including adjacency, incidence, loop, degree and Laplacian matrices, and rigorously verify their fundamental algebraic properties such as indexing consistency, symmetry and singularity. In addition, we formalize key matrix concepts such as Kron reduction and the Moore–Penrose pseudoinverse, enabling rigorous reasoning about reduced network models and spectral characteristics. The applicability of the framework is demonstrated through case studies on electrical and mechanical networks.

Modeling Interferon-Regulated Oncolytic Viral Therapy with Intracellular Delay

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Abstract

We develop and analyze a delay differential equation model of oncolytic viral therapy (OVT) incorporating tumor-virus-immune interactions and explicit type I interferon (IFN-I) regulation. A discrete intracellular delay represents the viral replication cycle, en-abling investigation of delay-induced dynamical effects. IFN-I is modeled as both an antiviral inhibitor and a regulator of immune response, capturing its dual biological role. Stabil-ity analysis shows that interferon-mediated viral suppression significantly alters equilibrium structure, while increasing delay can induce Hopf bifurcation and oscillatory tumor-virus dynamics. In the full tumor-immune-virus system, multiple equilibria and bistability arise, separating parameter regimes corresponding to tumor persistence and therapeutic success. Sensitivity analysis identifies IFN production, viral infectivity, and immune proliferation as primary drivers of system behavior. These results demonstrate how the interplay between intracellular delay and interferon-mediated feedback shapes treatment outcomes and provide a mathematical framework for understanding mechanisms that influence OVT efficacy.

Complex Interpolation of Closed Subspaces of Maximal Banach Function Spaces

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Abstract

In this talk, we introduce the notion of and use it to characterize the complex interpolation spaces of closed subspaces with the lattice property for arbitrary couples of maximal Banach function spaces (Banach lattices). As applications, we obtain several new results on the complex interpolation of closed subspaces of Morrey spaces and Lorentz spaces. Furthermore, for smooth function spaces that do not possess the lattice property, we investigate various closed subspaces and establish corresponding complex interpolation results by means of their real-variable characterizations.

Acknowledgement: This is joint work with Dachun Yang, Wen Yuan, and Mingdong Zhang (Beijing Normal University)

CONTRIBUTED TALKS

Approximation Capabilities of Deep Neural Network Interpolation Operators

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Abstract

This paper introduces deep neural network operators based on a special class of sigmoidal functions, using a constructive approximation approach. We begin by constructing a neural network operator for the univariate case with two hidden layers and inductively extend it to an operator with an arbitrary but finite number of hidden layers. The interpolation properties are established, along with error estimation in terms of the modulus of continuity. The results obtained in the univariate case are then extended to a multivariate case. These results show the denseness of the constructed operators in the space of continuous functions C[a,b] for both univariate and C(***R***), where ***R*** is a hyperrectangle in the multivariate case. This study also provides an error analysis comparing the approximation capabilities between deep and shallow neural network operators. Numerical experiments for both univariate and multivariate cases validate the theoretical results for these operators, highlighting their efficiency.

Keywords: *Deep neural network operators, Sigmoidal function, Function interpolation, Modulus of continuity, Error estimates.*

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Fixed Point Approach to a Fractional Differential Equation with Multipoint and Multi-Term Integral Boundary Conditions

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Abstract

This paper investigates the existence and uniqueness of solutions for a nonlinear fractional differential equation involving the Caputo derivative. The equation is subject to a general class of boundary conditions that combine separated multipoint conditions with multi-term integral conditions. The existence of at least one solution is established by applying Krasnoselskii's fixed point theorem for the sum of a contraction and a compact operator. Furthermore, the uniqueness of the solution is proved using the Banach contraction principle. The theoretical results are validated through the construction of illustrative examples. This work contributes to the qualitative analysis of nonlocal boundary value problems in fractional calculus.

Keywords: *Caputo fractional derivative, solution, Banach contraction principle, compact.*

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Arithmetic-Type Degree-Based Topological Indices with Exact Formulas, Extremal Bounds, and Antiviral QSAR/QSPR Applications

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Abstract

Degree-based topological indices are widely used in chemical graph theory because of their computational efficiency and structural interpretability. In this paper, we introduce a new arithmetic-type lifting that generates a family of graph invariants from symmetric edge-degree kernels, thereby extending several classical and recently proposed degree-based descriptors within a unified framework. We establish the well-definedness of the construction for undirected graphs, derive edge-contribution decompositions and mixed-sum representations, and obtain explicit formulas for representative graph families, including grid graphs and Dutch windmill graphs. In addition, we prove degree-extreme bounds for the proposed arithmetic indices in terms of graph order, size, and minimum and maximum degrees, and show that these bounds are sharp for regular graphs. To demonstrate practical relevance, we evaluate the new indices as molecular descriptors in antiviral QSAR/QSPR modeling using a curated ChEMBL-derived dataset of 2220 compounds. The results show that the arithmetic indices provide complementary predictive information, improve performance on several non-trivial physicochemical endpoints, and contribute meaningfully when combined with standard RDKit descriptors. These findings indicate that the proposed arithmetic family forms a flexible, analytically tractable, and chemically informative extension of degree-based topological descriptors.

Keywords: *chemical graph theory; degree-based topological indices; arithmetic-type lifting; extremal bounds; antiviral QSAR/QSPR.*

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Development of a Coupled Strain-Based Finite Element for Nonlinear Analysis of Plate Structures under Large Displacements

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Abstract

In this paper, two strain-based finite elements are formulated and coupled: an in-plane element and an out-of-plane element. Both elements are formulated using the strain-based approach, initially developed for linear analysis, where they have exhibited high levels of accuracy, and they are herein extended to represent nonlinear plate behavior effectively. In this case, the bending part has three nodal degrees of freedom (w, θx, and θy), and the membrane part has two degrees of freedom (u and v). By integrating these formulations, the element possesses a total of five degrees of freedom per node. The nonlinear equilibrium equations are solved using the Newton–Raphson iterative scheme, and all computational procedures, including element formulation and numerical implementation, are carried out using MATLAB. The numerical results obtained from the considered examples demonstrate strong agreement with available analytical solutions and experimental results reported in the literature. These findings validate both the accuracy and the computational efficiency of the proposed approach in the nonlinear analysis of plates under large displacement conditions.

Keywords: *Nonlinear analysis, Large displacement, Strain-based approach, Numerical implementation, Plate structures.*

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Bianchi Type V String Cosmological Models with Late Time Acceleration

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Abstract

In the current work, the possibility of late time acceleration with string fluid as the matter source in Bianchi type V is considered. By assuming the functional form of the Hubble parameter, we explore cosmological hypotheses. The resulting models begin in the early stages of evolution as highly anisotropic and gradually move closer to an isotropic universe. Additionally, we have calculated cosmological parameters such as the string tension density, the particle density, the average Hubble parameter, shear scalar, scalar expansion and the energy density of the string. Physical and geometrical behavior of the universe has been discussed in detail.

Keywords: Bianchi type V, Deceleration parameter q, Hubble parameter H, String tension density λ.

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On S-r-Ideals and S-uz-Rings

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Abstract

This article investigates the concept of S-r-ideals in commutative rings, where S denotes a multiplicatively closed subset. We establish fundamental properties and provide various characterizations of S-r-ideals. Specifically, we present equivalent conditions for a proper ideal to be an S-r-ideal using localization maps. Additionally, we introduce the concept of an S-uz-ring, proving that every S-Artinian ring falls into this category. For cases where the multiplicatively closed subset is finite, we demonstrate that a ring is an S-uz-ring if and only if every disjoint principal ideal is an S-r-ideal. Furthermore, we analyze the behavior of S-r-ideals within polynomial rings, determining the precise conditions under which the polynomial extension of an ideal remains an S-r-ideal. Finally, the study extends these concepts to the framework of amalgamated rings, offering new insights into the structural properties of ideal extensions.

Keywords: *S-r-ideals, S-uz-rings, commutative rings, polynomial rings, amalgamated rings.*

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A Graph Theoretic Approach to Substitution Box Design for Symmetric Cryptography

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Abstract

Substitution boxes (S-boxes) play a vital role in ensuring the security of symmetric cryptographic structures via introducing nonlinearity. Conventional techniques frequently depend upon algebraic constructions or heuristic searches, which might not successfully utilize the underlying structural features of complicated networks. An assessment of current research reveals a gap in leveraging graph spectral representations for the S-box era. To address this situation, we propose a novel technique that constructs 256-entry S-boxes based on the degree distribution, eigenvalues, and energy of randomly generated graphs. A nonlinear formula integrates these graph parameters with random coefficients to supply bijective mappings with excessive cryptographic strength. The algorithm always achieves nonlinearity values of 107 or higher, enhancing resistance towards cryptanalytic assaults. The benefits of this approach consist of adaptability, randomness, and the combination of topological complexity. However, computational overhead and the variety of consequences resulting from randomization remain significant challenges. This graph-theoretic framework offers a promising direction for the future design of secure S-boxes.

Keywords: *Cryptography, substitution box(S-box) design, random graphs, graph energy, eigenvalues, nonlinearity, bijective mapping.*

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Generative AI and Deep Learning for Enhanced Credit Risk Classification

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Abstract

In the banking sector, credit scores are widely used to assess the likelyhood of the individual/company being able to pay back the load. Over the years various models have been crated and improved upon. In this project we plan to use adversarial learning to make a model that is not only more accurate but also more resistant to intentional data change caused by people trying to guess how the model works and trying to circumvent it. Adversarial technique is chosen to simulate these circumvention attemps. Craxnet model will be used as a baseline Kaggle dataset is used for this Project.

Keywords: *Adversarial Machine Learning, Credit Scoring Models, Model Robustness, Data Manipulation, Financial Risk Assessment.*

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Real Interpolation Methods with Function Parameter

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Abstract

In the first part of my talk, I will give a short introduction to the theory of interpolation of linear operators. We give definitions of classical Lions-Peetre real interpolation methods (K and J methods), and some basic properties and theorems. In the second part of my talk, I will discuss two types of generalization of the classical Lions-Peetre real interpolation method using a function parameter. The first was considered by Gustavsson [2], and the second was considered by Janson [3]. We will show the relation between these two methods. The original definition of Gustavsson was restricted to the so-called quasi-power parameter. We can consider this method for a general function. Using ideas from the book [1], we show that the generalized method and Gustavsson and Janson's method are equivalent. Many properties obtained by Janson were difficult to obtain using the original Gustavsson method. It was the reason that Gustavsson considered a restricted class of parameters. We will obtain results for the general Gustavson method without any restriction on the parameter.

Keywords: *real interpolation methods, K-functional, J-functional, K method, J method*

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Two-Weighted Inequalities for Multidimensional Hardy Operators and Their Commutators in Local Weighted Morrey Spaces

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Abstract

Hardy's integral inequality has been studied by a large number of authors during the twentieth century and has motivated some important lines of study which are currently active. We study the generalizations classical Hardy's integral inequality. In this work, we give a characterization of two-weighted inequalities for multidimensional Hardy operators and their commutators in local weighted Morrey spaces $L^{\{0\}}_{P,\lambda,\omega}\left(R^n\right)$. We prove the boundedness of multidimensional Hardy operators H and H^* and their commutators $[b,H]$, $\left[b,H^*\right]$ from the spaces $L^{\{0\}}_{P,\lambda,\,\omega_1^{\delta}}\left(R^n\right)$ to the spaces $L^{\{0\}}_{P,\lambda,\,\omega_2^{\delta}}\left(R^n\right)$, where $1<p<\infty$, $0<\delta<1$, $0\leq\lambda<n$ and $\left(\omega_1,\omega_2\right)\in\widetilde{A}_p\left(R^n\right)$.

Keywords: *Hardy operator, commutator, weighted local Morrey space, BMO space.*

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Solutions of Fractional Differential Equations via Laplace Transforms

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Abstract

In this study ,we investigate the analytical solutions of the fractional differential equations by employing the Laplace transform method within the framework of fractional calculus. Fractional derivatives, which generalize classical integer-order differentiation, have proven to be highly effective in modeling memory and hereditary properties in various physical and engineering systems.
We focus on fractional differential equations involving caputo-type derivatives and apply the Laplace transform technic to convert these equations into algebric forms in the Laplace domain. These approach significantly simplifies the solution procedure and allows for the systematic derivation of exact solutions. The inverse Laplace transform is than utilized to obtain solutions in the time domain.
Several examples are presented to show the efficiancy of the proposed method. The results show that Laplace transform is a powerful and reliable method for solving fractional-order problems, particilary in comparison with traditional analytical technics.

Keywords: *Fractional differential equation, Laplace transform, Fractional derivative*

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Caputo and Caputo–Fabrizio Modeling of Atherosclerotic Reaction–Diffusion Dynamics

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Abstract

This study develops and analyzes a three-dimensional nonlinear fractional reaction–diffusion model based on Caputo and Caputo–Fabrizio fractional derivatives. The model captures the spatial–temporal biochemical interactions of low-density lipoprotein (LDL), lipoprotein(a), and C-reactive protein (CRP) within arterial walls, which are key biomarkers in the progression of atherosclerosis. By replacing classical integer-order time derivatives with fractional operators, memory effects and hereditary properties inherent in biological systems are incorporated into the mathematical framework. A hybrid numerical strategy combining finite difference schemes for temporal discretization and spectral collocation techniques for spatial approximation is employed to obtain stable and accurate solutions. Comparative evaluation of the Caputo and Caputo–Fabrizio formulations reveal their distinct capabilities in representing both chronic and acute inflammatory dynamics. The proposed fractional reaction–diffusion framework provides deeper insight into cardiovascular disease mechanisms and offers a mathematically robust foundation for advanced modeling in mathematical biology with potential relevance to clinical interpretation and future biomedical applications.

Keywords: *Reaction-diffusion system; Caputo derivative; Caputo-Fabrizio derivative; LDL; lipoprotein(a); CRP.*

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Darboux Rotation Axis of Curves in 3D Lie Groups with Myller Configuration

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Abstract

In this study, Darboux-type vectors are defined via the Myller configuration in 3-dimensional Lie groups. A new frame is constructed in 3-dimensional Lie groups using the Myller configuration. Furthermore, the relationships between the Darboux axis and the condition for a curve to be a helix are investigated. Additionally, as a natural consequence of the Myller configuration, several special cases of Darboux vectors are presented in Euclidean space and in Lie groups.

Keywords: *Lie groups, Myller configuration, Darboux-type vectors*

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A Hybrid Cryptographic Architecture Based on Generalized Josephus Permutation and Fibonacci Sequence

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Abstract

This study introduces "Fibo-Josephus," a novel symmetric encryption algorithm designed to secure digital data against statistical attacks by strictly implementing Claude Shannon's confusion and diffusion properties within a chaotic mathematical model. The proposed cryptographic scheme operates on the finite field Z_{256}, utilizing a pseudo-random key stream generator derived from the Fibonacci sequence defined by the recurrence relation $F_i = \left(F_{i-2} + F_{i-1}\right)(mod\ 256)$. This sequence is combined with plaintext data via the bitwise XOR operation $\left(C_i = P_i \oplus F_i\right)$ to mask the value space and achieve high confusion.To ensure diffusion and eliminate structural correlations, particularly in high-redundancy data such as images, the algorithm employs the Generalized Josephus Problem. This is modeled not as an elimination process, but as a chaotic permutation function π: $\{0,\ 1,\ \ ...,\ N-1\} \rightarrow \{0,\ 1,\ \ ...,\ N-1\}$, reordering data indices based on a deterministic step parameter k. For image encryption, the system utilizes an isomorphic mapping function $f: Z^2 \rightarrow Z$ to transform 2_D pixel matrices into 1_D vector spaces, thereby maximizing the scattering effect of the Josephus permutation.Experimental analyses confirm that the proposed encryption scheme exhibits high resistance against statistical attacks by satisfying critical security criteria such as histogram flattening and low correlation. Consequently, the Fibo-Josephus system presents a computationally efficient and mathematically rigorous alternative model for secure communication protocols.

Keywords: *Cryptography, Generalized Josephus Problem, Modular Arithmetic, Fibonacci Sequence, Chaotic Permutation, Image Encryption*

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Modeling Complex Dynamics via Mixed Fractional Order Differential Systems: Flexibility and Numerical Stability

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Abstract

While standard fractional calculus provides a robust framework for memory-dependent processes, many real-world systems exhibit heterogeneous behaviors that a single fractional operator cannot fully capture. This communication investigates mixed fractional differential systems, which integrate multiple types of fractional derivatives or varying orders within the same mathematical framework.
The core interest of this approach lies in its unprecedented flexibility: by mixing operators (such as the conformable derivative for its computational ease and the Caputo derivative for its memory effects), we can better represent systems with switching regimes or multi-scale dissipation. We analyze the existence and uniqueness of solutions for these hybrid systems and discuss their advantages in terms of parameter tuning and experimental data fitting. Furthermore, we present a [numerical scheme / stability analysis] showing that mixed systems offer a superior balance between mathematical rigor and physical accuracy. These findings are particularly relevant for complex phenomena in viscoelasticity, anomalous diffusion, and bio-engineering, where the flexibility of the derivative choice is crucial for capturing the true nature of the evolution process.

Keywords: *Mixed fractional derivatives, Hybrid systems, Mathematical flexibility, Memory effects.*

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μ-Statistical Convergent Sequences of Fuzzy Numbers

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Abstract

This study introduces and investigates new classes of fuzzy number sequences through the synthesis of μ-statistical convergence and Musielak-Orlicz functions. The primary purpose is to define generalized sequence spaces for fuzzy numbers by incorporating the generalized de la Vallee-Poussin mean and the difference operator of order r. The methodology involves examining the structural properties of alpha-statistical convergence and strong summability for distinct non-decreasing sequences within the unit interval. Key findings include the establishment of several inclusion relations between these newly defined spaces under specific conditions related to the underlying Musielak-Orlicz functions. Additionally, the research provides formal mathematical proofs for the uniqueness of limits within these spaces and characterizes the fundamental relationship between statistical convergence and strong summability. These results extend existing theories of fuzzy sequence spaces and contribute to the broader mathematical understanding of summability theory and functional analysis. The provided framework offers a complete overview of the convergence behaviour for sequences of fuzzy real numbers in generalized spaces.

Keywords: *Statistical convergence, difference sequence, Orlicz function, Musielak-Orlicz function, fuzzy numbers*

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q-Tribonacci Polynomials

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Abstract

Recognized as a natural generalization of Fibonacci polynomials in the literature of number sequences and special polynomials, Tribonacci polynomials have wide applications in fundamental mathematical disciplines such as combinatorial analysis, number theory, and linear algebra.Tribonacci polynomials are defined by following recurrence relation for $n\geq 3$

$$T_n(x) = x^2 T_{n-1}(x) + xT_{n-2}(x) + T_{n-3}(x)$$

with the initial conditions $T_0(x) = 0, T_1(x) = 1, T_2(x) = x^2$. There are many generalization of these polynomials in the literatüre. One of them is q − analogue of Tribonacci polynomial. q −Tribonacci polynomials defined by following recurrence relation for $n\geq 3$

$$T_n(x,q) = x^2 T_{n-1}(x,q) + xq^{n-2} T_{n-2}(x,q) + q^{n-3} T_{n-3}(x,q)$$

with initial conditions $T_0(x,q) = 0,\ T_1(x,q) = 1,\ T_2(x,q) = x^2$.

In this study the q −Tribonacci polynomials and q −Tribonacci-Lucas polynomials are defined referred to Tribonacci polynomials. Furthermore we obtained many properties of these polynomials, such as explicit formulas, generating functions and various summation properties.

Keywords: *Tribonacci polynomials, q-Tribonacci polynomials, generating functions.*

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Linear-Time Analysis of Critical Road Pairs and Urban Vulnerability Mapping in Directed Road Networks

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Abstract

This study proposes a novel and efficient graph analysis method to identify critical road segments whose simultaneous closure would severely disrupt urban transportation. Modeling road networks as directed graphs, detecting pairs of edges that disconnect the network is a complex mathematical challenge often limited to theoretical studies. To address the lack of practical applications on real-world data, our approach integrates Depth-First Search (DFS) with β (v) profile for back-edges and the *lowest* reachability metric. This combination enables the rapid detection of critical edges in a single pass, yielding sub-second execution times even on large datasets. Utilizing the OSMnx library, real road networks of selected regions are extracted to visualize network fragmentation and regional vulnerabilities upon critical edge removals. The proposed framework provides a highly practical analysis tool for disaster management, emergency response planning, and urban mobility enhancement.

Keywords: *Directed Graphs, Critical Path Analysis, Algorithm Design, Urban Transportation Networks.*

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Classification of Some Biased Estimators

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Abstract

To overcome the multicollinearity problem in linear regression, a class of estimator, namely modified ridge regression estimator is introduced by Swindel. This estimator is a general estimator which includes ridge estimator (RE) of Hoerl and Kennard, Liu estimator (LE) of Kejian, two parameter estimator (TPE) of Özkale and Kaçıranlar, Dawoud-Kibria (DK) estimator and Kibria-Lukman (KL) estimator. The aim of this study is to mathematically demonstrate how other estimators are special cases of the modified estimator by analyzing its solution under equality and inequality constraints. This will provide guidance to those who wish to define alternative estimators.

Keywords: *Multicollinearity; Modified ridge estimator; Liu estimator; Ridge estimator; Two parameter estimator*

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Investigation of Qualitative Properties of Generalized Solutions for a Strongly Dissipative Hyperbolic Equation with Nonlinear Boundary Conditions

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Abstract

In this study, the qualitative properties of generalized solutions to a strongly dissipative hyperbolic differential equation with nonlinear boundary conditions are investigated. Such problems play an important role in various fields of mathematical physics, particularly in the modeling of wave processes and energy dissipation phenomena. The research is based on methods of functional analysis, Sobolev space theory, and energy-based a priori estimates. Under the assumption of strong dissipation, an appropriate energy functional is constructed to establish the boundedness and stability of the solution. The influence of nonlinear boundary conditions is analyzed separately, and sufficient conditions for the existence and uniqueness of generalized solutions are obtained. Furthermore, the long-time behavior of the solution is studied. It is shown that, under certain conditions, the energy decays over time, leading to the asymptotic stability of the solution. In addition, the dependence of the solution on initial data and its regularity properties are examined. The obtained results contribute to the qualitative theory of hyperbolic equations with nonlinear boundary conditions and can be applied in the mathematical modeling of various applied problems.

Keywords: hyperbolic equations, dissipation, generalized solution, nonlinear boundary conditions, stability

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Weakly S − Prime Hyperideals of Multiplicative Hyperrings

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Abstract

Suppose that R is a commutative with identity multipliplicative hyperring and $S \subseteq R$ is a multiplicative closed subset of R. In this research, we will consider the definition and fundamental properties of weakly S − prime hyperideals. Assume that I is a hyperideal of R such that $I \cap S = \emptyset$. We called I is a weakly S − prime hyperideal of R then there exists an $s \in S$ such that if whenever $x, y \in R$ and $\{0\} \neq x \circ y \subseteq I$ then either $s \circ x \subseteq I$ or $s \circ y \subseteq I$. We set up the relations among prime hyperideal, S − prime hyperideal, weakly prime hyperideal and weakly S − prime hyperideal.

Keywords: *Multiplicative hyperring, prime hyperideal, weakly prime hyperideal, S −prime hyperideal, weakly S −prime hyperideal.*

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A Hybrid Physics-Informed Computational Framework for Fractional Differential Equations

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Abstract

Fractional differential equations are widely used in the modeling of memory-dependent and nonlocal phenomena arising in physics, engineering, and applied sciences. However, the numerical analysis of such systems remains challenging due to the nonlocal structure of fractional operators and the stability issues encountered in computational procedures. These challenges often lead to increased computational cost and complexity, particularly in high-dimensional problems. In this study, a hybrid computational framework combining physics-informed learning concepts with fractional numerical modeling strategies is presented for the analysis of fractional differential equations. The proposed structure aims to integrate mathematical model information into learning-based computational mechanisms within a unified and efficient framework. In addition, it seeks to improve the interpretability of machine learning models by embedding physical consistency into the solution process. The study focuses on the interaction between fractional modeling principles and scientific machine learning approaches, particularly in terms of stability behavior, residual-based learning structures, and computational adaptability. The proposed framework provides a flexible and robust mathematical and computational environment for the accurate numerical treatment of fractional-order systems.

Keywords: *Fractional differential equations, Physics-informed learning, Scientific machine learning, Hybrid computational framework, Numerical modeling*

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A Fractional-Order Fisher Information Framework for Noise-Robust Statistical Sensitivity Analysis

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Abstract

Fisher information is a fundamental quantity in statistical estimation and information theory, characterizing the sensitivity of probability distributions through local variations of the log-density function. However, the classical Fisher framework may exhibit unstable behavior under noisy environments due to its highly local structure. In this study, we investigate the effect of fractional-order sensitivity modeling for improving robustness against noise perturbations. The proposed approach incorporates nonlocal memory behavior into statistical sensitivity analysis, enabling a more stable response under stochastic fluctuations and corrupted observations. Numerical experiments on Gaussian probability densities demonstrate that the proposed fractional-order framework preserves significantly more stable behavior than the classical Fisher information under increasing noise levels. The obtained results indicate that fractional-order effects may provide an effective robustness mechanism for noisy statistical environments and may offer new perspectives for robust estimation, noisy signal analysis, and uncertainty-aware learning systems.

Keywords: *Fisher information, fractional-order effects, noise robustness, statistical sensitivity analysis, nonlocal memory*

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Calculating the Risk of Smartphone Addiction with a Hybrid Model Based on Fermatean Fuzzy Sets and Machine Learning (WINGS-MABAC)

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Abstract

The rapid advancement of technology and the widespread use of smartphones have made “smartphone addiction,” which can negatively affect individuals’ social lives and mental health, an important area of research. In this study, the assessment of smartphone addiction risk is addressed as a Multi-Criteria Decision-Making (MCDM) problem. In this context, a novel hybrid MCDM model is proposed by integrating machine learning algorithms with Fermatean Fuzzy Sets-based WINGS and MABAC methods. The developed model aims to evaluate individuals’ smartphone addiction risk levels in a more precise and reliable manner. The proposed approach is expected to assist experts in obtaining faster and more accurate predictions in their decision-making processes.This study demonstrates that the proposed hybrid model contributes to the literature from a methodological perspective and can also be used as a practical and applicable decision support tool in various fields.

Keywords: *Smartphone Addiction, Fermatean Fuzzy Sets, WINGS, MABAC, Machine Learning.*

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On S-2-Prime Hyperideals of Commutative Hyperrings

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Abstract

In this paper, we present the notion of S-2-prime hyperideals, which provides a unifying generalization of 2-prime and S-prime hyperideals within multiplicative hyperrings. We explore their key algebraic properties and investigate their connections with other hyperideal classes. We emphasize the unique aspects that differentiate S-2-prime hyperideals, illustrating their role in expanding the theoretical framework of hyperideal structures. We examine how these hyperideals behave under hyperring homomorphisms, extensions, and standard algebraic operations, demonstrating that many known properties of prime, 2-prime, and S-prime hyperideals extend naturally to the S-2-prime setting. We provide illustrative examples to highlight important differences and to offer practical insight into their structure. Overall, we enhance the theoretical understanding of hyperideals in multiplicative hyperrings and establish a framework for future research in this area.

Keywords: *2- prime hyperideals, S- prime hyperideals, S-2- prime hyperideals*

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On Hyper-dual Extension of the E. Study Mapping

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Abstract

In this study, E. Study hyper-mapping theorem is proved in Minkowski 3-space. Then, a numerical example is used to show the validity of the detailed demonstration for the Minkowski space formulation of the E. Study hyper-mapping theorem. Furthermore, a unified framework for Euclidean and Minkowski geometries is obtained by introducing a generalized inner product that depends on the parameters μ and ϑ. In this context, the classical Euclidean and Minkowski examples are derived as special cases from a generalized form of the E. Study hyper-mapping theorem. The theoretical findings are then further supported by numerical examples.

Keywords: *E. Study hyper mapping, Lorentzian unit-hyper dual sphere, hyperbolic unit hyper-dual sphere*

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Picture Fuzzy Bi-Ideals on Ternary Semigroups

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Abstract

In this study, using the algebraic operations previously defined on the set D^* via a type-3 ($\leq_3$) ordering, the notions of picture fuzzy subsemigroups and Picture fuzzy bi-ideals are introduced in ternary semigroups. It is shown that these structures preserve their properties under operations such as intersection and product. Moreover, it is established that they form a complete lattice with respect to the subset relation. Finally, the notions of image and inverse image are considered, and their relationships with level subsets are examined.

Keywords: *ternary semigroups, Picture fuzzy set, bi ideals*

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Spectral Energies of Redefined Zagreb Indices and Their QSPR Performance on Anticancer Drugs

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Abstract

In this study, we investigate the spectral energies associated with redefined Zagreb indices and assess their effectiveness as molecular descriptors in quantitative structure–property relationship (QSPR) modeling of anticancer drug compounds. The primary aim is to examine the extent to which graph-based descriptors derived from redefined Zagreb indices can contribute to the prediction of relevant physicochemical and biological properties. First, the mathematical definitions of the redefined Zagreb indices are presented, and the corresponding weighted spectral matrices are constructed. The associated spectral energies are then computed from the eigenvalue distributions of these matrices. Subsequently, a dataset of selected anticancer drug molecules is analyzed, and regression-based QSPR models are developed to evaluate the predictive performance of the proposed descriptors. Model accuracy is assessed using standard statistical measures, including the correlation coefficient and mean squared error. The obtained results indicate that the spectral energies of redefined Zagreb indices exhibit strong predictive ability and, in several cases, outperform classical topological indices in modeling the selected molecular properties. These findings demonstrate the applicability of the proposed spectral descriptors as effective tools in cheminformatics and drug design. Overall, the study emphasizes the role of spectral graph theory in improving molecular descriptor design and enhancing QSPR modeling for pharmaceutical applications.

Keywords: *Zagreb indices, Spectral energy, QSPR, Anticancer drugs, Graph theory*

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On Anisotropic Eigenvalue Problems

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Abstract

We study a nonlinear eigenvalue problem involving the anisotropic (p,q)-Laplacian. By employing variational methods, truncation techniques, comparison principles, and critical group theory, we establish that, for sufficiently small values of the parameter, the problem admits extremal solutions of constant sign as well as sign-changing (nodal) solutions.

Keywords: *Variable Lebesgue and Sobolev spaces , Extremal solutions of constant sign, Nodal solutions*

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Comparative Analysis of the Approximate Solutions of Time Caputo Fractional Kawahara Equations by Using Various Techniques

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Abstract

The system of Kawahara equations is a class of nonlinear partial differential equations that extend the Korteweg-de Vries equations to model wave propagation with higher-order dispersive effects, such as those found in shallow water waves and magneto-acoustic waves. This paper introduces the Sawi residual power series method (SRPSM), which combines the Sawi transform with the residual power series technique. This technique, along with the Caputo fractional operator, allows us to obtain both analytical and numerical solutions for the time Kawahara equation (TKE) by calculating the coefficients of the power series. We will employ the SRPSM in solving the TKE under two cases: one with a perfect initial condition and another with an approximate initial condition. We will demonstrate the efficiency, capability, and reliability of SRPSM by presenting graphical representations of the numerical results alongside the analytical solutions. Furthermore, we compare our solutions with other solutions of the TKE obtained by the natural transform decomposition method and residual power series method.

Keywords: *Caputo derivative operator; Sawi transform; Residual power series.*

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Feedback-Linearization-Based Control of a Buck Converter with State and Parameter Estimation

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Abstract

This paper presents a current-sensorless control strategy for a buck converter based on input–output feedback linearization and extended Kalman filter (EKF)-based state and parameter estimation. The proposed approach aims to improve output-voltage regulation under operating-point variations while eliminating the need for direct inductor-current measurement. First, a nonlinear averaged model of the buck converter is considered, and input–output feedback linearization is employed to compensate for the inherent nonlinear dynamics and obtain a control-oriented representation suitable for high-performance regulation. A proportional–integral–derivative controller is then designed on the linearized dynamics to achieve a fast and well-damped output-voltage response. To realize sensorless operation, an EKF is formulated to estimate the inductor current and load resistance online using only input- and output-voltage measurements. In this way, the proposed scheme combines nonlinear control with model-based estimation to address both dynamic performance and implementation cost. The effectiveness of the method is evaluated in MATLAB/Simulink under reference changes, input-voltage disturbances, and load variations. Simulation results show that the proposed strategy provides improved transient performance, reduced overshoot, and accurate estimation of the unmeasured state and load parameter. These results indicate that the method offers a practical and low-cost solution for embedded buck-converter applications requiring current-sensorless operation and robust voltage regulation.

Keywords: *Nonlinear state-space modeling, current-sensorless control, feedback linearization, extended Kalman filter, state-parameter estimation.*

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Mapping Properties of the Commutators of B-fractional Maximal Operator

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Abstract

In this study, we investigate the boundedness of the commutator of the fractional maximal operator associated with the Laplace-Bessel operator. Let Δ_B denote the Laplace-Bessel operator and M_γ^β the corresponding fractional maximal operator. For a locally integrable function b, the commutator generated by M_γ^β and b is defined by $\left[M_\gamma^\beta, b\right]f = M_\gamma^\beta(bf) - bM_\gamma^\beta(f)$. Our main goal is to study the boundedness properties of the commutator of the B-fractional maximal operator on variable Lebesgue spaces $L_{p(\bullet),\gamma}(R^n_{k,+})$, and, under suitable assumptions on the exponent function $p(\bullet)$, to establish sufficient conditions for its boundedness. These results extend and complement existing studies on fractional maximal operators to the setting of the Laplace-Bessel operator and variable exponent Lebesgue spaces.

Keywords: *BMO space, commutator, fractional maximal operator, variable Lebesgue space*

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Minimization in Generating Space and Fixed Point

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Abstract

A non-convex minimization theorem has been established for generating space of quasi 2-metric family for sequence of mappings with non commuting weak compatible condition. Also supported by an example.

Keywords: *Generating space of quasi 2-metric family, weak compatible mapping, Minimization theorem, common fixed point.*

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Characterization of Weighted Inequalities for Discrete Integral Operators on the Cone of non-Increasing Sequences

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Abstract

Assume that $\{a(m)\}$, $\{b(m)\}$ and $\{c(m)\}$ are given non-negative weight sequences on Let $U: N\times N \to [0, \infty)$ be a regular kernel (Oinarov kernel) if U is nonincreasing in the first variable, nondecreasing in the second variable and there exists a positive constant C such that

$$U(i, n) \le C(U(i, j) + U(j, n)) for\ every\ i, j, n \in N, i \le j \le n. \quad (1)$$

Let $0 < p, q < \infty$. In our talk, we present the characterisation of the weighted sequences $\{a(m)\}$, $\{b(m)\}$, and $\{c(m)\}$ for which the following inequalities

$$\left(\sum_{m=1}^{\infty} \left(\sum_{k=1}^{m} U(k,m)c(k)x(k) \right)^q a(m) \right)^{\frac{1}{q}} \le C \left(\sum_{m=1}^{\infty} x(m)^p a(m) \right)^{\frac{1}{p}} \quad (2)$$

hold for all non-negative, non-increasing sequences (x(n). Our approach is based on the reduction theorem, which reduces these inequalities to corresponding inequalities on the cone of non-negative sequences, and utilizes the results from the paper [3] to obtain the final characterization. When $U(k,n) = 1$, and $c(k) = 1$ was considered in the papers [1] and [2].

Keywords: *weighted inequalities, discrete kernel operator, cone of non-negative sequences.*

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Existence Criteria via Measure of Noncompactness for Hybrid Fractional Boundary Value Problems

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Abstract

This paper investigates a nonlinear boundary value problem involving hybrid Hadamard fractional differential equations with nonlocal hybrid Hadamard integral boundary conditions. In order to extend the available tools to a class of boundary value problems and employ less restrictive conditions, one needs to explore more refined tools of functional analysis, such as the topological degree theory combined with notions of noncompactness and convexity. Accordingly, we utilize the technique of measure of noncompactness together with degree theory to establish existence results for the proposed problem under appropriate assumptions. Furthermore, we examine the uniqueness of solutions and conduct a comprehensive stability analysis. The theoretical findings are validated through a numerical example demonstrating the applicability of our results. This work contributes to the growing field of hybrid fractional calculus by extending the analysis to Hadamard-type operators with nonlocal hybrid conditions.

Keywords: *Hadamard fractional integral, Kuratowski measure, Lipschitz, Stability.*

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Global Domination in Graphs and Total Domination in Fuzzy Graphs: Degree and Index Approaches

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Abstract

Domination theory has important extensions in both graphs and fuzzy graphs. In this paper, we introduce the global domination degree and global domination index in graphs, together with the total domination degree and total domination index in fuzzy graphs. These parameters offer new ways to measure the contribution of vertices to minimum dominating structures. Exact values, explicit expressions, and structural characterizations are established for several standard graph families, along with illustrative examples. We also derive relationships with classical domination parameters and prove bounds and monotonicity properties involving complements, spanning subgraphs, spanning trees, independence-type parameters, and graph operations. The results demonstrate that these degrees and indices provide useful new invariants for studying domination in crisp and fuzzy graph frameworks.

Keywords: *global domination degree; global domination index; total domination degree; total domination index; fuzzy graphs.*

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Berezin Radius Inequalities Advanced by Applying Convexity Methods

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Abstract

In this article, for reproducing kernel Hilbert spaces, we present more powerful upper bounds on the Berezin radius of bounded operators. The approach we propose combines a mixed Schwarz type inequality with a convexity argument. Improved estimates for the Berezin number and its powers result from having the appearance of a revised coefficient under natural order assumptions relating $|T|$ and $\left|T^*\right|$. We also get connected bounds for operator products, such as $ber\left(S^*T\right)$ expressions. The parameters chosen in the order assumptions can be defined with the use of a helpful adequate condition. The improvement of the obtained bounds is demonstrated and compared with previous estimates in a number of explicit numerical examples on a discrete reproducing kernel Hilbert space.

Keywords: *Berezin radius, Berezin symbol, functional Hilbert space, convex function, operator inequalities*

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Complexity of Separately Harmonic Function

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Abstract

The aim of this paper is to give some results on the growth of an entire separately harmonic function using it complexity. We give also an estimation on Taylor series expansion coecients and some results on arithmetical entire functions.

Keywords: *Separately Harmonic Function, Growth of an Entire Function, Taylor Series Expansion Coecients, Arithmetical Function .*

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Some Topological Indices of m-Graphs

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Abstract

In this paper, we study several degree-based and distance-based topological indices of the (m)-graph associated with a finite abelian group. The (m)-graph, recently introduced in [1] as a generalization of power-related group graphs, exhibits rich combinatorial and algebraic properties. Exploiting its tree structure in the connected case, we derive explicit formulas for important topological descriptors, including the Zagreb indices, Randic index, harmonic index, atom-bond connectivity index, geometric-arithmetic index, and Wiener index [2]. These formulas are expressed in terms of the order of the group and the parameter (m). Our results provide new connections between algebraic graph theory and chemical graph theory, and they further illuminate the structural characteristics of (m)-graphs.

Keywords: Wiener index, m-graph, finite abelian group

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On Topological Indices of Certain Families of Graphs, Physica Scripta, 100 (2024), Article 015001.

Numerical Solutions of Ordinary Differential Equations in Einstein-Gauss-Bonnet Gravity via Functional Link Artificial Neural Networks

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Abstract

This study investigates numerical solutions of ordinary differential equations (ODEs) in Einstein-Gauss-Bonnet (EGB) gravity using Functional Link Artificial Neural Networks (FLANN). To overcome the computational challenges of traditional methods in complex non-linear systems, we propose robust, single-layer FLANN architectures. Our methodology expands input data into a higher-dimensional space utilizing Chebyshev and Legendre orthogonal polynomials, trained with the Adam optimization algorithm to systematically minimize error. Evaluating these networks against exact analytical solutions reveals that functional link models successfully capture complex non-linear dynamics. Comparative error analysis demonstrates that FLANN models achieve high precision and extremely low error margins. Ultimately, these single-layer architectures provide highly accurate and computationally cost-effective mathematical tools for solving non-linear ODEs in advanced physical frameworks.

Keywords: *Einstein-Gauss-Bonnet gravity, Functional Link Neural Networks, Ordinary Differential Equations, Chebyshev polynomials, Legendre polynomials.*

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An Enhanced α-Fractal Approximation and Its Shape-Preserving Properties using Lupaş-type Post-Quantum Operators

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Abstract

In this paper, we propose a new class of *α*-fractal functions, constructed through Lupaş-type (p, q) −Bernstein operators employed as the base functions. A sequence $f_n^{(p,q,\alpha)}$ of (p, q, α) −fractal approximants is developed corresponding to a continuous function f on a compact interval with a nonzero scaling vector *α*; this sequence achieves uniform convergence to f without imposing the classical condition of vanishing scaling vectors. Further, these (p, q, α) −fractal functions are analyzed in Hölder spaces, where the existence, uniqueness, and convergence of the related approximants are established. Additionally, the constrained approximation problem is examined within this new framework. The findings from graphical analysis reveal that using Lupaş-type (p, q) -Bernstein operator as a base function in *α*-fractal approximation is more efficient than using that of Phillips type q-analogue and (p, q)-analogue of Bernstein operator.

Keywords: *(p,q)-Bernstein operators; fractal interpolation functions; order preserving properties; α-fractal approximation*

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On New Diamond-$\propto$ Ostrowski and Grüss-Type Dynamic Inequalities

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Abstract

In this study, new Ostrowski and Grüss-type dynamic inequalities are established within the framework of diamond$-\propto$ calculus on time scales. The diamond$-\propto$ derivative, as a convex combination of delta and nabla derivatives, provides a unified approach that bridges discrete and continuous analysis. By constructing appropriate Montgomery-type identities in the diamond$-\propto$ setting, we derive Ostrowski and Grüss-type inequalities for functions that are diamond$-\propto$ differentiable.

Keywords: *Ostrowski inequality, Grüss-type inequality, Montgomery identity, Diamond$-\propto$ integral*

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Partially Ordered Quantale-Valued Quasi-Metric Spaces and Some Coupled Fixed Point Results

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Abstract

In this study, we first introduce partially ordered quantale-valued quasi-metric spaces and investigate some of their fundamental topological properties. Then, we establish new coupled fixed point theorems in these spaces. Our results provide a generalization and extension of the works presented in [1-4]. Moreover, we discuss the consequences of the obtained results in the settings of quasi-metric spaces and partial quantale-valued metric spaces.

Keywords: *Partial order, action, value-quantale, coupled fixed point*

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An Introduction to Generalized Osculating Ruled Surfaces in Three-Dimensional Lie Groups

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Abstract

This study investigates osculating ruled surfaces, a specific class of generalized ruled surfaces, within the context of three-dimensional Lie groups. Initially, fundamental concepts of three-dimensional Lie groups and the definition of ruled surfaces are introduced. The study then focuses on the construction of generalized osculating ruled surfaces, providing their formal definitions and exploring their geometric structures. Key characterizations, such as the conditions for surfaces to be developable or cylindrical, are established using the Frenet-Serret frame. Furthermore, the equation for the line of striction is derived, and its relationship with the base curve is analyzed. These results represent a natural generalization of classical ruled surface theory from three-dimensional Euclidean space to the more complex algebraic structure of Lie groups.

Keywords: *3-dimensional Lie groups, Frenet frame, Osculating ruled surfaces*

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An Algebraic Cryptoanalysis of AES Using Gröbner Basis

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Abstract

This study illustrates how the intrinsic algebraic characteristics of the AES algorithm can be leveraged to construct a system of multivariate polynomial equations, whose solution reveals the secret key. The computational difficulties involved in solving these systems require the use of advanced algebraic methods, such as Gröbner basis algorithms, to simplify and resolve them efficiently. We represent the cipher as a set of polynomial equations over GF(2), using only the variables from the initial key. To achieve this, we present a system of equations that emerges naturally within the AES framework. Through normal form reductions, all intermediate variables are systematically eliminated. The final system, expressed solely in terms of key variables. Afterward, we attempt to solve this system by employing Gröbner bases.

Keywords: *Algebraic Cryptanalysis, Advanced Encryption Standard (AES), Gröbner Basis Methods*

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On the Solvability of a Class of Nonlinear Non-Uniformly Elliptic Equations in Non-Uniform Sobolev Spaces

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Abstract

In this work, we study the solvability results for a class of nonlinear, non-uniformly elliptic equations. The data for the problem is assumed to belong to Lebesgue spaces (including the limiting case $L^1(D)$). We establish the existence of "very weak" solutions by identifying specific non-uniform coercivity conditions on the equation. The exponents arising from these conditions and the nonlinearity of the operator determine the functional class of the solution, specifically the integrability degrees of the solution itself and its derivatives. A key aspect of our approach involves utilizing continuous and compact embedding theorems within non-uniform Sobolev spaces. Furthermore, we prove a priori estimates for the solution and its gradients. These estimates are obtained based on a new methodology introduced in [1], which provides an enhanced approach through a refinement of Stampacchia's Lemma.

Keywords: *Nonlinear elliptic equations, weak solvabilit, non-uniform growth, existence and uniqueness.*

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On Necessary and Sufficient Conditions for Dynamic Inequalities

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Abstract

This work presents necessary and sufficient conditions for new structures of dynamic inequalities with diamond$-\propto$ calculus on time scales. These results differ from classical Hardy-type inequalities because they are examined on time scales that combine discrete and continuous cases.

Keywords: *Hardy-type inequalities, Diamond$-\propto$ Calculus, Hölder's inequality.*

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Cobalancing Polynomials: Structural Properties and Applications to Pseudo-Random Sequence Generation

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Abstract

In this paper, we introduce a new family of Cobalancing polynomials and investigate their fundamental properties. In particular, we derive their recurrence relations and examine their connections with classical balancing-type sequences. Furthermore, we construct a sequence generated from these polynomials and analyze its behavior in the context of pseudo-random number generation via normalization modulo 10^5. To assess its statistical performance, we conduct several numerical experiments, including empirical analysis and standard randomness tests such as the chi-square test, the Kolmogorov–Smirnov test, and the autocorrelation test. The obtained results indicate that the generated sequence exhibits an approximately uniform distribution along with negligible correlation between successive terms. These findings suggest that Cobalancing polynomials provide a promising framework for the construction of sequences with pseudo-random characteristics.

Keywords: *Cobalancing polynomials; Pseudo-random sequences; Recurrence relations; Uniform distribution; Statistical tests.*

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Numerical Modeling Applied to the Analysis of Cylindrical Shells under Uniform Distributed Loading

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Abstract

This work presents a simulation-driven optimization framework for semi-cylindrical shell structures subjected to uniformly distributed loads, representing realistic conditions in large-span applications such as stadium roofs and airport facilities. Using a three-dimensional finite element, a parametric study examines the influence of geometric ratios and mesh refinement on structural response, revealing robust convergence and predictive accuracy. Building on this, a metaheuristic optimization is applied to identify the optimal stiffener configuration, considering both thickness and location under a constant volume constraint. Results demonstrate that the optimized design significantly enhances structural stiffness while maintaining material efficiency, highlighting the superiority of the design strategy over conventional approaches that rely solely on material addition. This study underscores the potential of coupling numerical modeling with optimization algorithms to achieve efficient, high-performance shell structures.

Keywords: *Numerical Modeling, Finite Element Method, Cylindrical Shells, Parametric Study. Optimization Algorithms.*

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Dynamical Behavior Analysis of a Cancer Therapy Model by Virus Injecting in the Frame of Caputo Fractional Order Derivative

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Abstract

Cancer is a disreputable killer of the mankind and its treatment processes are varied and erratically efficacious. From the clinical trials of head and neck cancer, it is obvious that the virus infecting tumor cells lead a new therapeutic approach in cancer treatment. The interactions among the growing tumor, the replicating virus and possible immune responses are multi factorial and nonlinear in nature. Therefore, for proper understanding of how virus and host characteristics impact on the outcome of therapy requires a suitable mathematical model. From this context, in this paper we develop an UIVS fractional cancer therapy model by virus injecting in the frame of Caputo fractional order derivative (CFOD) to show the efficiency of a therapeutic approach for controlling the cancer cells through a particular virus injecting into the patient's tumor site. In this paper, we investigate the possible scenarios that could be relevant for therapy as viral cytotoxicity alone destroy tumor cells. Here, we analyze the existence and uniqueness of model's solutions by using Banach fixed point theorem. Routh-Hurwitz stability criterion and Ulam-Hyers stability criterion has been used for stability analysis. Furthermore, we study a bifurcation analysis, an optimal control of the virus replication rate and the optimality of viral cytotoxicity. For validating of the analytical results, we perform a numerical simulation using Fractional-Adams-Bashforth-Moulton method and MATLAB code fde12.m. Some corresponding phase portraits are presented to support the consistency of the analytical results. The obtained results of this paper provide a significant guideline for selecting an appropriate cancer therapeutic approach. Finally, in this project we validate the applicability of the CFOD operator to form a suitable cancer therapy model by virus injecting.

Keywords: *Caputo fractional order derivative; Fractional-Adams-Bashforth-Moulton method; UIVS fractional cancer therapy model by virus injecting.*

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A Comparative Analysis of Alternative Range Kernels in Bilateral Image Filtering

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Abstract

In this study, the effect of alternative kernel functions on the performance of bilateral image filtering is investigated. The bilateral filter is a well-known edge-preserving smoothing method that combines spatial proximity and intensity similarity in the filtering process. Although the Gaussian kernel is commonly used in the classical bilateral filter, different kernel functions may provide different advantages in terms of denoising quality, edge preservation, and computational efficiency. For this purpose, Gaussian, Cauchy, Tukey biweight, Epanechnikov, triangular, box, and generalized Gaussian kernels are integrated into the range component of the bilateral filter. The performances of these kernels are comparatively analyzed under different noise models such as Gaussian noise, salt-and-pepper noise, and speckle noise. The experimental results are evaluated using image quality and edge-preservation criteria such as MSE, PSNR, SSIM, and computational time. The aim of the study is not to introduce a completely new filtering paradigm, but to provide a systematic comparison of alternative range kernels and to discuss their practical effects in edge-preserving image denoising.

Keywords: *Bilateral filter, image denoising, kernel functions, edge preservation, range kernel, Gaussian kernel, speckle noise*

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The Marchenko Method in the Inverse Scattering Problem for the Third-Order Equation

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Abstract

In this paper we present a solution method for an inverse scattering problem associated with the third-order equation $\psi_{xxx} + Q\psi_x + P\psi = k^3\psi$, where the complex-valued potentials Q and P are assumed to belong to the Schwartz class. This method is the counterpart of the Marchenko method used to solve the inverse scattering problem for the full-line Schrödinger equation. We establish the Marchenko equation for the third-order equation, which is a linear integral equation using the appropriate scattering data as input to the integral kernel and the nonhomogeneous term. The two potentials Q and P in the third-order equation are recovered from the solution to the established Marchenko integral equation.

Keywords: *Inverse scattering for the third-order equation, bound-state dependency constants, Riemann-Hilbert problem, Marchenko integral equation*

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A Generalized Jensen Framework via h-Deformed Quasi-Arithmetic Means and Gauss-Polya Type Inequalities

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Abstract

In this paper, we introduce a generalized Jensen-type framework based on h-deformed weight structures and quasi-arithmetic means generated by strictly monotone functions. Using this approach, we establish new integral inequalities for both positive and signed weight systems under suitable monotonicity and convexity assumptions. The main results extend classical Jensen and Gauss-Polya type inequalities by incorporating a nonlinear deformation through a function h. In particular, the proposed operatör J_h provides a unified structure that covers several known mean inequalities as special cases. We also show that the classical results in the literature are recovered when $h(t)=t$, which confirms the consistency of the presented framework. Finally, some special cases and applications are given to illustrate the main results.

Keywords: *h-convexity, Jensen inequality, Jensen-Steffensen inequality, quasi-arithmetic mean, Gauss-Polya inequality.*

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On the Stability of a Second-Order Integro-Differential Equation with Multiple Unbounded Variable Delays

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Abstract

This paper investigates the asymptotic stability of zero solution of a second-order nonlinear integro-differential equation with multiple unbounded time-varying delays. Using the Lyapunov second method, new sufficient conditions for stability are derived. The results of the papers are illustrated through examples, verifying the applicability of the new conditions. These findings extend existing results in the literature and provide a systematic framework for analyzing a broad class of second-order nonlinear integro-differential equations with unbounded variable delays.

Keywords: *Integro-differential equation, asymptotically stable, unbounded variable delays*

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A New Approach to Grüss and Ostrowski-Type Inequalities via Delta Integral on Time Scales

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Abstract

The Ostrowski inequality gives the absolute deviation of the function from its integral mean. Delta and nabla calculi are the first two approaches to study time scale calculus. This article presents the Ostrowski inequality for univariate first-order delta differentiable functions by using the Montgomery identity established for delta integrals. Some extensions of the dynamic Ostrowski-type inequality are investigated with the help of integration by parts for delta integrals, properties of the modulus, and polynomials on time scales. Furthermore, dynamic Grüss-type inequalities are established in their generalized form for twice delta differentiable functions by utilizing the Montgomery identity. In addition, the obtained inequalities are discussed for continuous and discrete time scales.

Keywords: *Ostrowski inequality · Grüss-type inequality · Montgomery identity · Delta integral*

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A Comparative Evaluation of Generative AI Tools in Academic Reference Accuracy

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Abstract

This study examines the research accuracy of four widely used generative artificial intelligence tools: ChatGPT, Gemini, Claude, and Copilot. The main aim is to evaluate how accurately these tools provide academic reference information across different research fields. For this purpose, selected queries from medicine, mathematics, law, artificial intelligence, and social sciences were submitted to each tool. The generated references were evaluated according to five criteria: article title, author name, journal name, publication year, and volume/issue information.

The findings indicate that the accuracy of generative AI tools varies depending on both the tool and the academic field. While some tools produced relatively consistent reference information in certain areas, incomplete, partially correct, or fabricated bibliographic details were observed in others. These results show that generative AI tools may support preliminary academic research, but their outputs should not be accepted without verification from reliable academic databases.

This study highlights the importance of critical evaluation, source verification, and AI literacy in academic research. It also provides a comparative framework for assessing the reliability of generative AI tools in producing bibliographic information.

Keywords: *Generative artificial intelligence, ChatGPT, Gemini, Claude, Copilot, research accuracy, academic references,*

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Fractional Analysis Operators and Their Applications

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Abstract

In this study, new fractional integral and derivative operators are introduced by using generalized M-series and K-functions as kernel functions. These operators provide a unified framework that includes several known fractional operators, such as Riemann–Liouville, Erdélyi–Kober and Saigo-type operators, as special cases for suitable parameter values. The main properties of the proposed operators are investigated, and their left- and right-sided forms are examined separately. In particular, their effects on certain classes of functions are obtained in closed form, and reduction relations to classical operators are explicitly established. The results demonstrate that the proposed operators extend existing fractional operators by incorporating more general kernel structures and provide a broader setting for fractional analysis.

Keywords: *Fractional calculus, Fractional operators, Special functions, M-series, K-function*

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A Modification of Szasz-Mirakyan Operator and Auxiliary Results

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Abstract

In this paper, we introduce a new modification of the classical Szász–Mirakyan type operators defined on an unbounded interval. The proposed operators are constructed in such a way that they preserve the constant test function 1 exactly, while the test functions x and x^2 are preserved in the asymptotic sense. We investigate the fundamental approximation properties of the newly defined operators by employing Korovkin-type theorems on appropriate weighted function spaces. In particular, we establish convergence results in weighted spaces and obtain quantitative estimates in terms of the modulus of continuity. Furthermore, a Voronovskaya-type theorem is derived, which describes the asymptotic behavior of the operators and highlights their approximation order. The presented results contribute to the analysis of approximation processes on unbounded domains and provide a framework for further investigations of Szász–Mirakyan type operators.

Keywords: *Szasz-Mirakyan Operators, Voronovskaya theorem, Modulus of continuity, Korovkin type theorem.*

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A New Variant of Jain Operators in the Variation Seminorms

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Abstract

The primary objective of this paper is to develop a new generalized family of Jain operators and to investigate their principal approximation properties. We examine these operators not only within classical normed function spaces but also in the framework of variation seminorm. Using Korovkin-type theorems, we establish convergence results, and we determine the rate of convergence by employing standard tools such as the second modulus of continuity and Peetre's K-functional. Furthermore, we derive an asymptotic expansion of the operators and study the behavior of their derivatives. Particular attention is devoted to the variation-detracting nature of the generalized Jain operators, and we provide both the convergence in variation seminorm and an estimate of the corresponding rate.

Keywords: *Jain Operators, Variation Seminorms, Voronovskaya-type theorem, modulus of continuity.*

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Sine Trigonometric Aggregation Information based on Fermatean Hesitant Fuzzy Sets

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Abstract

The Fermatean hesitant fuzzy set, obtained by combining Fermatean fuzzy sets and hesitant fuzzy sets, can be used in practice to simplify the solution of complex multi-criteria decision-making problems. The sine trigonometric function maintains symmetry and periodicity about the origin and thus fulfills the ambitions of decision makers in selecting the best options. In this presentation, some basic operations using the sine trigonometric function are presented for Fermatean hesitant fuzzy sets. We define Fermatean hesitant fuzzy weighted average and Fermatean hesitant fuzzy weighted geometric aggregation operators. Based on these new aggregation operators, we propose an algorithm for multi-criteria decision-making with Fermatean hesitant fuzzy information.

Keywords: *Sine trigonometric function, aggregation operators, Fermatean hesitant fuzzy sets, decision making.*

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Fairly Aggregation Operators for Disc Interval-Valued Fermatean Fuzzy Sets

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Abstract

In fuzzy-type decision-making, aggregation operators are mathematical tools for combining multiple fuzzy values into a single representative value. Fuzzy Fairly Aggregation Operators are advanced methods for aggregating fuzzy information in a balanced and equitable manner, ensuring that the final decision fairly reflects the collective input—particularly in situations involving uncertainty, imprecision, and conflicting judgments. These operators bridge fairness theory and fuzzy decision-making, offering a more nuanced and realistic alternative to traditional linear aggregation techniques. In this study, we provide Fairly Aggregation Operators for disc interval-valued Fermatean fuzzy sets and examine their basic properties. An ELECTRE method based on the disc interval-valued Fermatean fuzzy sets framework is proposed to quantify the decision-making process accurately. This methodology integrates disc interval-valued Fermatean fuzzy concordance and discordance matrices, facilitating a comprehensive evaluation of performance across multiple criteria.

Keywords: *Fairly aggregation operators, disc interval-valued Fermatean fuzzy sets, ELECTRE, decision-making.*

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Temporal and Bezier-Supported Future Frame Prediction for Video Anomaly Detection

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Abstract

Video anomaly detection aims to identify events that deviate from normal scene dynamics. Future frame prediction is a useful approach for this task, since anomalies can be revealed by the mismatch between the predicted frame and the ground-truth next frame. In this study, a baseline future frame prediction model was extended with temporal consistency regularization and Bezier curve-based motion regularization. To preserve training stability, these components were introduced progressively through a staged learning schedule rather than being applied at full strength from the beginning. Experiments were conducted on the UCSD Ped2 dataset, where four consecutive frames were used to predict the next frame. Anomaly scores were computed from PSNR values between predicted and ground-truth frames and then normalized at the video level. Performance was evaluated using frame-level ROC-AUC. The best result was obtained with the B3 configuration, which achieved an AUC of 0.9561, compared with 0.9501 for the baseline. These findings show that temporal consistency regularization and Bezier curve-based motion regularization can improve anomaly detection performance when they are introduced gradually during training.

Keywords: Deep learning, video anomaly detection, future frame prediction, temporal consistency regularization, Bezier curve-based motion regularization

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Fractal Approximation via Phillips-type (p,q)-Bernstein Operators

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Abstract

This paper presents a new class of α-fractal functions generated using Phillips-type (p, q)-Bernstein operators as base functions. For a continuous function f on a compact interval and a nonzero scaling vector α, a sequence $\{f_n^{(p,q,\alpha)}\}$ of (p, q, α)-fractal approximants is constructed that converges uniformly to f without the conventional requirement of vanishing scaling vectors. The study also explores (p, q, α)-fractal functions within Hölder spaces, confirming the existence, uniqueness, and convergence of the associated approximants. Additionally, the constrained approximation problem is examined within this novel framework. The findings reveal that the deformation parameters p and q provide flexibility in approximation which is also supported by graphical demonstrations.

Keywords: *(p, q)-Bernstein operators; fractal interpolation functions; order preserving properties; α-fractal approximation*

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On Prime Filters, Ideals and Their Neutrosophic Counterparts in BV-Algebras

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Abstract

In this study, prime filters, ideals, and their neutrosophic counterparts in BV-algebras, which are among the structures of universal algebra, are investigated. BV-algebras differ from similar algebraic structures such as BE-algebras in terms of their defining properties. This distinction necessitates a reconsideration of the concepts of filters and ideals within the framework of BV-algebras.

At the beginning of the study, the fundamental properties of BV-algebras are briefly introduced, and the notions of filters and ideals within this structure are presented. Subsequently, the concept of prime filters is examined, and the main properties of these structures are discussed.

In addition, the neutrosophic counterparts of filters and ideals defined in BV-algebras are considered, and some of their fundamental properties are analyzed.

This study aims to provide a different perspective on the structural aspects of BV-algebras and to lay the groundwork for further evaluations within the scope of neutrosophic approaches.

Keywords:*BV-algebra, prime filter, ideal, neutrosophic structures, algebraic structures*

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Designing Perfect Quantum Codes over the Hurwitz Integers

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Abstract

Although perfect E-error-correcting codes establish a well-known fundamental bound in classical coding theory, their quantum analogs have not yet been defined in the current literature. This research bridges this theoretical gap by providing a mathematical framework for perfect E-error-correcting quantum codes over the ring of Hurwitz integers. In this study, a novel CSS (Calderbank-Shor-Steane) quantum code construction method is proposed by utilizing classical linear codes defined over the residue class rings of Hurwitz integers. Through this approach, the parameters of the newly generated quantum code families are explicitly calculated, and those achieving the perfect code bound are specifically classified. The findings demonstrate the algebraic potential of Hurwitz integers in quantum error correction theory and introduce a robust class of quantum codes to the literature.

Keywords: *Perfect error-correcting codes, Hurwitz integers, quantum codes.*

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Homomorphism by Using Intuitionistic Fuzzy Functions and its Properties

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Abstract

This paper develops the theory of intuitionistic fuzzy group homomorphisms, extending classical algebraic structures into the intuitionistic fuzzy framework. Building on the foundational definitions of intuitionistic fuzzy functions by Milles et al. (2020), we formalize surjective and injective intuitionistic fuzzy mappings and establish homomorphisms between intuitionistic fuzzy subgroups. Fundamental theorems are proved, generalizing classical results and demonstrating that the composition of two intuitionistic fuzzy homomorphisms remains within the same category. We further show that intuitionistic fuzzy subgroups and normal subgroups are preserved under direct and inverse images. The kernel of an intuitionistic fuzzy homomorphism is introduced, shown to be an intuitionistic fuzzy subgroup, and analyzed in relation to injectivity. Collectively, these contributions provide a rigorous bridge between classical algebra and intuitionistic fuzzy algebra, laying the groundwork for future extensions to rings, modules, and vector spaces.

Keywords: *intuitionistic fuzzy homomorphism, kernel of an intuitionistic fuzzy homomorphism, intuitionistic fuzzy normal subgroups, intuitionistic fuzzy functions, surjective and injective intuitionistic fuzzy mappings.*

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A study on Entire GA and AG Topological Indices

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Abstract

Topological indices serve as numerical representations of graphs and serve as power tools for analyzing and understanding the structural properties of molecules and networks in general. The entire topological indices offer a comprehensive representation of molecular structure by considering not only the degrees of vertices and edges, but also their adjacency and incidence relationships. In this research, we introduce two novel version of entire indices, namely the entire geometric-arithmetic index $\left(GA^{E}\right)$. and the entire arithmetic-geometric index $\left(AG^{E}\right)$. These new indices are defined mathematically, and by define a new graph partation called entire partation, we analyze their behavior through significance families of standard graphs like regular graphs, complete graphs, path graphs, complete bipartite graphs, tadpole graphs, wheel graphs, gear graphs, book graphs and stacked book graphs. Furthermore, exact formulae for these new indices are obtained for various molecular structures, like triangular benzenoid graphs and honeycomb graphs.

Keywords: *Entire geometric-arithmetic topological index, Entire arithmetic-geometric topological index, honeycomb graph, triangular benzenoid graph.*

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Characterızatıon of Weıghts Discrete Hardy Inequalıtıes for non-Increasıng Sequences

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Abstract

We provide a complete characterisation of the weighted discrete Hardy inequality restricted on the cone of non-increasing sequences. The main approach relies on the so-called reduction technique established in our earlier papers [1, 2], where the inequality was reduced to corresponding inequalities on the cone of non-negative sequences. By applying two different types of reduction theorems, we obtain two distinct equivalent characterisations of the discrete weighted Hardy inequality on the cone of non-increasing sequences. Our first result provides a new, simplified proof of the classical Bennett–Grosse-Erdmann theorem (2006) [3], while the second establishes a completely new equivalent characterisation. These results unify previous findings and extend the application of reduction methods to discrete operators.

Keywords: *Hardy inequality, monotone sequences, reduction, kernel operator, discrete inequality.*

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Analytical and Numerical Solution of Conformable Fractional Differential Equations via Conformable Fractional Laplace Transform and Homotopy Perturbation Method

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Abstract

This study presents a novel and highly efficient analytical algorithm, the Conformable Laplace Transform-Homotopy Perturbation Method (CLT-HPM), designed for solving linear and nonlinear conformable fractional differential equations (FDEs). While traditional fractional operators, such as Riemann-Liouville and Caputo, frequently suffer from singular kernels and require the evaluation of complex Mittag-Leffler functions, the proposed method leverages the unique advantages of the conformable fractional derivative. This approach successfully maintains fundamental classical calculus properties, including the product, quotient, and chain rules. By integrating the algebraic simplicity of the conformable Laplace transform with the powerful iterative capabilities of the Homotopy Perturbation Method, the algorithm effectively eliminates unwanted "noise terms" through an inherent self-canceling mechanism. The robustness and accuracy of the methodology are rigorously validated through various test cases. Notably, for nonlinear problems, the CLT-HPM achieves exact analytical solutions in merely two iterations. In contrast, standard classical methods remain constrained to approximate power series expansions that exhibit significant truncation errors. Ultimately, the results demonstrate that the CLT-HPM provides maximum computational efficiency and absolute mathematical precision without requiring complex discretization or heavy computational loads.

Keywords: *Conformable Fractional Derivative, Homotopy Perturbation Method, Laplace Transform, Nonlinear Differential Equations, Exact Solutions.*

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Mathematical Modeling of Paradoxical Success in Student Performance: A Qualitative Competency Approach

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Abstract

This study addresses limitations in traditional academic assessment by examining "Paradoxical Success" in student achievement. Conventional evaluation methods often rely on Normal Scores, which prioritize the quantity of correct answers without accounting for the inherent difficulty of individual items. This research proposes a shift toward Weighted Scores as a more accurate metric for qualitative competence. Utilizing an analytical framework, the methodology identifies students demonstrating high proficiency in solving questions with significant cognitive complexity despite having lower aggregate raw scores. These paradoxical patterns suggest that raw metrics frequently mask the true cognitive depth of learners. Key findings indicate that difficulty-weighted analysis reveals a distinct category of students characterized by "qualitative mastery" who are often misclassified in standard performance tiers. Ultimately, this work advocates for the integration of paradoxical success analysis into personalized learning modules to foster a more individualized competency-based educational model.

Keywords: *Educational Data Mining, Paradoxical Success, Student Performance Prediction, Weighted Scoring, Mathematical Proficiency.*

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Complexity, Chaos, and Control in Discrete Predator–Prey Dynamics with Herd Behavior

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Abstract

In this study, we investigate a discrete-time predator–prey model incorporating herd behavior, where generalist predation and prey population dynamics are significantly influenced by collective defense mechanisms that alter predator–prey interactions. We show that the interplay between discretization and herd behavior generates rich dynamical phenomena, including stability loss, period-doubling cascades, quasi-periodicity, and the onset of chaos. By employing bifurcation theory and center manifold reduction, precise analytical conditions for flip and Neimark–Sacker bifurcations are obtained, revealing how small parameter changes can trigger drastic qualitative transitions. To mitigate chaotic oscillations, we introduce an OGY-based feedback control strategy and demonstrate its effectiveness in stabilizing unstable equilibria. Numerical simulations, supported by bifurcation diagrams, phase portraits and Lyapunov exponent analysis, confirm the theoretical predictions.

Keywords: *Discrete predator–prey model, Stability analysis, Bifurcation analysis, Chaotic dynamics, OGY method*

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Population Dynamics and Chaos Control in a Discrete Leslie–Gower Predator–Prey Model with Strong Allee Effect

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Abstract

In this study, we investigate the complex dynamics of a modified discrete Leslie–Gower predator–prey model incorporating a strong Allee effect in the prey population and generalist predation. A rigorous analytical framework is developed to examine the existence, feasibility, and local stability of coexistence equilibria. The system is shown to exhibit rich dynamical behaviors, including flip, Neimark–Sacker bifurcations, for which explicit parametric conditions are derived. Using center manifold theory and normal form analysis, we characterize the direction of bifurcations and determine the stability of emerging solutions. The analysis reveals the onset of periodic oscillations and more intricate dynamical regimes, which are further supported by numerical simulations. To mitigate chaotic dynamics arising in certain parameter regimes, an OGY-based feedback control strategy is implemented, successfully stabilizing the system.

Keywords: *Leslie–Gower predator–prey model, Discrete-time dynamics, Stability analysis, Bifurcation analysis, OGY chaos control*

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Computation of Syzygy Module Using Recursive QR Decomposition

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Abstract

This study presents a linear algebra–based approach for the computation of H-bases and syzygy modules of homogeneous polynomials. The primary aim is to develop efficient and structurally simple algorithms that avoid the limitations associated with traditional Gröbner basis techniques, such as dependence on monomial ordering and numerical instability. The proposed methodology relies on matrix-based computations, particularly row reduction and QR decomposition, to construct syzygy bases and define a consistent reduction procedure. A recursive framework is introduced to compute the syzygy module, leading to an effective H-basis construction algorithm. The results demonstrate that the proposed approach reduces computational complexity while maintaining numerical reliability. Furthermore, the method eliminates the need for additional matrix operations and provides a clear termination criterion. Overall, this study offers a practical and efficient alternative for H-basis computation within a unified linear algebraic framework.

Keywords: *Syzygy Module, H-bases, QR Decomposition, Homogeneous Polynomials.*

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Eigenvalues and Eigenvectors of a Certain Type of 3×3 Dual and Hyperdual Number Tridiagonal Matrices

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Abstract

In this study, we present an application to the eigenvalue–eigenvector theory of a certain type of 3×3 dual and hyperdual number tridiagonal matrices of the form $A = A_s + A_d\varepsilon$ and $A = A_s + A_{d_1}\varepsilon + A_{d_2}\varepsilon^* + A_{d_3}\varepsilon\varepsilon^*$ respectively. Here, $\varepsilon^2 = (\varepsilon^*)^2 = (\varepsilon\varepsilon^*)^2 = 0$, $\varepsilon\varepsilon^* = \varepsilon^*\varepsilon \neq 0$, $\varepsilon \neq 0$, $\varepsilon^* \neq 0$, $\varepsilon \neq \varepsilon^*$, $\varepsilon, \varepsilon^* \notin R$. In the dual case, the eigenvalues of A are expressed in terms of the contributions of both A_s and A_d, with the standard part arising from A_s and and the dual part from A_d. Likewise, in the hyperdual case, the eigenvalues of A are described in terms of the contributions of A_s, A_{d_1}, A_{d_2} and A_{d_3}. The analysis is carried out for cases classified by the algebraic multiplicities of the eigenvalues of A_s in both the dual and hyperdual settings. Moreover, explicit examples are presented to support the theoretical results.

Keywords: *dual numbers, hyperdual numbers, tridiagonal matrices, eigenvalues, eigenvectors.*

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Soliton Solutions of the Nonlinear Telegraph Equation

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Abstract

In this study, we investigate soliton solutions of the nonlinear Telegraph equation, which is widely used in the analysis of signal transmission and propagation. First, the nonlinear ordinary differential form of the investigated problem has been obtained via a suitable wave transformation. Then, the proposed method has been utilized to obtain soliton solutions from the nonlinear ordinary differential form, by giving the algorithm of the method. As a result, the soliton solutions of the nonlinear Telegraph equation have been achieved by assigning appropriate parameter values contained in both the problem and the method. The obtained results are presented and discussed in detail.

Keywords: *Soliton solution, Telegraph equation, Wave transform.*

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Soft Mappings and Soft Contiunuity with an Application to Software Project Selection

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Abstract

This paper presents a detailed study of mappings on soft classes and their role in soft set theory and soft topology. We introduce soft images and soft inverse images induced by soft mappings and analyze their fundamental properties. This work investigates the concept of soft continuity is examined and several results concerning the preservation of soft separation axioms under various classes of soft mappings are established. An application to a software project selection expert system is provided to illustrate the practical usefulness of the proposed framework.

Keywords: *Soft set, soft continuity, soft point, soft separation spaces, software project selection expert systems*

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On Fractional Kantorovich--Meyer--König--Zeller Operators

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Abstract

We introduce a family of fractional Kantorovich--Meyer--König--Zeller operators $K_{n,\mu}$, defined via a Beta-type weighted averaging controlled by a positive parameter μ. Exact expressions for moments and central moments are obtained, along with their asymptotic behavior through comparison with the classical case. Using these results, we establish uniform convergence on $C[0,1]$ and L_p-boundedness and convergence for $\mu \geq 1$ and $1 \leq p < 1$. The rate of approximation is described via the modulus of continuity, and a Voronovskaja-type theorem highlights the influence of μ on the first central moment. A differential identity for the operators is also derived, extending the classical theory to a fractional framework.

Keywords: *Fractional operators; Kantorovich--Meyer--König--Zeller operators; Moments; Modulus of continuity; Voronovskaja theorem.*

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Weighted Statistical Convergence Sequences of Order (a,ß) Defined via Musielak-Orlicz Function

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Abstract

The concept of difference sequence were introduced in the 1980's and after that many mathematicians studied sequence spaces. In this paper, we introduce and study a new notion of weighted statistical convergence of order (a,ß) defined via Musielak-Orlicz functions. Fundamental properties of this convergence method are investigated, including linearity, inclusion relations, and uniqueness of limits. Furthermore, we establish connections between weighted statistical convergence of order (a,ß) and other well-known convergence notions such as ordinary statistical convergence and weighted summability. Appropriate examples are provided to illustrate the effectiveness and generality of the proposed approach. The results obtained in this work extend and unify various convergence concepts in the framework of Musielak-Orlicz sequence spaces.

Keywords: *Weighted Statistical Convergence, Statistical Convergent Sequences, Sequence Spaces.*

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On a Phragmén–Lindelöf Type Theorem for Degenerate Nonlinear Elliptic Equations

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Abstract

In this study, an analogue of the classical uniqueness theorems for the Dirichlet problem in unbounded domains, such as cylindrical and angular type domains, is established for a class of degenerate nonlinear elliptic equations. The proof is based on Landis's well-known growth theorem method for narrow domains. In the degenerate nonlinear case, the corresponding growth lemma for narrow domains is derived from the results of F. I. Mamedov. The obtained theorem extends the classical Phragmén–Lindelöf principle to a wider class of nonlinear degenerate elliptic equations. These results may be useful in the qualitative theory of boundary value problems, especially in the study of uniqueness and asymptotic behavior of solutions in unbounded domains.

Keywords: *Degenerate elliptic equations, Dirichlet problem, Phragmén–Lindelöf principle, uniqueness theorem, unbounded domains.*

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A Fractional Continuous-Time Interpretation of Transformer Architectures

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Abstract

Transformer architectures have recently been interpreted through continuous-time integro-differential formulations to provide a mathematical understanding of attention-based deep learning models. However, classical continuous frameworks remain limited in modeling long-term memory effects and temporal nonlocality, which are fundamental characteristics of sequence learning. In this study, a fractional continuous-time extension of Transformer dynamics is proposed by incorporating the Caputo--Katugampola fractional derivative into the continuous Transformer framework. The proposed formulation models the layer evolution of Transformers as a memory-dependent fractional dynamical system and introduces nonlocal temporal interactions into the attention propagation mechanism. In contrast to recent fractional attention models, the present work considers a fractional formulation at the level of full Transformer dynamics.In addition, a fractional operator-splitting approach based on the (GL_{1-2}) discretization scheme is considered for the numerical evolution of the proposed system. The developed framework aims to establish a theoretical connection between fractional calculus and operator-theoretic Transformer modeling while providing a mathematically interpretable structure for memory-aware deep learning dynamics. Preliminary observations indicate that the proposed fractional formulation may yield smoother evolution behavior and improved stability properties compared to classical continuous Transformer models.

Keywords: *Transformer architectures, fractional calculus, Caputo--Katugampola derivative, (GL_{1-2}) discretization, operator splitting*

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Lacunary Sequence Spaces Defined via Musielak–Orlicz Functions of order (α, β)

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Abstract

In this work, we study a class of lacunary sequence spaces defined via the Euler transform in the setting of n-normed spaces, employing Musielak–Orlicz functions of order (β). These spaces are constructed using Euler and matrix transformations of order (β), and their fundamental structural and topological properties are examined. We establish key inclusion relations and analyze the impact of these transformations on convergence behavior. The results provide new insights into convergence and stability over n-normed spaces.

Keywords: *Lacunary sequences, euler summability, Orlicz function, Musielak-Orlicz function*.

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Bifurcation Structure and Stability Analysis of a Predator–Prey System with Allee Effect and Constant Harvesting under Beddington–DeAngelis Functional Response

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Abstract

In this work, we present the bifurcation structure and stability analysis of predator preproduction model with Allee effect and constant harvesting under Beddington–DeAngelis functional response. First, the existence of boundary equilibria is analytically derived, and the conditions under which they are biologically feasible are characterized. Subsequently, the existence of interior equilibria is examined though the intersection of non trivial prey and predator nullclines on the positive axis. Different intensities of constant harvesting lead to the emergence of multiple coexistence equilibria. The stability of boundary equilibria is analyzed using linearization techniques. The stability of coexistence equilibria is further verified through phase portrait analysis. Moreover, bifurcation analysis reveals that variations in key ecological parameters, such as the harvesting rate and the Allee effect, can induce qualitative changes in the system's dynamics. We examine the impact constant harvesting through codimension one bifurcation. The modified model produces multiple bifurcations including Hopf and saddle bifurcations. The bifurcation thresholds and their transversaility conditions are verified analytically and numerically.

Keywords: *Allee effect, functional response, constant harvesting, bifurcation.*

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Numerical Solutions of Some Fifth-Order KdV Equations Using the B-Spline Finite Element Method

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Abstract

In present study, it is aimed to implement approach based on finite element method to get approximate soliton solutions of two special forms of fifth-order KdV equation (fKdV) that are of particular importance: Kaup–Kupershmidt (K–K) and Ito equations. To reach these aims, septic B-spline collocation method is introduced. L_2 and L_∞error norms are computed for single soliton solutions to demonstrate the proficiency and accuracy of the present method. The method is shown to be unconditionally stable by performing the von-Neumann stability analysis. The obtained have been displayed with tables. Additionally, to show the numerical behaviors of the single soliton, all figures are drawn in 2D and 3D. Numerical results ensure that the methods are more suitable and systematically handle the solution procedures of nonlinear equations arising in mathematical physics.

Keywords: *Soliton, fKdV, Kaup–Kupershmidt equation, Ito equation, Finite element method, Collocation*

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On Concircular Vector Field and Lie Derivative in Generalized Fifth Recurrent Finsler Space

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Abstract

This paper investigates specific types of concircular motions within a generalized fifth recurrent Finsler space, focusing on Cartan's fourth curvature tensor K^{i}_{jkh} in sense of Berwald. We established a new definition for the concircular vector field σh and studied the direction of the force acting on this field using the Lie derivative. In addition, we proved that the concircular vector field σ_h and the recurrence vector λ_m are equal under certain condition. The mathematical formulas for the Lie-derivative of recurrence vector λ_m and Lie-derivative of the product of two concircular vector fields within this space have been obtained. In conclusion, we have provided applications and practical examples that illustrate some of the results.

Keywords: *Finsler geometry, concircular motion, $GBK - 5RF_n$ space, the concircular vector field σ_h, the Lie-derivative L_v.*

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On the Stability Analysis of Mixed Time-Varying Multi-Delay Neutral Differential Equations

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Abstract

In this paper, we investigate the asymptotic stability, boundedness of the solutions, and exponential stability of a class of nonlinear neutral differential equations with multiple mixed-variable delays. By employing Lyapunov's direct method in conjunction with suitable inequality techniques, new sufficient conditions ensuring the stability properties of the considered equations are established. The proposed approach enables the analysis of both discrete and distributed delays within a unified framework. Furthermore, the effectiveness and applicability of the theoretical findings are demonstrated through illustrative examples and numerical simulations. These results contribute to the qualitative theory of neutral functional differential equations and are expected to be useful in various applied fields involving delayed dynamical systems.

Keywords: *Neutral differential equations, Asymptotic and exponential stability, Lyapunov's direct method, Mixed time-varying delays*

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On the (p,q)-Pell–Leonardo Numbers: Algebraic Properties and Generating Functions

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Abstract

In this paper, we introduce a new class of numbers, called the (p,q)-Pell–Leonardo numbers, and investigate their fundamental properties. We begin by establishing the recurrence relation that defines this sequence. Based on this relation, we derive several classical identities, including Binet-type formulas, as well as Catalan's and Cassini's identities. Furthermore, we construct the associated symmetric function and obtain an explicit formula for these numbers. In addition, we determine their exponential generating function. The results presented in this work provide a coherent and comprehensive framework for the study of the (p,q)-Pell–Leonardo numbers, and highlight their connections with classical integer sequences.

Keywords: *(p,q)-Pell Leonardo numbers; (p,q)-Pell numbers; Catalan's identity; Binet's formula; Generating function; Symmetric function.*

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Geometric Interactions of Darboux Osculating Curves on Differentiable Surfaces Under various Transformations

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Abstract

Osculating curves play a significant role in analyzing the invariance of geometric features, such as curvature and position vector components, under various transformations. This paper presents a geometric characterization of Darboux osculating curves on a smooth surface in Euclidean 3-space. First, we establish a condition that ensures the invariance of these curves under surface isometries. Additionally, we examine how the position vector components of these curves deviate along both the tangent vector and the principal normal to the surface in response to a given isometry. Furthermore, we derive a sufficient condition for the conformal invariance of Darboux osculating curves on a smoothly immersed surface in Euclidean space.

Keywords: *Darboux osculating curve, isometry of surfaces, conformal map, normal curvature.*

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Monotone Degree and Some Related Topological Indices

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Abstract

The degree monotone paths in graphs was introduced by Caro, Lauri, and Zarb, inspired by the classical Erdős–Szekeres theorem on monotone sequences. In this research, we introduce a new vertex parameter called the monotone degree and denoted by $d_m(v)$, defined as the number of vertices (other than v itself) reachable from v via a degree monotone path . This local measure captures the monotone influence region of a vertex. We study the basic properties of the monotone degree and introduce several novel topological indices based on this new degree, like first, second monotone Zagreb indices, the forgotten monotone index and the total sum of monotone degrees. We compute these indices for standard families of graphs including paths, cycles, complete graphs, complete bipartite graphs, regular graphs, wheel graphs, gear graphs, helm graphs, geenrlized Jahangir graph and star dendrimer graphs. Additionally, we study the behavior of these new indices under fundamental graph operations, specifically the subdivision and central graphs.

Keywords: *Monotonedegre,First monotone index, Second monoton index, Forgotten monoton index.*

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Credit Risk Assessment Using Artificial Neural Networks: Empirical Evidence from Türkiye

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Abstract

Credit risk assessment is a fundamental task in the banking and financial sector, directly influencing credit approval decisions, interest rates, and regulatory compliance. However, accurately predicting whether an individual or small and medium-sized enterprise will repay a loan remains a challenging problem. Existing approaches are typically either rule-based systems, which are interpretable but limited in learning capability, or black-box models such as deep neural networks, which offer high predictive performance but lack transparency.This study proposes a Logical Neural Network (LNN)-based approach that integrates symbolic reasoning with data-driven learning to address these limitations. The model formalizes decision-making by employing Sigmoid and ReLU activation functions to constrain neurons within a fuzzy logic framework. In the proposed model, financial data are transformed into symbolic representations, and logical rules are constructed using fuzzy logic operators. The framework handles uncertainty by representing truth values as intervals $[L, U] \subseteq [0, 1]$, and the parameters are optimized through a gradient-based Delta learning rule to ensure both logical consistency and predictive accuracy. Experimental results indicate that the proposed LNN model achieves an accuracy of approximately 80%, outperforming traditional methods such as logistic regression (75%) and standard neural networks (78%). In addition to improved predictive performance, the model provides interpretable outputs by explaining decisions through learned logical rules. These findings demonstrate that LNNs offer a promising framework for combining explainability, robustness, and predictive power in financial risk assessment.

Keywords: *Logical Neural Networks; Credit Risk Assessment; Fuzzy Logic Operators; Explainable AI; Activation Functions*

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Analysis of the Cusp Number of the Special Subgroup of the Modular Group

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Abstract

This study presents an analysis of the cusp number of a special subgroup of the modular group Γ . The focus is on understanding how the arithmetic structure of this subgroup determines its number of cusps. By combining group-theoretic and geometric techniques, the cusp number is computed explicitly, revealing its relation to the subgroup's signature. The results provide insight into the geometric and arithmetic properties of modular subgroups, highlighting the interplay between matrix constraints and the structure of the associated modular surface. This work lays a foundation for further studies on invariants of special subgroups beyond classical congruence cases.

Keywords: *Modular group, congruence subgroups, Fuchsian groups, cusp number*

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On Hybrid Fuzzy Nımbers and Interval Representation

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Abstract

In this study, a novel framework for hybrid fuzzy sets based on the algebra of hybrid numbers is presented. In the proposed approach, hybrid fuzzy numbers are defined as a quadruple of componentwise fuzzy real-valued membership functions corresponding to the scalar, complex, dual, and hybrid components, and their α-cut structure is subsequently analyzed. On these defined structures, addition and multiplication operations are formulated based on hybrid algebra and interval arithmetic. The obtained results show that the proposed model preserves closure under these operations and reveal the effect of component dependencies on interval expansion. Consequently, this study provides a consistent extension of classical fuzzy set theory to hybrid algebraic structures and establishes a bridge between fuzzy and interval-based representations of uncertainty.

Keywords: *hybrid number, fuzzy number, interval number, fuzzy set.*

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Similarity-Guided Physics-Informed Neural Networks for Power-law Rotating-Disk Flows

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Abstract

In this study, a similarity-guided physics-informed neural network (PINN) formulation has been developed for rotating disk power-law flows at the level of the non-Newtonian PDE system. The proposed PINN structure incorporates the nondimensionalized Navier-Stokes equations and associated boundary conditions directly into the learning process, allowing the neural network to satisfy the underlying physical structure of the power-law flows. Accordingly, the obtained results show that, across different Reynolds number regimes, the predicted base-flow profiles agree with classical reference solutions at the relative L_2 error level of $O(10^{-3})$. Overall, these findings indicate that the proposed methodology introduces an AI-based approach for constructing base-flow profiles in rotating-disk power-law fluids.

Keywords: *Rotating-disk flow; Non-Newtonian fluids; Physics-informed neural networks; Similarity solutions*

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A Unified Approach to Pinelis and Stolarsky Type Inequalities via Time Scale Calculus

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Abstract

In this paper, we establish new generalizations of Pinelis and Stolarsky type integral inequalities by employing the theory of calculus on time scales. By introducing a generalized weighted integral functional, we provide unified proofs that encompass continuous, discrete, and quantum analysis. We demonstrate that the monotonicity of a specific ratio involving the integrand and the delta derivative of the kernel determines the direction of the inequalities. Finally, numerical illustrations and analytical evaluations are provided to compare the behavior of these inequalities across different mathematical structures.

Keywords: *Time scales; Pinelis-type inequalities; Stolarsky-type inequalities; Delta integral; Quantum calculus.*

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Almost A-Statistical Convergence and Approximation in H_ω Space

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Abstract

Korovkin's theorem is a fundamental result in approximation theory, as it allows the uniform approximation of continuous functions to be studied via sequences of positive linear operators. Therefore, Korovkin-type theorems have been extensively studied by mathematicians under various types of convergence and in different spaces. Among these approaches, statistical convergence has been widely studied as a generalization of classical convergence. However, more recently, the concept of almost A-statistical convergence, which provides a more flexible perspective, has also found its place in the literature. In this study, we establish a Korovkin-type approximation theorem via the almost A-statistical convergence on H_ω, a space of functions defined on the positive semi-axis and characterized by a function of the type of modulus of continuity. Furthermore, we apply our theoretical findings to a specifically constructed sequence of positive linear operators. Finally, the corresponding rate of almost A-statistical convergence is derived using the modulus of continuity.

Keywords: *Almost regular matrix, almost A-statistical convergence, Korovkin theorem, rate of convergence*

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On Generalized Forchheimer Flows in Heterogeneous Porous Media With Non-Degree Condition

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Abstract

This study investigates generalized Forchheimer flows of slightly compressible fluids in heterogeneous porous media under a non-degree condition. The equation is considered in a bounded domain with Dirichlet boundary, where both the porosity and the coefficients of the Forchheimer polynomial may depend on the spatial variable. This spatial dependence makes the model more realistic by representing heterogeneous media, but it also creates analytical difficulties. In particular, the associated nonlinear flow term may exhibit degenerate or singular behavior with respect to the pressure gradient and the spatial variable. A main difficulty comes from the non-degree condition. In the standard degree-condition case, one can usually work with L^2-norm estimates by using suitable Poincaré–Sobolev inequalities. However, in the non-degree case considered here, this approach is no longer directly applicable. Therefore, the analysis is carried out in weighted L^{α}-estimates with $\alpha > 2$, which are more suitable for the stronger nonlinear structure of the problem.

By introducing a homogeneous boundary transformation, we derive energy estimates for the transformed pressure variable, its gradient, and its time derivative. The analysis is based on structural properties of the nonlinear flow term, weighted Young inequalities, and Gronwall inequalities. These estimates provide control of the solution in weighted norms. Finally, the results are used to discuss the continuous dependence of the pressure on the initial and boundary data. The study gives a mathematical framework for generalized Forchheimer flows in heterogeneous porous media beyond the standard degree-condition assumption.

Keywords: *Forchheimer, heterogeneous porous media, non-degree condition, nonlinear parabolic equations, continuous dependence.*

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Optimal Hotel Chain Network Design for Revenue Maximization: Using Fuzzy Hypersoft Topological Structures and PROMETHEE

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Abstract

In this study, a novel approach for converting topological numbers in fuzzy hypersoft environments is introduced, and several topological numbers are computed for fuzzy hypersoft graphical networks. Various Multi-Criteria Decision Aid (MCDA) techniques have been proposed in recent decades to assist in selecting the best compromise options. One of the most prominent techniques is the PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) family of outranking methods, which has gained significant attention from researchers. The technique presented in this article is compared with the fuzzy PROMETHEE method to demonstrate its accuracy and precision. The PROMETHEE technique has been applied in multiple fields, including business, finance, hydrology, and water management. Specifically, in business, it is used to assess potential investments based on various factors, such as risk, return on investment, and strategic fit. In this article, we apply the PROMETHEE method to maximize revenue in the hotel industry. The PROMETHEE I and II methods, two of the most widely used variations, are discussed. PROMETHEE I provides partial rankings based on preference flows, while PROMETHEE II provides a complete ranking using aggregated preference flows. By integrating the PROMETHEE approach with topological numbers, this study facilitates the selection of an optimal hotel chain network for revenue maximization.

Keywords: *Fuzzy hypersoft graph; fuzzy hypersoft first redefined Zagreb number; fuzzy hypersoft harmonic number; fuzzy hypersoft sum connectivity number; PROMETHEE technique*

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Fixed Point Results for Relational Suzuki Generalized L_R -Contractions in Dislocated Metric Spaces

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Abstract

In this paper, we present the concept of relational Suzuki generalized L_R-contractions and use it to establish several fixed point results in R-complete dislocated metric spaces under a binary relation framework. Our newly results refine and strengthen several previously established results in the literature. An illustrative example is provided to verify the validity of our main findings. In addition, we demonstrate the usefulness of our results by applying them to obtain a solution for a fractional thermostat model.

Keywords: *Mixed Monotone Property; rational type contraction; Binary relation; fractional differential quation.*

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Fixed Point Theorems for Generalized S-contraction and Kannan Type Contraction in Weighted Ψ-b Metric Spaces

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Abstract

In this paper, we define contraction mapping with their generalization name as s-contraction mapping and kannan type contraction. Also, introduced the b-metric space and their generalization name as weighted ψ-b metric space and supported some examples for weighted ψ-b metric space with their appliction in fixed point theory. Furthermore, I intrdocued the new contraction mappings like modified s-contraction mapping and modified kannan type contraction mapping with multiplicative coefficients α, β, γ. Further, we have proved some fixed point theorems for above modified contractions with weighted ψ- b metric spaces. Also, I supported some numerical applications related to modified s-contraction and modified Kannan type contraction with weighted ψ-b metric space.

Keywords: *S-Contraction, Kannan type contraction, Weighted ψ–b metric spaces, Fixed points, Multiplicative coefficients.*

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Applications of the Lie Derivative on Some Special 4-Dimensional Lorentzian Manifolds

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Abstract

The present study undertakes some applications of the Lie derivative on special classes of Ricci solitons which have been widely discussed recently in the framework of differential geometry. In line with this purpose, η-Ricci and Ricci Bourguignon solitons, which are very closely related to the Lie derivative, are investigated on 4-dimensional manifolds with Lorentz metric signature, referred to as space-times. Accordingly, various symmetries related to the Lie derivative of the metric tensor, such as affine, homothetic, and Killing symmetries, are examined on these structures. Several analyses are conducted and some results are obtained when the relevant Ricci solitons contain not only vector fields associated with symmetries, but also other special vector fields such as parallel and recurrent. A number of the findings are correlated with the Jordan-Segre classification of the Ricci tensor, and the holonomy theory of space-times. Finally, a couple of examples supporting the outcomes of the study are constructed.

Keywords: *Lie derivative, Ricci soliton, Lorentz metric, symmetry*

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Adaptive Control Design for Fixed-Time Systems with Input Saturation and Dead-Zone Effects

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Abstract

This work develops an adaptive fixed-time control scheme for strict-feedback nonlinear systems subject to input saturation and symmetric output dead-zone nonlinearities. To handle these nonsmooth effects and avoid the complexity explosion of conventional backstepping, an approximation-based adaptive dynamic surface control (DSC) approach is proposed. Unknown nonlinearities are approximated using radial basis function neural networks (RBFNNs), while a variable separation technique simplifies the controller design for high-order systems. By reformulating the nonsmooth dynamics into an affine form via the mean value theorem and employing fixed-time stability theory, fixed-time convergence of the tracking error and boundedness of all closed-loop signals are guaranteed. Simulation and experimental results validate the effectiveness of the proposed method.

Keywords: *Nonlinear systems; dead-zone nonlinearity; actuator saturation; unmodeled dynamics; fixed-time stability*

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Quadratic Spline Collocation Method for Time-Fractional Singularly Perturbed Problems

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Abstract

In this paper, we propose a quadratic spline collocation method for the numerical solution of time-fractional singularly perturbed problems, which are characterized by weak initial singularities and boundary layers induced by a small perturbation parameter. The time-fractional derivative is discretized by a suitable high-order scheme that accurately captures the inherent memory effect, while quadratic spline basis functions are employed for spatial approximation within a collocation framework.To effectively resolve the initial and boundary layer behavior, we incorporate layer-adapted meshes, including graded meshes in time and Shishkin-type meshes in space. These meshes are specifically designed to handle the low regularity of the solution near the initial time and the sharp boundary layers caused by the perturbation parameter. The resulting fully discrete scheme is shown to be stable, and rigorous error estimates are derived. In particular, we establish convergence results that are uniform with respect to the perturbation parameter under appropriate assumptions Numerical experiments are carried out to confirm the theoretical findings and to illustrate the robustness and accuracy of the proposed method. The results demonstrate that the scheme performs reliably even for very small values of the perturbation parameter and captures both the fractional dynamics and layer structures effectively.

Keywords: *Time-fractional differential equations; singularly perturbed problems; quadratic spline collocation; graded mesh; Shishkin mesh; boundary layers.*

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Some Fibonacci-Type Difference Operator and Lacunary Sequence Spaces over Modulus Function

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Abstract

In this paper, we introduce new difference sequence spaces generated by Fibonacci-type difference operators and modulus functions. In particular, we define the space ℓ(G(u,v), f, p) by using the generalized Fibonacci band matrix G(u,v) and a bounded sequence p of positive real numbers and examine its basic algebraic and topological properties, including completeness and duals. Further, by employing generalized difference operators, lacunary sequences and sequences of modulus functions, we construct several new lacunary difference sequence spaces and study their linearity, completeness, inclusion relations and associated dual spaces. These results extend existing frameworks in summability theory and functional analysis.

Keywords: *Difference operator, lacunary sequence, modulus function, α-,β- and γ- duals.*

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A Hybrid Cryptosystem Based on GF(8) Reinforced with Musical Steganography

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Abstract

This study presents a new model to reduce the risks arising from the predictable nature of traditional deterministic encryption methods and the algebraic weaknesses encountered in finite fields. The research proposes an interdisciplinary hybrid cryptosystem that combines Galois Field mathematics (GF(8)), digital signal processing, and steganography (data hiding) techniques. The data loss problem caused by the absorbing property of the zero (0) element in standard multiplicative encryption algorithms is solved in this project through an Affine Cipher architecture operating over the irreducible polynomial $P(x) = x^3 - x + 1$. Instead of using standard generators, the encryption keys $(K_1 \text{ and } K_2)$ of the system are dynamically generated using non-linear Fibonacci indexing from an entropy pool created by analyzing a physical audio file via Fast Fourier Transform (FFT). In the developed model, the 3-bit encrypted polynomial blocks obtained after the Affine transformation are mapped to 8 fundamental notes in Western music and converted into a listenable, aesthetic acoustic signal using 8-FSK (8-ary Frequency Shift Keying) modulation. Experimental results and inverse Affine matrix analyses show that the system effectively resolves the zero-element issue via XOR masking and provides a lossless decryption process without compromising data integrity. In conclusion, combining highly random dynamic keys with musical data hiding offers an innovative approach that simultaneously increases both mathematical and perceptual security against cyber attacks.

Keywords: *Galois Fields ($GF(2^3)$), Affine Cipher, Acoustic Entropy, Musical Steganography, Irreducible Polynomials.*

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Conformable Fractional Generalizations of Weighted Corrected Euler-Maclaurin-Type Inequalities Across Diverse Function Classes

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Abstract

In this paper, we construct novel weighted corrected Euler-Maclaurin-type inequalities for various classes of functions via conformable fractional calculus. Our methodology relies on a pivotal integral identity involving a positive weight function, recently given by Demir et al. [2]. By integrating this identity with fractional operators, we successfully deduce precise estimations for functions that are bounded, Lipschitz continuous, and of bounded variation.

Keywords: *Corrected Euler-Maclaurin-type inequalities, conformable fractional integrals, bounded functions, Lipschitzian functions, functions of bounded variation*

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On a Class of p(x)-Kirchhoff Type Equations with Logarithmic Nonlinearity

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Abstract

In this article, we study a class of Kirchhoff-type equations involving logarithmic nonlinearity with variable exponents subject to Dirichlet boundary conditions. Due to the nonlinear and nonlocal nature of the diffusion term, classical methods based on variational principles or monotonicity techniques are not applicable for the problem under consideration. We first present some toplogical features and compact embedding results for certain type nonlinear spaces, then by leveraging a general solvability result in these nonlinar spaces and the structural properties of them, we prove the existence of weak solutions of the problem under consideration.

Keywords: logarithmic nonlinearity, non-local equations, porous medium equation, non standart growth.

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Investigating of Wave Propagation via Triple Elzaki Transform Analysis of 3D Fractional Lossy Telegraph Models

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Abstract

The telegraph equation is used to describe the variation of electromagnetic waves over distance and time, to analyze signal losses, and to model wave propagation in heterogeneous media. Specifically, wave propagation modeling in lossy media such as wet soil and biological tissues is performed using the fractional form of the telegraph equation. The analytical solution of the three-dimensional fractional wave equation for modeling electromagnetic wave propagation in lossy media was investigated using the Atangana-Baleanu-Caputo (ABC) fractional derivative operator. The Triple Elzaki Transform (TET) method, which simultaneously maps spatial and temporal variables into spectral space, was employed. The obtained solutions were simulated for different fractional orders to investigate the effect of media with different dielectric properties on wave propagation. The results demonstrate that the proposed method is effective and convergent in solving high-dimensional fractional partial differential equations.

Keywords: *Triple Elzaki Transform, 3D Fractional Telegraph Equation, Atangana-Baleanu Operator, Dielectric Loss*

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Spectral and Basic Properties of the M −quasi −*− Paranormal Operators

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Abstract

In this work let T be a bounded linear operator on a complex Hilbert space H. An operator T is said to be a M −quasi −*−paranormal operator if there exist a positive real number M such that $\|T^*Tx\|^2 \leq M\|T^3x\| \bullet \|Tx\|$, for all $x \in H$. In this work, we establish the fundamental properties of this class of operators, including their structural characteristics and spectral behavior. Several characterizations are established and illustrative examples are provided to clarify the theory.

Keywords: *M −quasi −*−paranormal operator, M^* −paranormal operator, quasi−*−paranormal operators, approximate point spectrum of operator*

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Sequence Spaces Defined by Using Euler-Riesz Difference Operator

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Abstract

In this paper, we introduce and study new sequence spaces defined using the Euler-Riesz difference operator over a modulus function. We investigate the topological properties of these spaces providing a comprehensive analysis of their structure and behavior. Specifically, we examine the duals of these spaces exploring their relationships and inclusion properties. Furthermore, we establish matrix transformations related to these sequence spaces presenting conditions under which such transformations hold.

Keywords: *Euler transformation, sequence spaces, modulus function, matrix mapping*

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Picard Method to Solve of Second Order Ordinary Differential Equations With Singular Coefficients

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Abstract

In this paper, we present the application of the Picard Iteration Method (PIM) for solving nonlinear second-order ordinary differential equations with singular coefficients. Several illustrative examples are provided to demonstrate the efficiency and accuracy of the proposed method. The numerical approximations obtained by the method are compared with the corresponding exact solutions, and the results are presented in tables and graphical forms for Examples 1–5. The comparisons show the convergence, reliability, and applicability of the Picard Iteration Method in handling nonlinear second-order differential equations with singular coefficients.

Keywords: *Picard Iteration Method; Picard–Lindelöf method; second-order ordinary differential equations; nonlinear differential equations; singular coefficients.*

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Stability Analysis and Oscillatory Behavior of a Three-Dimensional Discrete Dynamical System with Time Delay

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Abstract

This paper examines the qualitative dynamics of a delayed three-dimensional discrete system. The study emphasizes fundamental properties, including local asymptotic stability, boundedness, persistence, and the oscillatory behavior of positive solutions. By introducing a delay parameter alongside a nonlinear exponent, the proposed model extends earlier multidimensional frameworks and underscores the combined effects of delay and nonlinearity on system behavior. The analytical findings provide explicit conditions that characterize regions of stability and instability, as well as criteria for the onset of oscillatory and persistent dynamics. Numerical simulations are conducted to confirm the theoretical results and to demonstrate the diverse range of dynamical behaviors arising under various parameter settings. Overall, the study offers deeper insight into the complexity of delayed nonlinear discrete systems and contributes to the advancement of multidimensional difference models in applied mathematics.

Keywords: *Asymptotic stability; system of difference equations; boundedness; oscillation.*

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Topology and Topography Optimization of Plate Structure Using ANSYS Software

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Abstract

In this paper a two-stage optimization process that incorporates topology and topography techniques within the ANSYS software are presented. The first stage focuses on topology optimization to reduce mass under deflection constraint . The second stage improves stiffness by applying topography optimization to minimize compliance while ensuring the mass does not exceed than the obtained value in the initial phase. The case study presented in this work involves a steel plate subjected to self-weight and a concentrated point load. The results show a 54% reduction in mass after topology optimization. Subsequent topography optimization has been used to further improve performance, with a 91% reduction in compliance and an 88% decrease in deflection relative to the original configuration being achieved. In summary, the findings of this study demonstrate the potential to achieve lightweight structures with enhanced mechanical performance.

Keywords: *Topography optimization, Topology optimization; ANSYS software, Plate structure*

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Soliton Solutions of a Non-Linear Partial Differential Equation

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Abstract

In this work, we aim to determine the possible soliton solutions and examine of a non-linear partial differential equation by using a Kudryashov method. We started by finding the non-linear ordinary differential form of the equation with the aid of a suitable wave transformation. Then, the Kudryashov method approach has been demonstrated and implemented to the obtained non-linear ordinary differential form. As a result, a polynomial expression has been obtained and converted to a linear algebraic equation system. Soliton solutions of the investigated equation are constructed by solving the system and choosing the suitable solution sets. Finally, graphical forms and gained results are given.

Keywords: *Soliton, Partial differential equation, Kudryashov method*

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On the Weak Solvability of a Non-Uniformly Parabolic Equation with L_2 Data

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Abstract

The assertion on the existence of weak solutions for a class of parabolic equations with a non-uniform degeneracy in the elliptic principal part is established via the Lions-Lax-Milgram principle. A non-uniformly weighted Sobolev inequality plays a crucial role in the derivation of this result, providing the necessary functional framework to handle the degenerating coefficients. The existence of a weak solution is demonstrated for the cases where the right-hand side of the equation belongs to a Lebesgue space. This work contributes to the theory of degenerate parabolic equations by extending the solvability conditions under non-uniform structural assumptions. The results provide a rigorous basis for further qualitative analysis of solutions in weighted spaces.

$$u_t = div_x\left(w(x)\nabla_x u\right) + \Delta_y u + f(x,t),\ x\in D,\ t > 0,$$

$$u|_{t=0} = \varphi(x),$$

$$u|_{S_T} = 0,$$

where $S_T = \partial D\times(0,T)$ with $D\subset R^N$.

Keywords: *Non-uniform degeneracy, Parabolic equations, Weak solutions, Lions-Lax-Milgram principle, Weighted Sobolev inequality.*

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On Generalized P-derivations Related to Ideals in Factor Rings

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Abstract

The main goal of this article is to delve deeper into the discussion of the commutativity of a factor ring R/P by analyzing certain differential identities that involve generalized P-derivations and P-multipliers connecting I to P. Here, I represents a non-zero ideal of an arbitrary ring R, and P is a prime ideal of R such that $P \subsetneq I$. Furthermore, we will explore some outcomes from our various theorems. To underscore the necessity of the primeness assumption in our theorems, we will provide some illustrative counterexamples.

Keywords: *Prime ideal; generalized P-derivation; P-multiplier; integral domain; factor ring.*

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Matrix Toda Flow and Orthogonal Matrix Polynomials

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Abstract

In this talk, we consider the matrix Toda flow in connection with orthogonal matrix polynomials (OMP). We show that the Toda equations describe the time evolution of the coefficients in the three-term recurrence relation associated with a family of OMP. This provides a natural interpretation of the matrix Toda flow in terms of a time-dependent block Jacobi matrix generated by a sequence of matrix moments. In this framework, we establish a direct link between the Toda dynamics and a Stieltjes-type matrix moment problem. In particular, we discuss how the flow preserves positivity and the solvability of the moment problem, and we highlight the role of spectral data in the evolution.

Keywords: *Matrix Toda equation, orthogonal matrix polynomials, Jacobi matrix, Stieltjes matrix moment problem.*

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Weighted Type Operators from Spaces of Cauchy Transforms

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Abstract

This paper investigates the boundedness and compactness of weighted type operators acting from the space of Cauchy transforms, denoted as K. The space K comprises analytic functions f on the open unit disk $\mathbb{D}$ that can be represented by a Cauchy-Stieltjes integral, specifically $f(z) = \int_{\partial D} \frac{d\mu(\zeta)}{1-\zeta z}$ for some complex measure μ on the unit circle $\partial\mathbb{D}$. The space K is endowed with a Banach space structure under the norm $\|f\|_K = \inf\{\|\mu\| : f(z) = \int_{\partial D} \frac{d\mu(\zeta)}{1-\zeta z}\}$, where $\|\mu\|$ denotes the total variation of μ. Notably, the space K has strong connections to classical Hardy spaces, satisfying the continuous embeddings $H^1 \subset K \subset \cap_{0<p<1} H^p$. Our primary goal is to compute the operator norm and characterize the boundedness and compactness of these weighted type operators. Furthermore, we characterize the multipliers from the space K to several other analytic function spaces.

Keywords: *Weighted type Operators, analytic functions, Banach space, Hardy spaces.*

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Subword Patterns in Integer Compositions

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Abstract

A composition $\pi = \pi_1\pi_2 \cdots \pi_m$ of a positive integer n is an ordered collection of one or more positive integers whose sum is n. The number of summands m, is called the number of parts of π. We determine formulas for generating functions that count compositions of n with m parts, according to the number occurrences of the subword pattern τ, and according to the sum, over all occurrences of τ, of the first and the last integers in their respective occurrences, where $\tau \in \{11, 12, 21\}$.

Keywords: *Compositions, Generating functions, Statistics*

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Local and Global Existence of Solutions for a Class of Semilinear Wave Equations with Dissipative Term and Non-Uniform Elliptic Part

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Abstract

In this work investigates the local and global existence of solutions for a class of semilinear wave equations characterized by a dissipative term and a non-uniform elliptic part. The Galerkin method was employed to construct approximate solutions, followed by the derivation of a priori estimates. By utilizing Hölder's and Young's inequalities, the boundedness of the solutions within specific function spaces was established. The Banach-Alaoglu theorem was applied to demonstrate the existence of a weak-star solution. Finally, a limit transition was performed using the weak convergence of sequences in conjunction with the Aubin-Lions compactness theorem, thereby proving the existence of a solution for the posed problem

Keywords: *The semilinear wave equations with dissipative term and non-uniform elliptic part, Galerkin's method, Holder's and Young inequality, Banach–Alaoglu theorem, Aubin–Lions theorems.*

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Generalizations of Kaplansky Theorem Related to Linear Operators

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Abstract

In the purpose of this paper is to generalize a very famous result on products of normal operators, due to I. Kaplansky. The context of generalization is that of bounded hyponormal and unbounded normal operators on complex separable Hilbert spaces. Some examples "spice up" the paper.

Keywords: *Products of operators. Bounded and unbounded: Normal, hyponormal, subnormal operators. Kaplansky theorem. Fuglede-Putnam theorem.*

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Local Linear Regression for Functional Ergodic Data with Missing at Random Response

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Abstract

In this work, we present a new kernel estimation approach for functional regression models in the presence of missing responses, the analysis is carried out in the setting of stationary and ergodic functional data. The primary objective of this research is to establish the asymptotic normality of the proposed estimator and to derive explicit convergence rates. An extensive simulation study is conducted to assess the finite-sample performance of the procedure.

Keywords: *functional data analysis, kernel method; local linear estimation method, uniform almost complete convergence, normality asymptotic, missing responses at random*

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Spectral Analysis of Transmission Resonances for Integer Spin Fields in a Localized Potential Well

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Abstract

This study investigates the spectral properties and scattering behavior of differential operators associated with integer spin fields under a localized Woods-Saxon perturbation. We demonstrate that the transmission coefficient undergoes a total extinction within a specific bounded interval of the potential magnitude, followed by the emergence of transmission resonances once the potential strength exceeds a critical threshold. Furthermore, by treating the energy as a spectral variable, we characterize the formation of significant resonance structures within the continuous spectrum, identifying these singularities across both the upper and lower branches of the operator's spectrum.

Keywords: *Potential well- Transmission resonances- Integer spin fields- Spectral analysis- Critical Threshold.*

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Existence Analysis for a Class of Integro-Differential Problems

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Abstract

This paper is devoted to the study of the existence of solutions for certain integro-differential problems. We employ a singular perturbation method as a natural analytical tool to establish existence. The perturbed problems considered are classical, nonlinear, nonlocal, and hyperbolic. By carefully analyzing the limits of subsequences of their solutions in weighted Sobolev-type spaces, we demonstrate that these limits provide solutions to the original problem. Furthermore, the existence of a solution for the nonlocal hyperbolic problem is ensured through the application of the Schauder fixed point theorem**.** This approach highlights the effectiveness of singular perturbations combined with functional analytic techniques in handling nonlocal and nonlinear effects within hyperbolic systems.

Keywords: *Integro-differential problems, Anisotropic singular perturbations, Nonlinear hyperbolic problems, Schauder fixed point theorem, Asymptotic behaviour.*

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An Accelerated Solution for Some Delay Differential Equations of First Order

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Abstract

In this paper, we present an efficient solution technique for a class of first-order delay differential equations. The proposed approach is based on the EL-Kalla polynomial method, which provides a simple and effective framework for constructing analytical or approximate solutions to nonlinear problems. The method is applied to several nonlinear delay differential equations to demonstrate its accuracy, applicability, and computational efficiency. The obtained results show that the EL-Kalla polynomial method is a useful tool for treating first-order nonlinear delay differential equations.

Keywords: *EL-Kalla polynomial; first-order delay differential equations; nonlinear delay differential equations; analytical approximation.*

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On the Weak Solvability of Non-Uniform Parabolic Equations

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Abstract

In this work, results concerning the existence of weak solutions for linear and nonlinear non-uniformly degenerate parabolic equations are established. Specifically, for cases where the initial data and the right-hand side functions belong to the L^2 class, a necessary condition is determined for the weight function causing the non-uniform parabolicity to ensure the existence of a weak solution. Furthermore, uniform a priori estimates for the family of solutions and their derivatives are proved; these results are subsequently applied to Galerkin approximations.

Keywords: *Nonlinear parabolic equations, weak solvability, weight functions, existence and uniqueness.*

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Probabilistic Assessment of Undrained Bearing Capacity of Skirted Foundations Considering Soil Spatial Variability

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Abstract

In recent years, improving foundation performance has increasingly relied on advanced computational and mathematical approaches to enhance vertical bearing capacity and reduce the risks of sliding and overturning. Among these solutions, skirted foundations have emerged as an efficient and economical option, particularly in offshore applications, due to their ability to confine the underlying soil and significantly increase load-carrying capacity. However, conventional evaluations of ultimate capacity often neglect the spatial variability of seabed soils, which can strongly influence foundation behavior. This study applies probabilistic methods in geotechnical engineering to address this limitation by investigating the deterministic and probabilistic undrained bearing capacity of skirted foundations with varying skirt embedment ratios. The analysis combines lower and upper bound finite element limit methods with Random Finite Element Limit Analysis (RFELA), incorporating both stationary and non-stationary random fields to represent soil heterogeneity. The results demonstrate that skirt embedment can increase bearing capacity by up to six times, depending on the heterogeneity index, while considering soil variability reduces capacity by approximately 8–12%. Moreover, significant changes in failure mechanisms are observed, highlighting how probabilistic modeling captures the effects of uncertainty and enhances the reliability of geotechnical design.

Keywords: *Skirted foundations, Bearing capacity, Probabilistic analysis, Random finite element limit analysis (RFELA), Soil spatial variability.*

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Differentiability of G-neutral Stochastic Differential Equations with Respect to Parameter

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Abstract

We study the differentiability of solutions of neutral stochastic differential equations driven by G-Brownian motion with respect to parameter. Under suitable assumptions, we show that solutions are differentiable with respect to the parameter which appears in the initial data. In addition, the stochastic differential equation of the derivative is given and the existence-uniqueness of solution is proved. Moreover, an example to illustrate the theoretically obtained results is presented.

Keywords: *Differentiability, Parameter, G-Brownian motion, neutral stochastic differential equations.*

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Fixed Point Theorems in Generalized b-Metric Type Spaces with Relaxed α, β-Conditions

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Abstract

In this paper, we investigate the existence and uniqueness of fixed points in the setting of generalized b-metric type spaces endowed with a relaxed α,β-condition. By weakening the classical triangle inequality, we obtain new fixed point theorems that extend and generalize the classical results of Reich and Chatterjea. The proposed approach unifies and sharpens several known fixed point results in b-metric type spaces and significantly enlarges their scope to a broader class of nonlinear mappings. An illustrative example is presented to highlight the applicability and effectiveness of the established results.

Keywords: *Fixed point ; Generalized b-metric type spaces; Relaxed α,β-conditions; Nonlinear analysis.*

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Approximation Associated with Kantorovich Version of Bezier (λ, q)–Bernstein–Schurer Operators

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Abstract

In the present paper, the Kantorovich modification of the Schurer type of (λ, q)-Bernstein operators, which are associated by the shape parameter $-1 \leq \lambda \leq 1$ and the Bezier basis function, is presented. Using Korovkin's theorem, we establish several local and global approximation properties. Lastly, we calculate the convergence properties for the functions that belong to Peetre's K-functional and Lipschitz maximum by using the classical modulus of continuity and second-order modulus of continuity. In the last section, graphical and numerical analysis are studied.

Keywords: *Bezier basis; q-integers; (λ, q)-Bernstein-polynomial; Lipschitz maximal functions*

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Essential Norm of Sandwich Weighted Composition Operators on Bloch-Type Spaces

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Abstract

The sandwich weighted composition operator, $SW_{\varphi,\psi}$, is constructed by applying a weighted composition operator between two differentiation operators. While the classical composition operator C_φ and the weighted composition operator $W_{\varphi,\psi}$ are extensively studied for their boundedness and compactness on various analytic function spaces, the differentiation operator D typically exhibits unbounded behavior in these settings. Inspired by prior work on products of these operators, particularly the pioneering studies by Hibschweiler and Portony on Bergman and Hardy spaces, we investigate the boundedness and compactness of $SW_{\varphi,\psi}$ between Bloch-type spaces. Our primary objective is to provide estimates for both the operator norm and, crucially, the essential norm of $SW_{\varphi,\psi}$ in these settings. The essential norm, defined as $\|T\|_{e,X\to Y} = \inf\{\|T - K\| : K \text{ is a compact operator from X to Y}\}$, serves as a critical tool for quantifying an operator's distance from the set of all compact operators. Its estimation for $SW_{\varphi,\psi}$ will offer significant insights into the operator's behavior and the properties of the inducing symbols φ and ψ.

Keywords: *Composition Operators, Differentiation Operators, Bloch-type spaces, Hardy spaces.*

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Graphs for the Construction of Cryptographically Secure S-boxes

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Abstract

Facial identification systems are crucial in biometric security, making their protection against adversarial attacks essential. Ensuring the robustness of encryption methods in these systems is vital to prevent identity fraud and unauthorized access. This research examines the intersection of cryptography, substitution boxes (S-box) and graph theory, which focus on creating very secure cryptographic systems. In particular, we check the use of random graphs with 16 vertices in the construction of S-box, which are important components of many cryptographic algorithms, including block cipher. This research paper delves into the relationship between the graph properties, such as degrees, closeness, eigenvector and their impact on the design of strong S-box. By using a random graph structure, we analyze how these graphs can be utilized to increase nonlinearity and analyze the properties of S-boxes, which are necessary to oppose cryptanalysis attacks. The study highlights the ability to use graph-theoretic concepts to generate S-box with better cryptographic protection contributes to a broad understanding of rareness and graphic properties that can be effectively used in cryptography. The results show the importance of integrating graph theory into cryptographic design, which provides a new approach to improve the flexibility and performance of the cryptographic system.

Keywords: *Cryptography, Substitution box (S-box) design, Edge probability, Eigenvector, Random graphs*

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Performance Evaluationof Particle Swarm Optimization with Trap Avoidance Operator (TAO-PSO) for Constrained Structural Vibration Control Problems

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Abstract

This paper investigates the efficiency of the Trap Avoidance Operator Particle Swarm Optimizer (TAO-PSO) for solving constrained structural vibration control problems. TAO-PSOis an enhanced metaheuristic algorithm designed to overcome premature convergence in complex, constrained optimization problems. While standard Particle Swarm Optimization (PSO) frequently stagnates at local optima, TAO-PSO employs a dynamic trap avoidance mechanism that continuously monitors the global best fitness. If the fitness improvement falls below a predefined tolerance, a selected percentage of particles undergo dynamic perturbation. This perturbation strength decreases linearly over successive iterations, enabling robust early-stage exploration and precise local exploitation.In this study the TAO-PSO is applied to a highly constrained mathematical model. The latter is aimed atfinding an optimal design of a passive control system that is integrated to control the vibration of a multi-degree-of-freedom structural system. The objective function minimizes the norm of the system's transfer function in the frequency domain, effectively minimizing the worst-case steady-state response to dynamic inputs. The search space is bounded by strict mathematical constraints, including total mass ratio, tuning frequencies, damping limits, and mass distribution inequalities. Convergence analyses demonstrate that while the standard PSO algorithm quickly stagnates at suboptimal solutions, the TAO-PSO's dynamic perturbation successfully resets the swarm to avoid local entrapment. Ultimately, TAO-PSO achieves a substantially lower optimized cost, exhibiting enhanced global search capability, stability, and precision for solving complex mathematical and constrained structural vibration optimization problems.

Keywords: *Trap Avoidance Operator, Particle Swarm Optimization, Structural vibration control, Constrained mathematical model*

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Effectiveness of the Fuzzy Multi-Choice Goal Programming Model (TABRIZI et al 2012) in Selecting Loan's Applicants at the Commercial Bank

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Abstract

This research aims at implementing the Tabrizi & al model which is called Fuzzy Multi Choice Goal programming (FMCGP) to rationalize the granting of loans at commercial banks. It is based upon a study case conducted at BDL bank in Maghnia ALGERIA. So, in order to solve the problems that bankers might encounter in choosing less risky projects without randomness, the granting or refusal of a loan must be based on scientific criteria to take the right decision. The FMCGP model has proved to be effective at solving various problems related to the loans' granting. The bank strategy adopts the FMCGP model in the choice and trade-offs (preferences) of a criterion at the expense of another. For that end, it has been concluded that the FMCGP model is an efficient and objective scientific approach that can be applied mainly in an economy characterized by rapid and randomly changes.

Keywords: *The goal Programming Model, Fuzzy Multi Choice Goal Programming Model, Making Decisions to Relocate Credit in Commercial Banks.*

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Mathematical Analysis of Growing Tumour and its Treatments with Chemotherapy and Immunotherapy

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Abstract

The analysis of growing tumour cells and the interaction between the host immune system and tumour cells helps to understand the dynamics of tumour growth. Such a system has various important methods of cancer therapy, such as virotherapy, immunotherapy, chemotherapy, radiotherapy, drug and vaccine therapy, such as chemotherapy, immunotherapy and many other scientific solutions to analyse the cancer cell dynamics. We analyse a mathematical model involving an ordinary differential equation system to interact between the growing tumour cells and cells in the immune system, including cytotoxic CD8+ T cells, combined with drug and vaccine intervention to these cells. This model of a control function represents the application of natural killer cells combined with CD8+ T cell treatment to the system. Further, the impact of additional CD8+ T cell regulation parameters with natural killer cell help to reduce the proliferation rate of tumour growth cells is also observed. The obtained result will help to develop a control mechanism and to provide the dynamic interactions between the tumour cells, immune system, and drug response systems.

Keywords: *Tumour growth, immüne system, chemotherapy, CD8+ T cell.*

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On the Solvability of Variable Exponent of Nonlinear Smallterm Elliptic Equation

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Abstract

The existence of a strong solution for elliptic equations with variable exponent nonlinearity in lower-order terms within variable exponent Sobolev spaces $W^{1,p(x)}(D)$ was investigated. A growth condition was imposed on the part containing the lower-order terms. The relationship between the exponent q(x) in that part and the exponent p(x) of the solution space was established. İt was assumed that both exponent functions satisfy the traditional local log-Dini condition.

Keywords: *Variable exponent Sobolev spaces, Lower-order terms, strong solution,growth condition,*

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On Strong Solvability of Nonlinear Gradient Term Elliptic Equation

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Abstract

In this work,the existence of strong solution in Sobolev spaces $W^{2,q}(D)$ for the homogeneous Dirichlet problem for elliptic type equations with super critical nonlinearity in lower-order terms

$$-\Delta u = f(x,u,\nabla u) \quad , D \subset R^N \ , \ u\big|_{\partial D} = o$$

,where $D \subset R^N$ is bounded domain with $\partial D \subset C$, has been proved. The relationship between the solution space and the parameters in the growth conditions imposed on the nonlinearity is established.

Although the obtained results coincide with known results in some cases,they also lead to new classes of results in the case of super critical exponents[1-3].

Keywords: *Nonlinear elliptic equations,critical nonlinearity,strong solution,growth conditions,super critical exponent.*

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On the Solution of a Mixed Problem for a Class of Equations with Changing Type

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Abstract

In the present paper by the contour integral method we study the existence and uniqueness of the solution of a mixed problem for a class of equations with complex-valued coefficients that behave as a parabolic, despite the fact that over “time” can change from parabolic type to Schrodinger type, or even to antiparabolic type. Note that in the paper [4], [5] it was shown that mixed problems can be both illposed for I.G. Petrovsky well-conditioned equations and well-posed for ill-conditioned equations.

Keywords: *Cauchy problem, parabolic equation, classical solution, existence, uniqueness.*

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Modeling and Active Vibration Control of an EMU Rail Vehicle Manufactured in Türkiye

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Abstract

This study investigates the vertical vibration and yaw motion of an electric multiple train (EMU) produced in Turkey and operating at a maximum speed of 160 km/h, within the framework of mathematical modeling and active control theory, aiming to improve ride comfort and dynamic compatibility between the vehicle and the rail. A 10-degree-of-freedom half-vehicle model consisting of a vehicle body, two motor bogies, and four wheel sets was derived using the Lagrangian method; the equations of motion were converted into matrix form, and the state-space model was implemented in the MATLAB environment. In the first stage, the passive suspension behavior of the vehicle under disturbing rail input was investigated in the time and frequency domains. In the second stage, a PID-based active suspension controller was integrated into the model. Simulation results show that a properly tuned PID controller suppresses body vibrations and pitching oscillations, and improves transient settlement behavior.

Keywords: *Half-vehicle model, active suspension, PID control, ride comfort, Lagrange method.*

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Investigating Existence and Decay of Solutions For The Nonlinear Hyperbolic-Type Klein-Gordon Equation

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Abstract

This paper is concerned with a nonlinear hyperbolic-type Klein-Gordon equation with delay term. Under suitable conditions, we prove the existence and decay of solutions. Many scientific problems can be represented using nonlinear partial differential equations, which enables researchers from a range of fields, including engineering and physics, to more accurately characterize natural events. Hyperbolic-type PDE become upon applications in various fields of engineering and science, including fluid dynamics, hydrodynamics, wave propagation, random motion theory, thermal motion, electromagnetics, and materials science. The hyperbolic-type form of PDE was developed to evaluate engineering and physical science models that often-included physical rules such as Newton's law of balance of forces. Generally, delays are involved in challenging areas of information technologies and communication: stability of highspeed communication networks or networked control systems. Recent years, controlling the behavior results for PDE's with time delay effects has become an active research area.

Keywords: *Klein-Gordon Equation, Existence, Decay.*

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On The K-Analogue Of Gottlieb Polynomials And Their Properties

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Abstract

This study aims to introduce the *k*-analogue of the Gottlieb polynomials and to explore their fundamental properties. The *k*-Gottlieb polynomials are first defined via a generating function. Subsequently, their explicit forms are derived, and several properties are established, including generating function relations, a Mellin transform formula, representations in terms of *k*-hypergeometric functions, and various integral representations.

Keywords: *k-Gottlieb polynomials, k-analysis, generating function, fractional derivative operator*

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Blow-up in a Damped Wave Equation with Dynamic Boundary Condition

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Abstract

In this study, we analyze the finite-time blow-up behavior of solutions to a semilinear damped wave equation of the form

$$u_{tt} - \Delta u + a u_t = |u|^{p-2}u$$

with dynamic boundary conditions. The model describes a second-order hyperbolic equation in a bounded domain, coupled with an evolution equation on a part of the boundary that reflects boundary inertia. By constructing an appropriate energy functional and employing a Levine-type concavity argument, we derive conditions ensuring the nonexistence of global solutions. In particular, solutions blow up in finite time when the itial energy is negative. The results show that boundary dynamics play a crucial role in the blow-up behaviour.

Keywords: *Semilinear wave equation, dynamic boundary condition, finite time blow-up*

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Analysis of User Behavior and Prediction of Purchase Probabilities in E-Commerce Using Markov Chains

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Abstract

Analyzing user behavior in e-commerce and predicting future actions are essential for improving conversion rates and user experience. Clickstream data enable detailed analysis and prediction of user journeys, yet their high-dimensional and sequential nature complicates traditional modeling[1]. Markov chains are widely used to model user navigation behavior probabilistically[3], while Hidden Markov Models reveal latent user intentions in online shopping environments[2]. This study proposes a multi-layered framework comprising: (i) first-order Markov chain session modeling, (ii) transition entropy for behavioral uncertainty, (iii) absorbing Markov chain analysis for purchase probability per page category, (iv) machine learning-based conversion prediction, and (v) HMM for revealing user intent. Applied to approximately 100,000 Google Analytics records, absorbing Markov chain analysis revealed that users in the Cart category complete purchases with a probability of 76.2%. Additionally, machine learning models achieved a ROC-AUC of 0.997, and HMM identified dominant exploration behavior across 619 of 710 time periods.

Keywords: *Clickstream Analysis, Markov Chain, Absorbing Markov Chain, Hidden Markov Model, Conversion Prediction*

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Second-Life Battery Supported PV–EV Charging for Workplaces: Optimal Sizing and Feasibility Assessment

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Abstract

This study presents a stochastic multi-objective optimization and predictive control framework for the integration of second-life batteries (SLBs) into grid-connected photovoltaic (PV)-based workplace electric vehicle (EV) charging systems. The main methodological challenge addressed in this work is the heterogeneous state-of-health (SoH) behavior of retired battery modules, which is commonly simplified or ignored in conventional homogeneous energy storage models. To represent this uncertainty, a stochastic module-level SoH modeling approach is developed by considering variations in available capacity and internal resistance. Based on this representation, a multi-objective optimization problem is formulated to simultaneously minimize net present cost and carbon emissions while maximizing the self-sufficiency ratio. The resulting optimization problem is solved using the NSGA-III algorithm. In addition, a model predictive control (MPC) strategy with a 24-hour prediction horizon is implemented to improve the operational decision-making of the PV–SLB–EV charging system under dynamic solar generation and stochastic EV demand conditions. Simulation results based on annual meteorological data and probabilistic EV charging profiles show that the proposed framework enhances system efficiency, reduces grid dependency and emissions, and supports more reliable utilization of second-life batteries compared with conventional homogeneous battery modeling approaches.

Keywords: *Second-life battery, energy management systems, multi-objective optimization, model predictive control, electric vehicle.*

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