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2025 ICMDSAI’25

International Conference on Mathematics, Data Science and Artificial Intelligence

Book of Abstracts

Hassan II University of Casablanca, Faculty of Sciences and Techniques, Mohammedia, Morocco

Preface

It is our great pleasure to present the book of abstracts of the *First International Conference on Mathematics, Data Science and Artificial Intelligence (ICMDSAI'25)*, held on November 28, 2025 at the Faculty of Sciences and Technology of Mohammedia (FSTM), University of HassanII-Casablanca (UH2C), orgonized by the Laboratory of Mathematics, Computer Sciences and Applications (LMCSA) in collaboration with the Moroccan Association of Mathematics and Artificial Intelligence (A2MIA).

The conference covers a broad range of contemporary topics, including but not limited to **statistics, probability and their applications in artificial intelligence**, highlighting recent progress in stochastic modeling, uncertainty quantification, and statistical learning frameworks. The **mathematical methods in physics and new technologies**, presenting analytical and numerical techniques that support advances in modern physical modeling and emerging technological systems.

The conference also hosts contributions in **algebra and functional analysis**, including structural, spectral and operator–theoretic approaches with relevance to both pure and applied mathematics. The fourth topic addresses **dynamical systems**, with works exploring stability, bifurcations, long-term behavior and complex dynamics in natural and engineered systems.

Developments in data-driven disciplines are represented through the **big data and business intelligence**, illustrating how large-scale analytics, decision support, and data architectures contribute to organizational and industrial innovation. The sixth topic highlights **computer sciences for artificial intelligence**, including algorithms, computational architectures, intelligent systems, and software technologies enabling modern AI.

The seventh theme unites **mathematical modeling and image processing**, showcasing contributions in inverse problems, PDE-based models, segmentation, restoration and feature extraction. Finally, the eighth topic encompasses **data mining, machine learning, deep learning and artificial intelligence**, featuring novel methods, architectures and applications across various scientific and industrial domains.

We extend our gratitude to all authors for their valuable submissions, to the reviewers for their careful evaluations, and to the organizing and scientific committees for their unwavering commitment to ensuring the quality and success of this conference. We also express our appreciation to the participating institutions and sponsors whose support has made this event possible.

We hope that this volume will serve as a useful reference for researchers and practitioners, and that the ideas shared during ICMDSAI'25 will inspire future collaborations and innovations across mathematics, data science, and artificial intelligence.

ICMDSAI'25 Conference Chairs : **N. AZOUAGH, A. MOUSSAID**

ICMDSAI'25

The First International Conference on Mathematics, Data Science and Artificial Intelligence

November 28th, 2025 – Mohammedia, Morocco

Topics of the Conference

- Statistics, probability and their applications in AI
- Mathematical Methods in Physics and New Technologies
- Algebra & Functional Analysis
- Dynamical Systems
- Big Data and Business Intelligence
- Computer Sciences for AI
- Mathematical Modeling and Image Processing
- Data Mining, Machine Learning, Deep Learning and AI

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Solving CFD Problems Using High Performance Computing: From Classical Numerical Methods to Physics Informed Neural Networks

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Keywords: High-Performance Computing, Computational Fluid Dynamics, Finite Volume / Finite Element Methods, Physics-Informed Neural Networks, HPC–AI Hybrid Architectures

Abstract

Computational Fluid Dynamics (CFD) has long relied on classical numerical methods such as finite volume and finite element, executed on high-performance computing (HPC) systems to solve large-scale flow problems with ever-increasing accuracy. These approaches, rooted in discretization and iterative solvers, have powered decades of scientific progress. However, as geometries, physical models, and computational domains become more complex, even massively parallel HPC architectures face limits in scalability and efficiency.

In this talk, I will trace the evolution of solving CFD problems using HPC, from traditional deterministic solvers to modern Physics-Informed Neural Networks (PINNs). While classical CFD methods advance the solution by discretizing and iterating the governing equations in space and time, PINNs learn continuous solutions that enforce the governing physical laws through learning-based optimization.

This evolution redefines the role of HPC, from running large-scale numerical solvers to enabling the training of physics-informed learning models. Finally, I will discuss how hybrid HPC–AI architectures enable large-scale training of PINNs, paving the way for the next generation of physics-based simulations that combine numerical rigor with data-driven intelligence.

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Infographie, Mathématique et Proportion dorée : Redécouvrir le Génie Mathématique de l'art Géométrique Islamique

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Keywords: Art géométrique islamique – Symétrie – Pavages quasi-périodiques – Auto-similarité – Proportion dorée – Génération algorithmique

Abstract :

L'art géométrique islamique constitue l'une des expressions les plus fascinantes du dialogue entre les mathématiques et l'esthétique [1]. Ses motifs étoilés, rosaces et pavages traduisent une compréhension profonde de la symétrie, des proportions et de l'harmonie. Ces principes ont été redécouverts aujourd'hui par la science moderne, suscitant un profond émerveillement [1,2,3].

La découverte des quasi-cristaux au XX^{e} siècle [5] a ravivé l'intérêt des scientifiques pour les structures quasi-périodiques, déjà présentes depuis des siècles dans les décors architecturaux islamiques. Cette correspondance entre art ancien et science contemporaine a inspiré de nouvelles approches visant à analyser et à reconstruire ces motifs complexes [6].

L'objectif est de présenter un cadre génératif systématique pour la création de motifs islamiques périodiques, quasi-périodiques et auto-similaires[6, 7, 8]. La méthode repose sur la théorie des groupes de symétrie, les pavages quasi-périodiques et la subdivision successive des triangles d'or afin de produire des compositions géométriques à la fois fidèles à la tradition et ouvertes à l'innovation. Chaque motif est construit à partir d'une région fondamentale ou d'un pavé, subdivisé en triangles symétriques, puis reproduit par des transformations géométriques rigoureusement définies. Cette approche, illustre comment la rigueur mathématique et la technologie numérique peuvent préserver, analyser et réinventer l'héritage visuel de l'art islamique. Elle ouvre ainsi un espace de dialogue entre la pensée scientifique et la créativité artistique, où le patrimoine devient source d'innovation contemporaine.

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The Price of Creativity : Understanding and Resolving the Generative AI Paradox

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Keywords: Generative Artificial Intelligence (GenAI), AI Paradox, Environmental Sustainability, Epistemic Integrity, Responsible AI Development

Abstract

Generative Artificial Intelligence (GenAI) has moved very rapidly from an ambitious concept of early symbolic systems to a technological paradigm that shapes science, culture, and industry. Early models were bound by handcrafted rules and narrow domains. The emergence of deep learning, foundation architectures, large-scale datasets, and unparalleled computation gave rise to systems endowed with the capacity for highly realistic synthetic text, images, code, and multimodal content. This marks a radical shift: intelligence no longer stops at prediction and perception but becomes creative. This transformation, however, has brought out into the open a structural tension at the heart of the success of GenAI, and that is the Generative AI Paradox.

The paradox issues from three reinforcing contradictions. First, the environmental paradox: state-of-the-art generative systems currently depend on extensive computing resources, massive energy consumption, and rare semiconductor supply chains that challenge global sustainability objectives and widen geopolitical inequities. Second, the epistemic paradox: GenAI accelerates the production of synthetic knowledge whose truth status is uncertain, thereby destabilizing information ecosystems that rely on authenticity, accountability, and verifiability. Third, the socioeconomic paradox: while GenAI democratizes creativity and enhances productivity, it simultaneously concentrates technological power among a limited number of entities, raises unresolved intellectual property concerns, and disrupts labor and educational structures.

This keynote reflects critically on how these paradoxes arose out of the history of GenAI development and how continuing on a scaling-for-capability trajectory may further environmental burdens, erode trust, and undermine the scientific integrity of knowledge systems. Unless the field of study explores other research pathways, such as responsible scaling, energy-efficient architectures, model distillation and specialization, and transparent provenance infrastructures, future generative technologies will not be socially beneficial, credible, or ecologically responsible. By setting GenAI in its historical context, explaining the nature of its paradox, and outlining actionable strategies for its resolution, this talk challenges researchers to reconsider the very foundation of generative intelligence. The future of GenAI will not be defined by only the next breakthrough model but by how well we can design systems that create value without unsustainably extracting it-systems that create trust rather than diminish it. Ultimately, the talk is a call to move away from competitive scale races and toward

collaborative innovation agendas underpinned by scientific rigor, environmental stewardship, and social responsibility. The price of creativity must be paid wisely.

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Modeling and Analysis of Complex Systems

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Keywords: Modeling, Analysis, Complex systems, Complex networks, Neuroscience

Abstract
The field of complex systems and networks (CS) has developed considerably over the last twenty years, both in terms of methods and in terms of the formalization and analysis tools used for these systems. A CS can be defined as a system consisting of a large number of heterogeneous entities that form the basis for local interactions, generating collective structures and organizations on many different scales. This presentation fits within this definition, in particular by studying networks of differential equations (PDEs or ODEs), for example systems of PDE systems and the patterns that emerge from them, mainly with applications to living organisms. Thus, after giving a general overview of CS, I will present examples of ODE or PDE (from neuroscience, epidemiology, or issues of biodiversity and ecosystems) and show the concrete value of thinking "complex". If time permits, I will present an innovative complex network of reaction-diffusion systems located in distinct domains, with couplings at the boundaries, modeling the evolution of interacting populations living in a fragmented environment, whose individuals migrate from one part of their habitat to another.

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L'intégration des nouvelle technologies IA et Blockchain dans les systèmes d'informations portuaires

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Keywords: systèmes d'informations portuaires, blockchain, IA, transition numérique, logistique.

Abstract
Les systèmes d'information portuaires connaissent aujourd'hui une transformation profonde, portée par l'intégration croissante de l'intelligence artificielle et de la blockchain. Sous l'impulsion d'un cadre réglementaire international de plus en plus exigeant, la digitalisation et l'interopérabilité des infrastructures deviennent essentielles. Cette transition numérique s'accompagne d'un besoin accru de sécurité et de confiance dans les transactions liées au transport de marchandises. La blockchain constitue une réponse particulièrement adaptée à ces enjeux. Combinée aux smart contracts et aux approches de machine learning, elle permet de construire un écosystème d'automatisation sécurisé, indispensable à la fluidification du passage portuaire. Dans cette intervention, nous présenterons la dynamique d'innovation qui s'est structurée autour de ces technologies au cœur de la Vallée de Seine en France. Cette trajectoire a abouti à la création de SmartLogiLab, un laboratoire commun (LabCom) labellisé par l'Agence Nationale de la Recherche (ANR), dédié à l'exploration et au développement de solutions IA et blockchain pour la chaîne logistique portuaire.

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Abstracts

A Bilevel Optimization Framework for Nonlocal Anisotropic Diffusion-Based Image Restoration

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Keywords: Bilevel Optimization, Nonlocal Operator, Diffusion Tensor, Anisotropic Diffusion, Image Restoration, Partial Differential Equation.

Abstract (*150 –200 words*)

This paper presents a bilevel optimization framework for image restoration based on a nonlocal anisotropic diffusion tensor model. The lower-level problem governs image evolution through a nonlocal anisotropic diffusion EDP, where the diffusion tensor is derived from a nonlocal structure tensor capturing pixel geometry. The upper-level problem optimizes a cost functional with respect to the nonlocal control, combining data fidelity and gradient regularization to ensure smoothness. This framework adaptively smooths homogeneous regions while preserving edges and fine textures, providing a robust and flexible tool for nonlocal, geometry-aware image restoration.

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A Game Theoretic Framework for Optimization in Computer Vision

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Keywords: computer vision, game theory, deep learning, optimization, visual recognition, equilibrium modeling, intelligent systems

Abstract (150–200 words)

This study investigates a novel framework that applies game-theoretic reasoning to enhance optimization and decision-making within computer vision systems [1]. The primary goal is to explore how equilibrium concepts can improve the coordination and stability of processes in visual recognition models. The proposed approach draws on strategic interaction principles to model relationships among system components and to achieve more adaptive and balanced performance in complex image environments [2]. Methodologically, the work integrates learning-based modeling with equilibrium analysis to support dynamic optimization without relying on rigid rule-based suppression or fixed thresholds [3]. Preliminary investigations indicate that strategic reasoning can contribute to more consistent detection outcomes and greater robustness under varying visual conditions. Although the research remains in progress, the findings suggest promising directions for integrating theoretical frameworks with practical computer vision applications, ultimately supporting the development of more efficient and intelligent visual systems.

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A Hybrid CBIR Model Combining Deep Features and Pareto Front Theory

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Keywords: Content-Based Image Retrieval (CBIR), Deep Learning, Convolutional Neural Network (CNN), Multi-Layer Perceptron (MLP), Pareto Front.

Abstract

Content-Based Image Retrieval (CBIR) is a key area in computer vision. It consists of submitting a query image and retrieving the most visually similar images from a dataset. To achieve this, we leverage three types of visual features: color, texture, and shape. Color features are extracted using RGB histograms, while shape and texture features are derived from a Convolutional Neural Network (CNN) trained on a custom dataset. We propose a hybrid approach that combines these two sources of information, where similarities are fused using adaptive weights (α, β), automatically predicted by a Multi-Layer Perceptron (MLP). Experimental results on the COREL dataset demonstrate that our method outperforms approaches relying solely on CNN. Additionally, a Pareto front is plotted to analyze the trade-off between the contributions of color and shape descriptors.

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A Learned Branch-and-Bound Framework for the Packing While Traveling Problem

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Keywords: Branch and Bound, Combinatorial optimization, Feed-forward network, Knapsack problem, Vehicle Routing problem.

Abstract: Branch-and-Bound (B&B) is a classical tool for optimally solving combinatorial optimization problems, particularly in routing and packing tasks. However, achieving fast convergence on large-scale problems requires careful design of the branching strategy and node exploration order, since exploring the entire search tree is computationally infeasible.

In this paper, we address the Packing While Traveling (PWT) problem, a hybrid optimization task that combines elements of the Traveling Salesman Problem and the Knapsack Problem. Our objective is to learn an effective branching policy using a feed-forward neural network. The training dataset is constructed from depth-first searches performed on small-scale B&B trees, which provide the sequence of optimal branching decisions and the corresponding node features. This learned policy aims to guide the branching process in larger instances, reducing search effort while maintaining solution quality.

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A Mathematical Model of Financial Contagion in Banking Systems under Varying Growth Rate

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Keywords: systemic risk, growth rate, financial contagion, stability, interbank network, mathematical modeling, numerical simulation.

Abstract

This study analytically investigates financial contagion within a banking system that includes the growth rate of new banks. We use an epidemiologically inspired compartment model, where banks can be either undistressed banks, exposed banks, distressed banks, recovered banks, or liquidated banks. The growth rate reflects the inflow of new banks entering the system and, as such, affects the overall dynamics of financial contagion. We start by establishing boundedness and positivity of solutions to keep the model economically meaningful and within realistic financial bounds. The equilibrium points are then determined analytically, and thereafter, local stability analysis is carried out using the Jacobian matrix and eigenvalue criteria. Global stability is analyzed through Lyapunov-based arguments and qualitative analysis. Numerical simulations support the theoretical results: high growth rate increases contagion risk by creating undercapitalized and highly interconnected banks, while moderate growth rate enhances resilience by reducing systemic vulnerability. The results call for regulatory authorities to monitor and control the growth rate of new bank introductions to maintain financial stability.

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A Mixed hemivariational Approach for Modeling Frictional Contact Problems in Electro-elasticity

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Keywords: Hemivariational inequality,Frictional contact,Hemivariational–variational problem, Hemicontinuity, Weak solutions, Fixed point result for set-valued mappings.

Abstract

We consider a mathematical model that describes the frictional contact of a piezoelectric body with an electrically conductive foundation. The material's behavior is described by means of an electroelastic constitutive law, the contact is described by unilateral Signorini contact conditions, while the tangential response follows a generalized nonmonotone Tresca friction law. On the electric side, the transmission across the contact surface is represented through a regularized nonmonotone electrical conductivity condition. After presenting the strong electromechanical formulation, we derive a mixed hemivariational variational formulation and is demonstrated to have a last one solution.

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A Physics-Informed Neural Networks for Solving some PDEs

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Key Words: *PINN, Machine Learning, Neural Networks, Partial Differential Equations.*

Abstract:

This study investigates the application of Physics-Informed Neural Networks (PINNs) to the solution of partial differential equations (PDEs). The central concept underlying this approach is the integration of physical laws directly into the neural network's loss function via automatic differentiation. The proposed framework is evaluated on a series of benchmark problems, encompassing both linear and nonlinear cases, including the Burgers' and Navier-Stokes equations. The findings demonstrate the robustness, flexibility, and accuracy of PINNs, establishing them as a promising alternative to conventional numerical simulation methods for solving complex physical systems.

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A Robust Hybrid Scheme Integrating Fractional Nonlocal Diffusion and Bilateral Convolution for Noisy Image Recovery

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Keywords: Image; Denoising; Caputo derivative; bilateral convolution; Perona-Malik model; Fractional PDE; Gaussien noise; filter.

Abstract

Fractional computations can provide a flexible and nuanced approach to analyzing and processing digital images, complementing conventional bilateral filters to potentially achieve better results in terms of SSIM, PSNR, and SNR metrics. While traditional bilateral filters excel at preserving edges and reducing noise, fractional-order derivatives and integrals allow greater control over filtering processes, particularly in regions with complex textures or gradual intensity changes. We propose a new method for solving fractional partial differential equations (PDEs) in space-time, incorporating bilateral convolution. We present a simulation of Caputo's integer and fractional order derivatives using the finite difference method, and we demonstrate the existence and uniqueness of a weak solution to the proposed mathematical model. The hybrid model we developed offers a robust and accurate solution to the processing of degraded digital images using both PDEs and bilateral convolutions. We tested our algorithm's effectiveness on grayscale and color images that were degraded by Gaussian noise at different levels of intensity. The method allows significant edge enhancement to be achieved, while reducing the staircase effect at the same time as producing higher SSIM, PSNR, and SNR values. Based on the results of the experiment, it was revealed that the proposed method produced better reconstructions of images with complex structural details and color variations than existing techniques.

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A Secure Image Encryption via eXOR-CBC Integration with Hyperchaotic 4D Lü System

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Keywords: Cryptography, Image encryption, eXor operator, Chaos, CBC, Confusion, Diffusion

Abstract

In this paper, a novel image encryption technique based on the Lü chaotic system is proposed. the scheme employs the basic concept of chaos theory's confusion and diffusion processes, using an eXOR operator to achieve the confusion step through several non-linear operations defined by some specific algorithms, while the diffusion step is reinforced by incorporating the Cipher Block Chaining (CBC) concept to improve the resiliency of the method towards differential attacks. Comprehensive simulations carried out on a colored and grayscale images have verified that the resulting images after the encrypting procedure have uniform distributions of histograms, high levels of entropy value, and reduced correlations of pixel values. At the same time, its performance was found to excel with strong results for differential analysis of UACI (Unified Average Change of Intensity) and NPCR (Number of Pixels Change Rate) criteria. Also, a key space analysis was carried out to verify that the key space of this method was sufficiently large enough to be secured against brute force and statistical attacks.

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A Stochastic Model for Group Testing under Random Sample Size

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Keywords: Group testing, Pooling, SARS-CoV-2, Dilution effect, Sensitivity, Specificity, Binomial distribution.

Abstract
In the classical Dorfman group testing procedure, a population of fixed size N is partitioned into k pools of equal size n. Each pool is tested once: a negative result clears all n individuals, whereas a positive result necessitates individual testing within that pool. The expected number of tests, denoted by X_N, is $E(X_N) = \frac{N}{n}(1 + n(1-(1-p)^n))$, where p represents the infection prevalence in the population. This study analyzes the distribution of X_N, allowing the determination of threshold probabilities for exceeding a specified testing capacity. The model is then extended to incorporate random population sizes N and test misclassification through sensitivity (Se) and specificity (Sp). In this stochastic framework, the expected number of tests becomes $E(X_N) = \frac{N}{n} + NSe + N(1-p)^n(1 - Se - Sp)$, emphasizing the joint effects of population variability and diagnostic accuracy.

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A Study of the Safety Set in an Epidemic Model

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Keywords: Epidemic process; discrete-time system; positivity; stability

Abstract

We analyse conditions on a given a non-linear SEIRS epidemic model parameters, to provide a safety set for the epidemic containment, which means identifying an area in which the parameters of the epidemic remain under control and prevent an uncontrolled spread of the disease. After having determined this set, we look for control actions constraining the epidemic to remain within the safety set with infection rates below an allowed threshold. This means that for any initial state in a certain safety set of the state space, there exists an appropriate control strategy maintaining the state of the system in the considered safety set. Using advanced mathematical tools one can determine conditions for the stability of the epidemic and identify boundaries for the safety set. These borders delimit the values of the parameters where the epidemic remains under control and does not lead to a peak in propagation. To ensure the solvability under feedback control of our problem, sucient assumptions are derived in terms of linear inequalities on the input vectors at the vertices of a polytope. The results of this study are of great importance to policy makers and public health professionals, as they provide critical information on the management of outbreaks in limited populations. By identifying risk areas and critical parameters, these results could contribute to the implementation of preventive measures and targeted interventions to control the spread of infectious diseases in such population.

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A data-driven approach for the prediction of complex dynamical systems

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Keywords: *manifold interpolation, Stiefel manifold, non-intrusive model reduction, fluid dynamics, parameterized model reduction, dynamical systems, data-driven model reduction*

Abstract:
Many engineering problems involve parameter-dependent dynamical systems. To reduce the computational cost of evaluating new parameter values, an efficient approach consists in interpolating the singular matrices that represent solution data. However, classical interpolation methods often fail to preserve the physical structure, as the data lie on nonlinear manifolds rather than linear spaces.

A well-known strategy addresses this issue by performing interpolation in the tangent space of the Grassmann manifold [1], allowing the reconstruction of spatial modes. The temporal modes are then obtained by projecting the high-fidelity model onto the interpolated spatial basis using a Galerkin procedure. Despite its accuracy, this approach remains intrusive, since it requires access to the governing equations.

To remove this restriction, a non-intrusive variant was proposed by Oulghelou and Allery [2], which avoids the original equations but introduces two additional low-dimensional optimization problems after interpolation.

In this work, we propose a new non-intrusive technique based on Interpolation on the Tangent Space of the Stiefel Manifold (ITSSM) [3]. Unlike previous methods, ITSSM does not require post-interpolation calibration. The approach is assessed on a standard fluid dynamics benchmark — the two-dimensional cylinder wake flow. Results demonstrate that ITSSM accurately reconstructs the physical fields for unseen parameter values while maintaining computational efficiency suitable for real-time applications.

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A generalized fractional hepatitis B virus infection model with both cell-to-cell and virus-to-cell transmissions

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Keywords: Global stability ; General incidence function; Viral ; Cell-to-cell ; Virus-to-cell

Abstract

In this work, we propose a generalized fractional model for Hepatitis B viral infection that considers two modes of transmission: cell-to-cell and virus-to-cell. These two transmission pathways are described by generalized incidence functions. The model also incorporates the human body's adaptive immune response, represented by antibodies and cytotoxic T-lymphocyte (CTL) responses. We begin our analysis by establishing several theorems concerning the existence, positivity, and boundedness of the model's solutions. Our results show that the model admits one disease-free equilibrium point and four endemic steady states. We further explore the relationship between the existence of these steady states and their corresponding basic reproduction numbers. Using the Lyapunov stability method and LaSalle's invariance principle, we derive several theorems on the global stability of the equilibria. Numerical simulations are provided to support the theoretical results and to illustrate the influence of the fractional derivative order on the stability of all equilibrium points. We find that the use of generalized incidence functions enhances our understanding of equilibrium stability and encompasses a wide range of classical incidence forms. Finally, we demonstrate that effective infection treatment plays a crucial role in eliminating the disease.

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A mass-conserving numerical model to study the effect of surface texture and cavitation on periodic squeeze films

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Keywords: Periodic squeeze film, Surface texturing, Cavitation, Numerical model, Tribological performance

Abstract

This research aims to evaluate how surface texture affects the tribological performance of a periodic squeeze film. To perform this analysis, a numerical model was developed. This model is designed to analyze the combined influence of surface texture geometry and the cavitation phenomenon within a squeeze film confined between two parallel, oscillating, coaxial discs of the same dimensions. The study considered three distinct texture geometries: cylindrical, spherical, and conical. Under the assumption of hydrodynamic lubrication, the modified Reynolds equation is derived, incorporating the texture geometry and surface kinematics, and employing the Elrod-Adams mass–conserving cavitation boundary conditions to accurately account for the effects of cavitation phenomena. The resulting governing equation is solved using the finite difference technique and an iterative Gauss-Seidel scheme. The results demonstrate that cylindrical textures are particularly effective, significantly impacting the film pressure and cavitation, thereby outperforming the other two tested textures. The surface texture clearly influences both the distribution of the lubricant film load capacity and the extent of the cavitation region.

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A novel PDE-constrained model Based on the Weickert controlled Diffusion Model for Image Denoising

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Keywords: PDE, control optimal, Weickert, diffusion, anisotropic.

Abstract

This paper presents an optimal control approach applied to a partial differential equation (PDE) based on the Weickert anisotropic diffusion model, a powerful framework for image denoising and enhancement. The proposed method formulates the diffusion process as a controlled PDE, where the control function regulates the degree of anisotropy to balance noise removal and edge preservation. We establish the existence and uniqueness of the weak solution to the state system, as well as the existence of an optimal control minimizing a suitable cost functional. The corresponding adjoint system and first-order optimality conditions are derived. Numerical experiments demonstrate the effectiveness of the proposed approach in achieving high-quality image restoration with well-preserved structural details compared to classical diffusion-based methods.

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Keywords: Fractional Brownian motion, Fractional Gaussian noise, Stationary process, Power Spectral Density, Lamperti transform, Biomedical imaging, Osteoporosis.

Abstract (150–200 words)
Fractional Gaussian noise (fGn), a stationary process derived from the increments of fractional Brownian motion (fBm), has been widely used to model textures in medical images because of its ability to capture stable local statistical properties. This makes fGn particularly suitable for analyzing trabecular bone structures in osteoporosis, as these structures exhibit microarchitectures that alter spatial textures due to their stochastic nature. In this paper, we propose replacing fGn by the stationary process obtained by applying the inverse Lamperti transform to fBm. Using complex polygamma functions, we provide a detailed study of the power spectral density (PSD) of this transformed stationary process, for which a new expression is derived. We believe that this approach is original and offers promising perspectives for biomedical imaging, particularly in the context of osteoporosis.

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Advancing Blind Deconvolution through Fractional Derivatives and Bilateral Total Variation

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Keywords: Blind deconvolution; bilateral total variation; Nash game; deblurring image; optimization; Fractional order derivatives

Abstract (*150 –200 words*)

In image processing, blind deconvolution is a technique designed to simultaneously recover a latent image and the corresponding unknown blur kernel from a degraded or blurred observation. This work presents an innovative framework for blind deconvolution that integrates three key components: bilateral total variation (BTV), Nash game theory, and fractional-order derivatives. Bilateral total variation (BTV) acts as a robust regularizer that is able to keep the edges well and suppress the noise. Another category of methods takes a strategic and joint consideration for the blind deconvolution problem, with the blind deconvolution formulated a two-player game: one player estimates the latent image while the other reestimates the blur kernel. By enclosing complex image structures and considering multiple noise model, fractional-order derivatives can provide more flexibility and accuracy. The proposed method employs an iterative strategy, utilizing the Nash game framework to coordinate the image and kernel estimation tasks. BTV regularization is applied at each step to preserve spatial details, while fractional-order derivatives adapt to variations in degradation patterns. This combination effectively reduces over-smoothing and improves the recovery of fine textures, even in scenarios involving severe blur and non-Gaussian noise. The proposed framework achieves significant improvements in peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM) while maintaining computational efficiency. Applications of this method extend to various practical scenarios, including medical imaging, astronomical data analysis, and photographic restoration. This work underscores the potential of integrating advanced regularization, game theory approaches, and fractional calculus in advancing blind deconvolution techniques and image restoration methodologies.

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An Empirical Evaluation of Stemming Algorithms for Modern Standard Arabic and Moroccan Darija : A Comparative Experimental Study

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Keywords: Arabic NLP, Darija, Stemming, Morphological Analysis, Comparative Evaluation

Abstract

This study presents a comprehensive experimental evaluation of eight stemming algorithms applied to Modern Standard Arabic (MSA) and Moroccan Darija. We evaluated seven stemmers for MSA (Farasa, Tashaphyne, ARLSTem, Khoja, AMIR, MADAMIRA, Qutuf) and one specialized stemmer for Darija (ISRIStemmer) using a manually annotated corpus of 2000 words. Our evaluation employed several metrics including reduction rate, stemming accuracy, over-stemming/under-stemming rates, and processing speed. The results indicate that MADAMIRA achieves the highest accuracy for MSA (89.3%) while demonstrating an excellent balance between precision (87.2%) and recall (91.5%). For Darija, ISRIStemmer shows superior performance with 84.7% accuracy, although significant challenges remain due to morphological complexity and code-switching patterns. The study reveals that rule-based approaches such as Khoja and ARLSTem exhibit higher over-stemming rates (15.2% and 12.8% respectively), while statistical approaches such as MADAMIRA and Farasa demonstrate better accuracy. These results provide evidence-based recommendations for stemmer selection in Arabic NLP applications.

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An investigation of coupled velocity–pressure POD reduced-order model approaches for the incompressible Navier–Stokes equations

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Keywords: *Model reduction, Proper Orthogonal Decomposition (POD), Optimal control, Finite Element Method, Navier-Stokes, Cylinder wake flow, Galerkin projection, Minimum residual projection.*

Abstract:
Model reduction aims to replace a high-dimensional dynamical system with a lower-dimensional representation that retains the essential features of the full-order model. This process significantly accelerates numerical simulations, enabling efficient solutions of optimization and control problems [1].

The Proper Orthogonal Decomposition (POD), introduced by Lumley in 1967 in the context of turbulence [2, 3], remains the most widely used model reduction technique in fluid mechanics. As a linear procedure, POD extracts from a dataset an orthonormal basis that optimally captures the system's energy, and a reduced-order model is obtained by projecting the governing equations onto the subspace spanned by these modes (Galerkin projection) [4].

An extension constructs a POD-based reduced-order model (POD–ROM) to approximate both velocity and pressure fields for incompressible flows [6]. Two separate PODs are performed—one for velocity and another for pressure. Unlike previous Galerkin-based methods, the temporal modes are determined by minimizing the residual of the momentum equation only, without requiring a Poisson equation.

The methodology is applied to a laminar wake flow behind a circular cylinder at low Reynolds number. The incompressible Navier–Stokes equations are solved using a FreeFem++ finite

element code. Snapshots of the flow fields are collected to build the POD basis functions, and the reduced-order model is then obtained by projecting the governing equations onto the subspace spanned by these modes as well as by minimizing the residual of the momentum equation. A comparative study is conducted to assess the method's performance.

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Analysis of Flow Separation on a Ramp and Active Control Using Synthetic Jets

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Keywords: Ramp, URANS, Separation, Synthetic Jet, Drag

Abstract

This work presents a 2D numerical study of turbulent flow over a 25° descending ramp [1]. It aims to characterize the separation and mitigate it using a synthetic jet. The approach uses Unsteady Reynolds-Averaged Navier-Stokes (URANS) to simulate turbulent flows with the $k-\omega$ Shear Stress Transport turbulence model, which combines the advantages of $k-\omega$ models near walls and $k-\varepsilon$ models in free flow for greater accuracy. It is discretized by finite volumes and validated by comparison with experiments and DNS simulations. Without control, the attachment distance is approximately $5.45h$ (h = ramp height). The velocity and wall pressure profiles are consistent. The influence of the curvature radius of the upper edge is negligible. For control, a synthetic jet (oscillatory suction/blowing, zero flow rate) is modeled using a User-Defined Function, defined by the user in C language to implement custom physical conditions in C [2]. Optimizing the parameters (frequency f = 30 Hz, velocity ratio Vr = 3.33) reduces the attachment distance from 14.13% to 4.68h. The results show an improvement in aerodynamic performance. They open up prospects for 3D modeling and industrial applications in drag and emissions reduction.

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Analysis of chaotic dynamics initial and boundary value problem for the viscous van Wijngaarden-Eringen model

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Keywords: Chaotic semigroups, Van Wijngaarden-Eringen equation, Devaney chaos.

Abstract

Abstract

We study the chaotic dynamics of the initial-boundary value problem:

$$\begin{cases} y_{\theta\theta}(\theta,\xi) - y_{\theta}(\theta,\xi) = \sigma^{-1} y_{\theta\xi\xi}(\theta,\xi) + \delta^2 y_{\theta\theta\xi\xi}(\theta,\xi), & \theta \geq 0, \xi \geq 0, \\ y(0,\xi) - y_{\theta}(0,\xi) = 0, & \xi \geq 0 \end{cases}$$

in the intersection space

$$\mathcal{H}_{\rho} = (L^2([0,+\infty),\mathbb{C}) \cap \mathbb{V}_{\rho}) \oplus (L^2([0,+\infty),\mathbb{C}) \cap \mathbb{V}_{\rho})$$

We prove that the system generates a uniformly continuous C_0-semigroup that is Devaney chaotic, distributionally chaotic, and topologically mixing. Sufficient conditions for exponential stability are also established.

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Career Typologies and Longevity after Retirement: An Integrative Machine Learning and Survival Analysis of Moroccan Public Sector Retirees

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Keywords: career typologies; machine learning; survival analysis; Kaplan-meler estimator; Cox proportional hazards model; retirement; longevity; Moroccan pension system; actuarial relevance

Abstract
This study investigates how heterogeneous career trajectories shape post-retirement longevity among Moroccan public sector retirees. Using administrative data from the Caisse Marocaine des Retraites (2016–2021), we construct data-driven career typologies through unsupervised machine learning applied to key career and pension variables—years of service, salary, pension amount, replacement rate, and retirement age.
These typologies summarize distinct professional pathways, ranging from early and fragmented careers to long, high-income, or standard full-career profiles. Survival patterns are analyzed across clusters using Kaplan–Meier estimators and a Cox proportional hazards model with age as the time scale.
Results reveal significant longevity differentials between career groups: continuous and balanced careers exhibit the highest survival, while early or high-responsibility trajectories are associated with elevated mortality risks. Even after controlling for gender, marital status, and financial indicators, career typology remains a strong and independent predictor of mortality.
The findings highlight the actuarial relevance of integrating career structures into longevity modeling and provide new evidence on the interplay between professional history and survival in the Moroccan pension system.

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Darija Sentiment Analysis in the Literature: From Feature-Based Models to Pretrained Transformers

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Keywords: Moroccan Darija, Dialectal Arabic, Sentiment Analysis, Pretrained Language Models, Classical Machine Learning.

Abstract

This work presents a comparative review of methods for sentiment analysis in Moroccan Darija and related Arabic varieties. We contrast traditional, feature-based pipelines (normalization/transcoding, n-gram or static embeddings, classical classifiers) with approaches that adapt pretrained language models (PLMs). Using results reported across prior studies, we synthesize evidence along four axes: (i) data regime (size, balance, noise), (ii) preprocessing for dialectal variation and code-mixing, (iii) model capacity and resource cost for training/serving, and (iv) evaluation practices (splits, metrics, transparency). We aggregate recurring trends: PLM-based methods typically lead on accuracy and macro-F1 under moderate data, while well-engineered classical pipelines remain competitive when compute is tight or preprocessing is strong. The review foregrounds practical constraints, data availability, preprocessing effort, and computational budget, and shows how these factors shape method choice in Darija contexts. By assembling evidence often reported in isolation, this study offers an essential, literature-grounded comparison that helps readers identify which strategy best fits their goals and constraints.

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Dual Algorithm Optimization with Adaptive Penalty Parameter Selection for Elastoplastic Contact Problems

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Keywords: Elasto-plasticity; Signorini conditions; Hencky's constitutive law; Kacanov's method; Augmented Lagrangian; Uzawa block. **Abstract:**

In this article, we study a mechanical contact problem between an elastoplastic body and a rigid foundation. The material behavior is modeled using Hencky's nonlinear elastic law. We introduce an iterative method based on Kacanov's approach, using an augmented Lagrangian at each step. To make the algorithm more efficient in discrete cases, we propose a new approach that automatically and optimally selects the penalty parameter, along with an approximate algorithm. By eliminating two unknowns—the main and auxiliary ones—we create a purely dual algorithm, which allows us to carefully analyze its convergence. Finally, we present numerical experiments in two dimensions to show how well the method performs.

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Duhamel-Based Time Integration Using Extended Modal Analysis for Non-Proportional Damping Structure

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Keywords: Duhamel integral, differential equations, non-classical damping, modal analysis, MATLAB.

Abstract

In many physical systems, accurate prediction demands mathematical models that capture structural and boundary complexities. This work frames a rigid structure supported by semi-elastic base isolators. The structural assembly is idealized as a lumped-mass multi-degree-of-freedom system coupled to its supports through linear springs and viscous dampers. Mass, stiffness, and non-proportional damping matrices are assembled and the forced response is obtained by solving the second-order vector differential equation. The procedure of resolution begins by computing the Eigen-values and Eigen-vectors, determining damped and pseudo-damped frequencies and modal damping ratios, determining the complex-valued constants, and then we employ Duhamel's integral with an extended modal superposition scheme suitable for non-classically damped systems. The resulting convolution algorithm is implemented in MATLAB. It enables efficient evaluation of the response history for prescribed harmonic input excitation. Parametric variation on the damping characteristics demonstrate improved dynamic stability and reduced amplification. This formulation highlights how applied mathematical tools—matrix analysis, modal decomposition, and numerical quadrature—yield transparent control over accuracy and computational cost.

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Dynamic Optimization of Energy and Response Time in IoT-Fog Ecosystems: A Hybrid Metaheuristic Approach

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Keywords: Internet of Things (IoT), Fog Computing, Task Offloading, Energy Optimization, Latency Reduction, Dynamic Resource Management, Metaheuristic Algorithms, Genetic Algorithm (GA), Evolution Strategy (ES), Real-Time Decision-Making.

Abstract (*150 –200 words*)
The proliferation of Internet of Things (IoT) devices has introduced unprecedented challenges, particularly concerning resource constraints such as fast-draining batteries and the demand for timely responses. Existing research has proposed offloading processing tasks to resource-rich IoT fog nodes as a potential solution. However, these approaches often overlook the dynamic nature of both the fog and device landscapes.

This paper addresses the shortcomings of static optimizations in the context of dynamically evolving IoT ecosystems. We focus on the optimization of energy consumption and response time for offloaded tasks, recognizing the dynamic nature of both the fog and device sides of the IoT. Unlike static optimizations, our approach adapts to changes over time, acknowledging the shifting numbers of fog nodes and devices.

The formulated problem encompasses the dynamic challenges faced by both fog nodes and IoT devices, seeking to strike a balance between energy efficiency and timely task execution. We present a comprehensive analysis of the proposed optimization strategy and discuss its potential impact on the evolving landscape of the Internet of Things.

This research contributes valuable insights into addressing the dynamic complexities of IoT systems, shedding light on efficient strategies to optimize energy consumption and response time in a constantly changing environment.

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Dynamics of Parabolic Problems under Nonlinear Boundary Conditions

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Keywords: Parabolic problem, heat equation, nonlinear boundary condition, blow-up, initial energy.

Abstract :
In this work we considered the following linear parabolic equation $u_t - \Delta u + u = 0$ in $\Omega \times (0, T)$, under nonlinear boundary condition in a bounded domain $\Omega \times R^n, n \geq 1$ with smooth boundary. Our main objective is to establish a threshold result, which would distinguish between global existence and finite-time blow-up of solutions depending on the size of the initial energy.
Using energy methods and suitable estimates, we show that if the initial energy is below a critical level, then the solution exists globally and remains bounded for all $t > 0$.
Conversely, if the initial energy is above such a threshold, the corresponding solution blows up in finite time.
These results give new insights into how nonlinear boundary effects influence the long-time behavior of parabolic systems.

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Dynamics of Weak Solutions for a Fractional Laplacian Parabolic Equation

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Keywords: Fractional Laplacian; parabolic equations; Comparaison principale; Global existence of weak solutions

Abstract

The study of global existence and blow-up of weak solutions for parabolic equations has been extensively investigated in the literature due to its importance in understanding nonlinear diffusion and energy concentration phenomena. Y. Giga and R.V. Kohn(1987), introduced the similarity variables method, in which the blow-up behavior of solutions is characterized. Later, based on this approach, T. Cheng, H. Lan, J. Yang, and G.-F. Zheng (2013) studied the blow-up behavior of solutions to the semilinear equation

$$u_t = \Delta u + |u|^{p-1}u,\ (x,t) \in \Omega \times (0,T)$$

and they established that if Ω is star-shaped about a point $a \in \Omega$, and if $n \geq 3$ with the critical exponent $p = \frac{n+2}{n-2}$, then blow-up may occur.

Potential well theory is a powerful analytical tool in the study of nonlinear evolution equations. It was originally introduced by Sattinger (1968) in the context of nonlinear hyperbolic initial-boundary value problems. Since then, many researchers have applied and extended this theory to investigate the existence and qualitative behavior of solutions to various classes of evolution equations.

Xu, R., Cao, X., Yu, T. (2012), studied the initial boundary value problem

$$\frac{\partial u}{\partial t} = \sum_{i=1}^{N} \frac{\partial}{\partial x_i}\left(\left|\frac{\partial u}{\partial x_i}\right|^{p-2}\frac{\partial u}{\partial x_i}\right) + u^{\alpha+1}, \quad x \in \Omega, t > 0$$

They established the existence of both finite-time blow-up and global solutions at high energy levels. By combining the comparison principle with variational methods, we investigate the global existence and blow-up behavior of solutions to a nonlocal-parabolic equation.

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Efficient Numerical Schemes for Time-Fractional Integro-Differential Equations with Weak Singularities

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Keywords: ψ-Caputo fractional derivative, Fractional differential equations, Finite difference methods, Stability analysis.

Abstract
This paper presents a high-order finite difference scheme for solving time-fractional integrodifferential equations involving the generalized ψ-Caputo derivative and weakly singular ψ-fractional integrals. The proposed method utilizes $L_{1,2}$ time discretization and central difference approximations in space, enhanced by adaptive non-uniform meshes. Rigorous stability and convergence analyses confirm second-order accuracy. Numerical experiments highlight the method's effectiveness, particularly near initial-time singularities. This work provides new insights into the development of efficient solvers for generalized fractional models.

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ELLIPTIC PROBLEMS OF DIVERGENCE TYPE ON COMPACT RIEMANNIAN MANIFOLDS

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Keywords: Weak solutions, variational methods, generalized Lebesgue-Sobolev spaces.

Abstract
In this paper, we will study a second-order nonlinear elliptic problem generated by an operator of divergence type (or of Leray-Lions type):

$$\begin{cases} A(u) = f & \text{in } M, \\ u = 0 & \text{on } \partial M, \end{cases} \tag{1}$$

on (M, g) a compact Riemannian manifold and Γ its boundary.

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Empirical Investigation of Stability in Artificial Neural Networks for Seasonal Time Series Analysis

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Keywords: Time series,Automatic learning, Recurrent neural network, Long short-term memory, Machine learning

Abstract

Seasonal time series with trends are the most common data sets used in forecasting. This work focuses on the automatic processing of a non-pre-processed time series by studying the efficiency of recurrent neural networks (RNN), in particular both long short-term memory (LSTM) and bidirectional long short-term memory (Bi-LSTM) extensions, for modelling seasonal time series with trend. For this purpose, we are interested in the learning stability of the established systems using the mean average percentage error (MAPE) as a measure. Both simulated and real data were examined, and we have found a positive correlation between the signal period and the system input vector length for a stable and relatively efficient learning. We also examined the white noise impact on the learning performance.

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Evidential Markov Chain

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Keywords:Fuzzy Evidential Mass, HMC-IN, EMC-IN, Evidential Dempster-Shafer Theory, Triplet Markov Model

Abstract Hidden Markov models (HMMs) play a key role in image processing, notably in segmentation tasks for medical images (e.g., MRI), sonar imagery, and signal restoration. Here, we introduce the model of Markov *Evidential Markov Chain* (EMC), it is a recent Markov model that generalizes pairwise Markov models and, in turn, the classical HMM with independent noise. Built on Dempster-Shafer (DS) evidence theory, EMC captures both the *non-stationarity* of the hidden process X in the Markov pair (X, Y) and the *uncertainty* inherent to real data-ambiguity, imprecision, and conflicting information that standard probabilistic Hidden Markov Models struggle to represent.

In EMC, the prior probability $P(X)$ is replaced by an evidential mass $m_1(x)$, and the likelihood $P(Y \mid X)$ by a Bayesian mass $m_2(x)$. The posterior information is then obtained through DS fusion,

$$(m_1 \oplus m_2)(x),$$

which serves as the evidential counterpart of $P(X \mid Y)$.

We compare the model:*Evidentiel Markov Chain with Independent Noise (EMC-IN)* with the classical version *Hidden Markov Chain with Independent Noise(HMC-IN)*. The models are applied to segment both color and grayscale images. The performance was evaluated using PSNR (Peak Signal-to-Noise Ratio) and pixel error rate.

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TITLE

EXISTENCE OF INFINITE WEAK SOLUTIONS FOR A NONLOCAL EIGENVALUE PROBLEM IN FRACTIONAL ORLICZ-SOBOLEV SPACES WITH INDEFINITE WEIGHT.

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Keywords: *Eigenvalue problems, Infinite weak solutions, Frcational Orlicz-Sobolev spaces*

Abstract We are interested in studying the following non-local elliptic problem with Dirichlet type boundary conditions

$$\begin{cases} (-\Delta)^s_{a(.)}u + a(|u|)u = \lambda V(x)a(u) + f(x,u) & in\,\Omega, \\ u = 0 & on\ \mathbb{R}^N\backslash\Omega, \end{cases} \tag{1}$$

where Ω is a bounded open domain in $\mathbb{R}^N$ ($N \geq 3$) with smooth boundary $\partial\Omega$, $s \in (0,1)$, λ is a positive parameter, $(-\Delta)^s_{a(.)}$ is the nonlocal fractional $a(.)$-Laplacian operator introduced in [5] and defined for any $u : \mathbb{R}^N \to \mathbb{R}$ smooth enough by

$$(-\Delta)^s_{a(.)}u(x) = P.V \int_{\mathbb{R}^N} a\big(|D^s u|\big) D^s u \frac{dy}{|x-y|^N}, \quad \forall x \in \mathbb{R}^N. \tag{2}$$

Besides, V is a possibly indefinite weight function of indefinite sign, chosen in the class

$$W_A(\Omega) = \big\{ V \in L^A(\Omega) : V > 0 \ on\ a\ subset\ of\ \Omega\ with\ positive\ measure\ \big\}.$$

such choise of the weight function is a natural one.

The nonlinear term $f(x,u)$ satisfies assumption :
(H): $f(x,u)$ is locally Lipschitz continuous in u, and there exists a constant $C > 0$ such that

$$|f(x,u)| \leq C(|u|+1) \qquad for\ all\ (x,u) \in \Omega \times \mathbb{R}.$$

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EXISTENCE OF SOLUTIONS TO SYSTEMS OF FIRST-ORDER DIFFERENTIAL INCLUSIONS

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Keywords: differential inclusion, lower semi-continuous, boudary value problem, fixed point theorem, niemytzki operator, homeomorphism

Abstract

In this paper, we will establish the existence of solutions to following systems of first-order differential inclusions

$$(\phi(x(t)))' \in F(t, x(t))$$

with nonlinear differential operators satisfying the initial and terminal boundary value conditions, where $F(.,.)$ is a compact lower semi-continuous set-valued map and ϕ is an homeomorphism.

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Existence Results for Nonlinear Sequential Hybride Fractional Differential Equation based on Dhage's Fixed Point Theorem

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Key Words: *Existence; Fixed point theorem; Stability; Hybrid differential equation.*

Abstract

This paper is devoted to the existence Results to the following problem

$$\begin{cases} {}^cD^{\hat{\jmath}}\left({}^cD^{\zeta}\left(\frac{\hat{\mu}(\rho_1)}{\mathfrak{F}(\rho_1,\hat{\mu}(\rho_1))}\right) - \mathfrak{K}\left(\rho_1,\hat{\mu}(\rho_1)\right)\right) = \mathfrak{p}\left(\rho_1,\hat{\mu}(\rho_1)\right) \quad , \quad \rho_1 \in \mathbb{J} = [0,\tau] \\ \kappa_1 \frac{\hat{\mu}(0)}{\mathfrak{F}(0,\hat{\mu}(0)} + \omega_1 \frac{\hat{\mu}(\tau)}{\mathfrak{F}(\tau,\hat{\mu}(\tau))} = \ell_1, \\ \kappa_2 \, {}^cD^{\zeta}\left(\frac{\hat{\mu}(0)}{\mathfrak{F}(0,\hat{\mu}(0))}\right) + \omega_2 \, {}^cD^{\zeta}\left(\frac{\hat{\mu}(\tau)}{\mathfrak{F}(\tau,\hat{\mu}(\tau))}\right) = \ell_2, \\ \kappa_3 \, {}^cD^{\zeta}\left(\frac{\hat{\mu}(z)}{\mathfrak{F}(z,\hat{\mu}(z))}\right) + \omega_3 \, {}^cD^{\zeta}\left(\frac{\hat{\mu}(\tau)}{\mathfrak{F}(\tau,\hat{\mu}(\tau))}\right) = \ell_3, \end{cases} \tag{1}$$

where ${}^cD^{\hat{\jmath}}, {}^cD^{\zeta}$ denote the Caputo fractional derivative of orders $\hat{\jmath}$, ζ, respectively, $1 \leq \hat{\jmath} \leq 2$, $0 < \zeta \leq 1$. Dhage Fixed Point Theorem was used establish the existence of the solution. the U.H technique is employed to verify the stabiliy of this solution. Finally an application is given to illustrate our main result.

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Existence and Uniqueness Results for Intuitionistic Fuzzy Differential Equations with Integral Boundary Conditions

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Keywords: Intuitionistic fuzzy different, Intuitionistic fuzzy differential equations, Nth-order differential equations, Runge-Kutta method, numerical solution, transformation theorem.

Abstract

This paper investigates a class of second-order differential equations with integral boundary conditions. The main purpose of the study is to establish simple and verifiable conditions that guarantee the existence and uniqueness of solutions. Using fixed point theory, sufficient conditions for the solvability of the problem are derived. The existence of solutions is demonstrated through compactness arguments based on the Schauder and Leray–Schauder fixed point theorems. Furthermore, uniqueness is obtained by applying Banach's contraction principle under a suitable Lipschitz condition on the nonlinear term. To illustrate the theoretical findings, a detailed example is provided, including the explicit computation of the corresponding Green's function, the construction of the associated integral operator, and the numerical verification of the proposed hypotheses. The obtained results offer a rigorous and constructive framework for studying boundary value problems with nonlocal or integral conditions, which frequently occur in various areas of applied mathematics, physics, and engineering.

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Existence and continuous dependence results of stochastic pantograph integro-differential equation with Hilfer fractional derivative

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Keywords: Hilfer fractional derivative, stochastic pantograph equation, continuous dependence, mild solution, population dynamics, numerical simulation.

In this paper, we look at the existence and continuous dependence of solutions for stochastic pantograph integro-differential equation with Hilfer fractional derivative. The paper analyzes the existence of mild solutions through fixed-point theory while Picard operator theory demonstrates solution continuous dependence on initial conditions. The theoretical results are validated using an application.

References

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Existence of Mild Solutions for Conformable Fractional Evolution Equations with Nondense Domains

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Keywords: Caputo conformable fractional derivative, Fractional evolution equation,nondense domain .

Abstract (150–200 words)
This article investigates the existence of solutions for a class of Caputo conformable fractional evolution equations with non-densely defined operators. We first construct the integral solution of the corresponding nonhomogeneous problem by employing a combination of Laplace transform techniques and probability density functions. Building on this foundation, we utilize the method of measures of noncompactness to prove the existence of solutions for the associated nonlinear equation.

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Existence of Solutions for a Coupled Thermoelastic–Semiconductor Model

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Keywords: Thermoelasticity, Semiconductor equations, Existence of solutions, Capacity solution, Schauder fixed point theorem.

Abstract

This document gives a complete, detailed proof of the existence of a capacity solution for a coupled thermoelastic–semiconductor system with small accelerations. The model couples an elliptic equation for the electrostatic potential with parabolic drift-diffusion equations for carriers, a heat equation and a dynamic elasticity system. The proof uses regularization, a priori estimates, compactness arguments and Schauder's fixed point theorem. All estimates and intermediate steps are presented explicitly.

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Existence of Weak Solutions for Double Phase Problems with φ-Hilfer Fractional derivatives

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Keywords: Weak solutions, φ-Hilfer derivative, Double-phase problem, Topological degree theory.

Abstract
In this paper, we study the existence of weak solutions for a new class of double-phase problems driven by the φ-Hilfer fractional partial derivatives under Dirichlet boundary conditions. The analysis is carried out within an appropriate fractional functional framework and relies on topological degree theory for generalized demi-continuous operators of type (S+).

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Existence of Weak Solutions for Logarithmic Double-Phase Problems Involving Convection Terms via Young Measures

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Keywords: logarithmic double-phase operator, convection term, weak solutions, Young measures, Galerkin approximation, Musielak–Orlicz Sobolev spaces, variable exponent.

Abstract
This work focuses on a nonlinear class of elliptic Dirichlet problems driven by a logarithmic double-phase operator and influenced by a convection term depending on the gradient. By imposing appropriate growth assumptions on the convection term, we demonstrate the existence of weak solutions through the combined use of the Young measure framework and the Galerkin approximation technique. The analysis is carried out in the context of variable exponent Musielak–Orlicz Sobolev spaces.

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Existence of mild solutions for ψ-Caputo fractional integro-differential evolution problems

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Keywords: Existence of mild solutions, ψ-Caputo fractional derivative, ψ-fractional integral, C_0-semigroup, measure of noncompactness.

Abstract: The aim of this paper is to investigate the existence of mild solutions to a nonlocal ψ-Caputo fractional semilinear integro-differential evolution equation in any arbitrary Banach space. The existence of the results is proved by using the fixed point theorem for condensing maps. To illustrate our theoretical results, a non-trivial example is given as an application.

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Existence of weak solutions to fourth-order p(x)-biharmonic elliptic equations via topological degree

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Keywords: (Variable-exponent Sobolev spaces, fourth-ourder problems, topological degree methods)

Abstract This paper proves the existence of weak solutions for a class of nonlinear fourth-order differential equations. The analysis is performed within the demanding framework of Sobolev spaces with variable exponents. Our approach reformulates the problem as an equivalent abstract Hammerstein equation, which is subsequently solved using the topological degree theory.

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Fractional Musielak spaces: Analysis of non-local singular elliptic system

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Keywords: Singular problems, Fractional Musielak spaces, sub–supersolution method, variational approach.

Abstract

Our aim within the present study is to investigate the solvability of an elliptic system problem steered by the fractional $m_{x,y}(\cdot)$-Laplacian inside the fractional Musielak framework. The system is characterized by singular terms presenting both convex and concave behavior. Our strategy is based on the generalized Galerkin method, complemented by suitable perturbation arguments and comparison tools.

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Generalized solution of fractional transport equation in Colombeau algebra using fixed point

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Keywords: Generalized solution, Fractional transport equation, Colombeau algebra, Fixed point theorem, Association.

Abstract

In this paper, we study the results of the existence, uniqueness of the generalized solution to an important class for the fractional transport equation in Colombeau algebra $\mathcal{G}$. Using the fixed-point theorem and certain computational techniques with nonlinear initial conditions in the variable t. We also show the association between the classical solution and the generalized solution of the fractional transport equation.

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Global well-posedness of 3D homogeneous and inhomogeneous MHD system with small unidirectional derivative

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Keywords: Inhomogeneous MHD, Homogeneous MHD, Littlewood-Paley theory, Well-posedness, Navier-Stokes-Maxwell equations.

Abstract

In this presentation, we consider the global well-posedness of the 3D incompressible homogeneous and inhomogeneous magnetohydrodynamic (MHD) system when only one-directional derivative of the initial data is suitably small in some scaling invariant spaces.
More precisely, we prove that for a given initial density

$$a_0 = \left(\frac{1}{\rho_0} - 1\right) \in B^{\frac{3}{p}}_{p,1}(R^3),$$

and the velocity and magnetic datum

$$u_0 = (u_0^h, u_0^3) \in B^{-1+\frac{2}{p}}_{p,1}(R^3), \quad b_0 = (b_0^h, b_0^3) \in B^{-1+\frac{2}{p}}_{p,1}(R^3),$$

with $u_0^h, b_0^h \in \dot{H}^1(R^3)$.

Then the 3D inhomogeneous MHD system has a unique global solution provided that the following smallness condition holds:

$$\|a_0\|_{B^{\frac{3}{p}}_{p,1}} + \|\Lambda_h^{-1}\partial_3(u_0, b_0)\|_{B^{-1+\frac{2}{p}}_{p,1}}$$

is sufficiently small

for some bounded function f depending on the $\dot{H}^1 \cap B^{-1+\frac{2}{p}}_{p,1}$ norm of (u_0, b_0).

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Hybrid Deep Learning for Image Denoising: Balancing Noise Removal and Detail Preservation with Game Theory

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Keywords: : image denoising,multi-layer perceptron (MLP),UNet,game theory,Nash Equilibrium,image restoration.)

Abstract (*150 –200 words*)

Image denoising seeks to reduce noise while retaining fine image details—a persistent challenge in multimedia and computer vision tasks. Traditional convolutional models perform effective denoising but tend to over smooth textures. Recently, Multi-Layer Perceptron (MLP) architectures have demonstrated strong potential in image restoration. In this study, we introduce a hybrid framework that integrates an MLP-based denoising module with a U-Net-based detail preservation network. The interaction between these components is formulated within a game-theoretic setting, where noise suppression and structural fidelity are treated as competing objectives striving for a Nash equilibrium. Experiments on the Smartphone Image Denoising Dataset (SIDD) show that our method achieves higher PSNR and SSIM values compared to single-model baselines. Qualitative results further reveal sharper edges and richer textures alongside effective noise reduction. Overall, this work underscores the effectiveness of combining MLP-based architectures with game-theoretic principles for robust, detail-preserving image denoising.

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Hybrid Game-Theoretic Model with Variable-Order Fractional Derivatives for Robust Blind Image Deconvolution

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Keywords: Blind image deconvolution, Nash equilibrium, Game theory, Variable-order fractional derivatives, Image restoration, Alternating minimization.

Abstract

This paper presents a novel hybrid model for tackling the blind image deconvolution problem within the framework of Nash game theory. In the proposed formulation, the deconvolution process is modeled as a Nash game between two players: one responsible for image restoration (deblurring) and the other for estimating the point spread function (PSF) or blur kernel. The optimal solution corresponds to the Nash equilibrium, which is obtained through an alternating minimization strategy. Moreover, the proposed framework incorporates variable-order fractional derivatives to enhance the accuracy and robustness of the restoration process. Experimental results confirm the superiority of the proposed approach, producing visually improved reconstructions and higher Peak Signal-to-Noise Ratio (PSNR) values. This advancement highlights the potential of game-theoretic and fractional-order techniques to further extend the capabilities and applications of blind image deconvolution.

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Impact of External Variables on the Performance of Statistical and Artificial Intelligence Models in Time Series Forecasting

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- **Keywords:** Time Series Forecasting, SARIMAX, LSTM, Electricity Demand, External Variables

Abstract

This study examines the impact of external variables on the performance of time series forecasting models applied to electricity demand. Accurate forecasting of electricity demand is essential for management and planning, but models, whether statistical or based on artificial intelligence, can sometimes struggle to capture data distributions. To evaluate this influence, two models were studied: SARIMAX, a statistical model, and LSTM, a deep learning model, using real hourly data covering the period from January 1, 2020, to December 31, 2023. Two scenarios were compared: one without external variables and one incorporating weighted temperature and day type. The results show that including these external variables significantly improves forecasting accuracy for both models, confirming their critical role in time series modelling. This improvement highlights that accounting for relevant exogenous factors enhances the robustness and reliability of models, not only for energy forecasting but also for other complex temporal phenomena influenced by external conditions.

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Influence of Skew Angle on the Dynamic Response of High-Speed Railway Bridges

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Keywords: Railway Bridge, skew angle, dynamic, deflection, acceleration.

Abstract

The skew angle of railway bridges significantly influences their structural behavior under dynamic loading from high-speed trains. This study examines how varying skew angles affect the dynamic response of high-speed railway bridges. A mechanical model is developed to simulate the coupled train–bridge interaction. Several bridge configurations with different skew angles are analyzed to evaluate their effects on dynamic parameters, including deflections, and accelerations of bridges. The results show that increasing the skew angle significantly changes the bridges dynamic response. These findings result show the importance of accounting for skew angle in the dynamic analysis and design of high-speed railway bridges to ensure reliable and safe operation under high-speed train loads.

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Integrating Stochastic Modeling and Machine Learning for Responsive E-Health Services

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Keywords: Fog Computing, Internet of Medical Things (IoMT), Machine Learning, Stochastic Modeling, Resource Allocation, Healthcare Monitoring, Performance Optimization

Abstract

This study addresses the critical challenge of low-latency processing in modern healthcare monitoring systems within Internet of Medical Things (IoMT) environments. We propose a novel hybrid framework that integrates stochastic modeling and machine learning within a fog-cloud computing architecture. The core of our method employs a machine learning-based data segmentation approach, utilizing a k-fold Random Forest classifier to accurately categorize health data streams. Concurrently, a comprehensive queuing network model is developed to analytically capture key performance metrics, including response time and throughput, across the distributed computing layers. This model facilitates dynamic resource allocation and efficient task distribution in response to fluctuating IoMT workloads. Simulation results demonstrate the framework's high efficacy, showing a substantial 56% reduction in system latency while maintaining a 92% classification accuracy under service-level agreement constraints. The work concludes that the synergy of statistical learning and stochastic optimization provides a powerful foundation for building scalable, intelligent, and resilient e-health infrastructures capable of meeting real-time demands.

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Linear Representation of Asymmetric Pentagonal Fuzzy Numbers

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Keywords: Asymmetric pentagonal fuzzy number; Linear approximation; Fuzzy modeling; Membership function; Uncertainty representation; Fuzzy optimization; Decision-making.

Abstract

In this paper, we investigate the approximation of arbitrary fuzzy numbers using pentagonal fuzzy models based on the Euclidean distance measure. The study first examines the symmetric pentagonal fuzzy number and its approximation properties, including continuity, partial translation invariance, scale invariance, and identity. To address the limitations of symmetric representations in modeling real-world uncertainty, we further introduce a linear approximation approach for asymmetric pentagonal fuzzy numbers. The proposed model extends the classical pentagonal structure by incorporating an asymmetry parameter that allows different slopes on the left and right sides of the membership function. This enhancement enables more accurate representation of irregular and imbalanced fuzzy data. Analytical properties of both symmetric and asymmetric pentagonal approximations are discussed, demonstrating improved flexibility and computational efficiency. Finally, comparisons with traditional symmetric models and potential applications in decision-making and fuzzy optimization highlight the practical relevance and effectiveness of the proposed approaches.

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Mathematical Applications in Finance and Actuarial Science

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Keywords: New conformable fractional derivative , financial and actuarial models

Abstract

This In this study, we investigate the use of advanced fractional calculus in finance and actuarial science, focusing on the application of a recently proposed fractional derivative defined as :

$$\left(\mathcal{D}^{\beta}M\right)(t)=\lim_{h\to 0}\frac{M\left(t+he^{(\beta-1)t}\right)-M(t)}{h},$$

as outlined in [1], to model complex financial and actuarial processes exhibiting memory and hereditary properties. By integrating this novel derivative into standard models, we demonstrate enhanced flexibility and accuracy in capturing dynamic behaviors such as option pricing, risk assessment, and premium calculations. The results indicate that this approach provides a unified framework for handling both local and non-local effects in financial time series, offering potential improvements over classical integer-order methods.

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Mathematical Modeling and Numerical Simulation of cold Plasmas for new Technologies

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Keywords: Cold Plasma, CCP self-bias reactor, Mathematical Modeling, Numerical simulation, new Technologies.

Abstract
The question of clean energy has attracted the attention of many researchers. Indeed, renewable energy materials, clean hydrogen production and doping for solid state batteries become a reel challenge for energy transition using new technologies such as plasma processes. The mathematical modeling of physical plasmas is a vast field, as it seeks to describe the collective behavior of charged particles using equations derived from statistical physics, fluid mechanics, and electromagnetism. In this work, we represent the cold plasma mathematical model using continuity, momentum, and energy equations coupled with Poisson's equation. These nonlinear, dispersive and coupled system is solved using the finite element method. The results reveal the dynamic evolution of electron density, electric potential, ion flux, and ion energy in asymmetric RF capacitive coupled plasma self-bias reactors (CCP self-bias) while varying the excitation power. the analysis of these results reveals that RF CCP self-bias offer the most effective separate control of ion flux and ion energy. This capability preserves surface quality while improving surface treatment.

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Mathematical Modeling and Optimization of Solar Thermal Systems

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Keywords: Mathematical modeling, Solar energy, Thermal systems.

Abstract.

Parabolic trough collectors (PTCs) are widely utilized in solar thermal power systems due to their efficiency in harnessing solar energy. This work presents a detailed mathematical approach for modeling and optimization of a physics-based model couples heat transfer mechanisms, optical behaviour and environmental conditions for the study of efficiency and performance of solar parabolic collectors. Monte Carlo Ray Tracing (MCRT) technique with the Finite Volume Method (FVM) from computational fluid dynamics (CFD) are used to solve both opticall efficiency and conjugate heat transfer problems under varying environmental conditions and operational parameters. The proposed numerical model accounts for different design parameters and operational conditions identifing theirs influence on overall performances, as a result, the model provides valuable insights into optimal PTC configurations tailored to different climatic conditions.

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Mathematical Study of a Thermo-Viscoelastic Contact Problem Involving a Hemivariational Inequality

(*Use bold, concise, and descriptive titles using sentence case or title case, depending on the conference style guide*)

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Keywords: Variational formulation, Constituve laws,Hemivariational inequalities , Banach fixed point theorem, Galerkin's method, Clarke subdifferential.

Abstract (*150 –200 words*)
n this article, we study a class of inequality problems arising in the dynamic frictional contact between a thermo-viscoelastic body and a rigid, thermally conductive foundation. The model consists of a system comprising a hemivariational inequality of hyperbolic type for the displacement field, and a time-dependent elliptic equation for the temperature field. The contact conditions are described by a general normal damped response and a friction law expressed in subdifferential form. To establish the existence of a weak solution, we reformulate the problem as a second-order evolution inclusion for the displacement field, apply Galerkin's method to the temperature equation, and employ a fixed-point argument for the coupled system.

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Modeling Financial Market Stability Using Nonlinear Dynamic Systems with Feedback Control

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Keywords: Dynamic Systems, Financial Stability, Nonlinear Dynamics, Control Theory, Financial Modelling, Volatility.

Abstract

In this work we study a nonlinear dynamic systems model that describes financial markets. The model shows how prices and investor choices affect each other over time. First we study the well-posedness of our model and conditions of stability. Then we explore how using feedback control, like intervention policies or rules, can help keep the market steady. A numerical analysis and simulation can confirm our theoretical work. This study can help us understand the dynamics of the market and how the mathematical models can help the financial sector by offering a new innovative approach that can be used by the market institutions.

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Modeling Micropolar Fluid Flow Using a Generalized Viscosity Framework with Multivalued and Nonmonotone Slip Conditions

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Keywords: Flow micropolar model, incompressible, non-monotonic frictional law, hemivariational inequality, Clarke subdifferential, friction-type law, slip boundary condition, weak solution.

Abstract

We investigate a mathematical model for the flow of an incompressible micropolar fluid with shear-dependent viscosity in a bounded, smooth domain of $\mathbb{R}^3$[1]. The system is governed by non-standard boundary conditions: a non-homogeneous Neumann-type condition is prescribed for the angular velocity field, depending on the tangential component of the linear velocity, while a non-monotone friction law describes the slip behavior at the fluid–domain interface. The stress tensor is defined as $S(x, D(u)) = \mu_0 F(|D(u)|^2)D(u)$, where $F \in C^0(0, \infty)$ denotes a generalized viscosity function characterizing the non-Newtonian rheology of the fluid[2]. A variational formulation of the coupled system is derived, and by applying an abstract result on operator inclusions, we establish the existence and uniqueness of a weak solution to the problem.

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Modeling and Analysis of a Fractional SEIR Epidemic with Nonlinear Transmission and Treatment

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Keywords: Caputo fractional-order derivative, two-strain SEIR epidemic model, nonlinear incidence, treatment control, local and global stability

Abstract

In this work, we study a fractional two-strain SEIR epidemic model with general nonlinear incidence rates, incorporating treatment for each strain. The proposed model consists of six ordinary differential equations describing interactions among susceptible, exposed, infected, and removed individuals. We first demonstrate that the system admits a unique positive solution. Then, we investigate the local and global stability of the equilibria by constructing appropriate Lyapunov functions. Numerical simulations support the analytical results and illustrate the effect of the fractional-order derivative on convergence toward equilibria. Moreover, the efficiency of treatment in reducing the density of infected individuals is analyzed. This study provides a comprehensive framework for understanding the dynamics of multi-strain epidemics under treatment strategies, highlighting the importance of fractional-order modeling in epidemiology.

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Modélisation et simulation numérique de la dispersion de polluants provenant de sources ponctuelles continues

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Key Words: *Dispersion ponctuelle, panache Gaussien, stabilisation SUPG, θ-schéma*

Résumé:
Le travail modélise la dispersion de polluants atmosphériques émis par des sources ponctuelles continues. Le modèle résout l'équation dâadvectionâdiffusionâréaction dépendante du temps, intégrant lâadvection due au vent, la diffusion anisotrope, la dégradation chimique et une représentation régularisée de la source. Afin d'assurer la robustesse du schéma dans les régimes dominés par lâadvection, la méthode combine la stabilisation *Streamline Upwind/Petrov-Galerkin (SUPG)* avec une intégration temporelle implicite de type θ-schéma. La validation, réalisée à partir de solutions analytiques du panache gaussien, montre que le cadre reproduit avec précision les schémas de dispersion à une ou plusieurs sources, avec des erreurs relatives en norme L_2 généralement inférieures à 30 % dans les cas de diffusion modérée et inférieures à 60 % dans les régimes fortement advectifs.
Les études de raffinement de maillage confirment la convergence et mettent en évidence l'interaction entre la dynamique du panache, la vitesse du vent et la résolution numérique. Le cadre proposé constitue ainsi un outil fiable et flexible pour l'évaluation de la qualité de l'air urbain, lâanalyse des émissions industrielles et la planification réglementaire, avec des perspectives prometteuses dâextension vers le maillage adaptatif.

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Title

Monetary and fiscal policy interactions in Morocco : A Vector Autoregression (VAR) Model

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Keywords: Fiscal Policy, Monetary Policy, Interaction, Economic Growth, Morocco, VAR Model**.**

Abstract

Monetary and fiscal policies are key tools to keep a country's economy healthy. Both influence the economy, but in different ways. Monetary policy, managed by the central bank, focuses on controlling inflation and ensuring price stability, while fiscal policy, decided by the government, involves public spending and taxation to promote growth, stabilize the economy, maintain fiscal sustainability, and reduce poverty and inequality. This econometric investigation seeks to examine the interaction between fiscal and monetary policies in Morocco over the period 1980-2024.The study is situated within a national conjuncture characterized by persistent macroeconomic volatility and the imperative to reconcile price stability and development. By employing a Vector Autoregression model estimated using EViews, the stationarity of the time series was verified by means of the Augmented Dickey-Fuller (ADF) and Phillips-Perron tests. The results highlight that a positive exogenous shock to the money supply accentuates inflationary pressures in the short term but stimulates real growth in the mediumterm. Conversely, fiscal revenues exert a moderating effect on price dynamics but hinder the momentum of growth. The findings underscore the importance of coordination between the national bank and the government to optimize policy outcomes and foster economic stability.

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Keywords: Discrete problem, $p(k)$-Laplacian-like operators, critical point theory, capillary phenomena, Dirichlet condition

Abstract
In this paper, we consider a nonlinear discrete problem originated from a capillary phenomena, involving the $p(k)$-Laplacian-like operators with Dirichlet oundary condition. Under appropriate assumptions on the function f and its primitive F near zero and infinity, we investigate the existence and multiplicity of nontrivial solutions by using variational methods and critical point theory.

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Multiscale Numerical Simulation of Elastic Contact on Fractal Interfaces

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Keywords: Fractal Geometry, Multiscale Interfaces, Stress Localization, Elastic Contact, Effective Contact Law.

Abstract

This study presents a novel numerical framework for simulating the mechanical behavior of elastic materials with fractal contact interfaces, inspired by Apollonian packings. Utilizing a two- dimensional plane strain model, we approximate the fractal interface through a multiscale arrangement of circles generated iteratively. The governing Navier equations are discretized using centered finite differences on a structured grid, resulting in a sparse linear system that is efficiently solved with direct or iterative methods.

Our parametric analysis reveals that high-stress concentrations occur at multiscale contact zones, with maximum stress values increasing with higher iteration levels, while total elastic energy stabilizes, indicating convergence towards an effective contact law.

The findings demonstrate that fractal geometry significantly influences stress localization and distribution, providing insights into the mechanical properties of materials with complex interfaces. This framework serves as a computationally efficient tool for exploring the impact of multiscale geometries on contact mechanics, with potential applications in material design and microtechnology.

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Non-Newtonian squeeze film lubrication in magnetohydrodynamic journal bearings: A numerical study

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Keywords: Journal bearings, Magnetohydrodynamic, Non-Newtonian fluids, Modified Reynolds equation, Squeeze film, Numerical study, Finite difference method.

Abstract

This study presents a numerical model investigating the effects of magnetohydrodynamics on finite journal bearings under squeeze-film condition and lubricated with non-Newtonian fluids. Based on the governing equations of magnetohydrodynamics and the theory of Stokes, a modified Reynolds equation is established in the form of a partial differential equation. This equation is discretized using the numerical differentiation scheme, and the resulting algebraic system is solved iteratively via the Gauss–Seidel technique to determine the pressure film distribution. The load capacity and squeeze time are then calculated using the trapezoidal rule and analyzed for three values of Hartmann number and couple stress parameter, which respectively characterize MHD impacts and the the non-Newtonian behavior. The numerical results show that, relative to previous studies on finite journal bearings using non-Newtonian lubicants, the introduction of MHD impacts significantly enhances both load capacity and squeeze time, highlighting the importance of their combined influence on tribological performance.

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Nonlinear Parabolic Problems with L^1 Data in Generalized Orlicz Spaces

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Keywords: Inhomogeneous Musielak-Orlicz-Sobolev spaces, Parabolic problems, Musielak-Orlicz function, Renormalized solutions, Lower order term.

Abstract

In this research, we study a class of nonlinear parabolic equations involving two lower-order terms in the framework of inhomogeneous Musielak–Orlicz spaces. The main operator is of Leray–Lions type, characterized by nonstandard growth conditions, while the nonlinear term is assumed to be integrable and to satisfy a natural sign condition. The right-hand side of the equation belongs to $L^1(Q)$, which prevents the use of classical weak formulations. To overcome this difficulty, we employ the concept of renormalized solutions, which provides an appropriate analytical setting for problems with low regularity data. The proof is based on truncation and modular approximation techniques, together with compactness and monotonicity arguments adapted to the Musielak–Orlicz framework. No Δ_2-condition is imposed on the Musielak function, which makes the analysis applicable to a wide class of nonlinearities. Our results extend and generalize several previous existence theorems for nonlinear parabolic problems with nonstandard growth and measure-type data.

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Numerical Simulation of Biphasic Immiscible Flow in Porous Media: A Comparative FEM–FVM Study

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Keywords: Immiscible flow, porous media, finite element method, finite volume method, IMPES, numerical simulation, hybrid FEM–FVM

Abstract

This paper analyzes immiscible two-phase flow in porous media through a comparative numerical study using the finite element method (FEM) and the finite volume method (FVM). The governing equations, derived from mass conservation and Darcy's law, are solved using an IMPES (Implicit Pressure, Explicit Saturation) scheme, which treats pressure implicitly and saturation explicitly. FEM is employed to compute smooth and accurate pressure fields, while FVM captures sharp saturation fronts and ensures local mass conservation. Numerical experiments include the one-dimensional Buckley–Leverett displacement and two-dimensional heterogeneous permeability cases. Results demonstrate that FEM excels in producing precise pressure distributions, whereas FVM effectively handles discontinuities in saturation. The study highlights the complementary advantages of each method and discusses the potential of hybrid FEM–FVM strategies for improved simulation reliability and accuracy. These findings provide valuable insights for modeling multiphase flow in complex porous media and establish a solid foundation for future adaptive and large-scale numerical simulations in realistic geological formations.

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Numerical Study and Comparative Modeling of the Hygrothermal Behavior of Two Bio-Based Materials According to Künzel Model

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Keywords: Finite difference method , hempcrete , hygrothermal behaviors, straw bale .

Abstract

This research focuses on predicting the response of bio-based materials exposed to coupled heat and moisture transfer — a critical aspect in minimizing energy losses, preventing material deterioration, and enhancing indoor comfort. To simulate these coupled transfers, the study applies the Künzel model, which accounts for the main hygrothermal properties of materials, namely thermal conductivity, moisture diffusivity, and heat capacity.

The two-dimensional (2D) simulations, carried out using the finite difference method, offer a realistic assessment of coupled heat and moisture transfers under variable climatic conditions, allowing a detailed comparison between hempcrete and straw bale. The results highlight the complementary hygrothermal behaviors of the two materials: hempcrete demonstrates a thermal inertia approximately 2.5 times greater than that of straw bale, making it more effective for regions with pronounced temperature fluctuations to help stabilize indoor conditions. Conversely, straw bale shows a much higher moisture diffusivity—about five times greater—enabling faster drying and making it particularly suitable for humid climates.

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Numerical analysis of buckling and postbuckling of functionally graded material beams

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Keywords: Buckling, Postbuckling, Asymptotic numerical method, Finite element method, Geometric nonlinearty

Abstract

This study investigates the buckling and postbuckling behavior of functionally graded material beams. The kinematic formulation of the beam is developed within the framework of the first order shear deformation theory, while the effective material properties are characterized by a power-law distribution through the thickness. Based on the principle of minimum potential energy, the governing equations are formulated using the von Kármán strain–displacement relationship to account for geometric nonlinearity. Since the analytical solution of this type of equation is difficult or even impossible to obtain, the Asymptotic Numerical Method is employed as the solution procedure. This method involves three main steps: the representation of the unknowns as a Taylor series expansion, the discretization of the domain, and the application of a continuation technique. he effects of boundary conditions, power-law index, and aspect ratio on the buckling and post-buckling behavior are examined. Moreover, the accuracy and robustness of the proposed approach are validated through numerical examples.

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Numerical modeling of rough hydrodynamic journal bearings lubricated with a ferrofluid

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Keywords: Surface roughness, Finite hydrodynamic journal bearing, Dynamic performance, Stability map, Ferrofluid, Shliomis model

Abstract

This study investigates the effect of surface roughness on the dynamic behavior of finite hydrodynamic journal bearings lubricated with ferrofluids. The Christensen stochastic model is employed to describe the influence of surface roughness, while the Shliomis model accounts for the rotation and magnetic moments of ferromagnetic particles. A magnetic field is generated by a finite-length conducting wire carrying an electric current and placed at an optimal angle outside the rough bearing. The pressure distribution in the lubricant film is obtained by numerically solving the modified stochastic Reynolds equations for both longitudinal and transverse roughness orientations. The dynamic coefficients are evaluated using the perturbation method, enabling the determination of the whirl frequency and critical mass used to construct the stability map of the bearing. The proposed model is validated

through numerical experimental analyses under specific operating conditions. Results indicate that transverse surface roughness significantly enhances bearing stability, particularly at high relative eccentricities, whereas longitudinal roughness reduces it. These findings highlight the essential role of surface roughness in improving the stability and tribological performance of ferrofluid-lubricated hydrodynamic journal bearings.

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ON COMMUTING LIKE ELEMENTS IN PRIME RINGS

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Keywords: Prime ring, derivation, central elements, center of a ring.

Abstract

The principal aim of this paper is to study some differential identities on prime rings and their significant role in characterizing central elements for this class of rings. Moreover, we also present a classification of the involved additive mappings.

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On the Existence, Uniqueness, and Stability of Solutions to a Nonlinear Sequential ψ-Caputo Fractional Problem

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Keywords: Fractional-order differential equations; Existence results; Stability criteria; Fixed point theorems; Krasnoselskii's theorem.)

Abstract The primary objective of this study is to derive existence results and stability criteria for a non -linear sequential ψ-Caputo fractional differential equation by employing fixed point theorems. The existence results are established using Krasnoselskii's fixed point theorem, the Banach contraction principle, which provide a solid theoretical foundation for analyzing such equations. Special emphasis is placed on the application of Krasnoselskii's fixed point theorem to determine stability criteria for a specific class non -linear sequential ψ-Caputo fractional differential equation, offering a novel approach to addressing stability concerns in this context. To illustrate the practical relevance of the theoretical findings, an example is provided, demonstrating the effectiveness and applicability of the derived stability result in real-world scenarios.

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On the Set of Artinian Subrings

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Keywords : Zero-dimensional ring, Artinian ring, Directed union of Artinian subrings, Infinite products, Ring extensions.

Abstract : Given a commutative ring R, we investigate the structure of the set of Artinian subrings of R, $\mathcal{A}(R)$. We begin by revisiting foundational questions, establishing the fundamental conditions that govern the existence of Artinian subrings by linking their presence to zero-dimensionality and properties of the residue fields.

We examine this topic in two main contexts. First, we analyze the set of *intermediate* Artinian subrings for a ring extension $R \hookrightarrow T$. We present general conditions for when such intermediate subrings exist, particularly in the context of reduced rings and their overrings.

We also investigate the challenging case of *infinite products* of rings, $R = \prod R_\alpha$, exploring the conditions under which such products admit Artinian subrings. Finally, we conclude by examining key structural questions related to $\mathcal{A}(R)$, including its closure properties and the concept of rings as *directed unions* of their Artinian subrings.

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Optimal control problem of a class of fractional bilinear systems

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Keywords: (diffusion equation, bilinear control fractional optimal control, Riemann-Liouville fractional derivative, controllability)

Abstract
In this work, we study a fractional diffusion equation involving the Riemann-Liouville fractional derivative of order $\alpha \in (0,1)$. Fractional equations are useful for describing phenomena where the past influences present behavior. We begin by proving that the equation is well defined. Using eigenfunction expansions, we can write the solution in explicit form and better understand the dynamics of the system. Next, we prove that by choosing the control correctly, it is possible to approximate the fractional integral of order $1-\alpha$ of the state at the final time by a desired state. This means that we can influence the behavior of the system to almost reach the set objective. Finally, we provide a characterization of optimal control using an optimality condition that allows us to explain the form of this control that minimizes the given cost

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Optimal Detection of Threshold Effects in Regression Models with Bilinear Dependent Errors

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Keywords: Threshold effects, local asymptotic normality, pseudo-Gaussian tests, short panel data, first-order super-diagonal bilinear model

Abstract

This study investigates the existence of a threshold in a regression framework with first-order super-diagonal bilinear panel dependent errors. Specifically, it tests a classical regression model against a threshold specification under dependent errors in a short-panel context, characterized by a large cross-sectional dimension (n) and a small time dimension (T). We develop a parametric testing procedure that is locally and asymptotically optimal under Le Cam's theoretical framework, with the pseudo-Gaussian test serving as a specific case. Monte Carlo simulation results provide strong evidence of the effectiveness and robustness of the proposed approach.

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Optimal control of chronic hepatitis C and its treatment on the development of tuberculosis

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Keywords: Hepatitis C, Tuberculosis, Sensitivity, Mathematical modeling, Optimal control, Pontryagin maximum principle

Abstract

This study presents a mathematical model with eight compartments that describes the transmission dynamics of tuberculosis (TB) among individuals infected with chronic hepatitis C. The work investigates two main scenarios: the dynamics of TB in patients chronically infected with HCV and in those receiving direct-acting antiviral (DAA) treatment. The formulated model is analyzed mathematically by proving the existence of a unique solution and establishing the positivity and boundedness of all system variables, ensuring its epidemiological validity. Moreover, the model is extended to an optimal control problem incorporating three control strategies—awareness, treatment, and early detection—aimed at minimizing the prevalence of TB among HCV-infected individuals. Pontryagin's Maximum Principle is employed to derive the necessary conditions for optimal control. Numerical simulations are carried out using MATLAB to illustrate the theoretical results. The findings demonstrate that the combined application of treatment, early detection, and awareness significantly reduces TB transmission in HCV-infected populations compared with scenarios without control, leading to improved public health outcomes.

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Powering Industrial Maintenance with Artificial Intelligence

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Keywords: Predictive Maintenance, Industry 4.0, Artificial Intelligence, Machine Learning, CyberPhysical Systems,Data Fusion, Real-Time Analytics.

Abstract

The field of industrial maintenance is undergoing a transformative shift, moving from reactive approaches to intelligent, predictive strategies powered by the integration of real-time data and advanced analytics, key pillars of Industry 4.0. At the core of this transformation is Predictive Maintenance (PdM), enhanced by Artificial Intelligence (AI) and Cyber-Physical Systems (CPS). This paper presents a comprehensive review of recent PdM technologies and proposes a novel modular, cloud-based architecture to address current limitations. PdM is no longer limited to failure prediction but is now central to enterprise-wide decision-making, impacting operational efficiency, safety, and sustainability. While AI models like ANNs and Random Forests are widely adopted, their implementation faces significant hurdles. Specifically, scalability and data integration remain critical bottlenecks, especially in heterogeneous environments with legacy systems, leading to costly delays and operational risks. To overcome these challenges, our proposed architecture leverages cyber-physical agents to ensure interoperability and real-time data fusion, enabling more adaptive and robust maintenance strategies.

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Properties Around The First Eigenvalue Of A Partial Discrete Dirichlet Boundary Value Problem and Applications

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Keywords: Partial discrete Dirichlet problem, first eigenvalue, simplicity, critical point theory

Abstract

Let λ be a positive parameter and $\mathbb{Z}[N, M]$ represent the discrete interval $\{N, N+1, ..., M\}$, where N and M are integers and $N < M$. We consider the following partial discrete problem

$$(P_\lambda)\begin{cases} -\Delta_1(\varphi_p(\Delta_1 x(i-1,j))) - \Delta_2(\varphi_p(\Delta_2 x(i,j-1))) = \lambda m(i,j)\varphi_p(x(i,j)), \\ \qquad\qquad\qquad\qquad\qquad\qquad (i,j) \in \mathbb{Z}[1,\alpha]\times\mathbb{Z}[1,\beta], \\ x(0,j) = x(\alpha+1,j) = 0, \quad j \in \mathbb{Z}[1,\beta], \\ x(i,0) = x(i,\beta+1) = 0, \quad i \in \mathbb{Z}[1,\alpha], \end{cases}$$

where $\alpha, \beta \geq 2$ are fixed positive integers, Δ_1 and Δ_2 denote the forward difference operators defined by $\Delta_1 x(i,j) = x(i+1,j) - x(i,j)$ and $\Delta_2 x(i,j) = x(i,j+1) - x(i,j)$, $m \in M_+ =: \{m : \mathbb{Z}[1,\alpha]\times\mathbb{Z}[1,\beta] \to \mathbb{R} / \exists (i_0, j_0) \in \mathbb{Z}[1,\alpha]\times\mathbb{Z}[1,\beta] : m(i_0,j_0) > 0\}$, φ_p denotes the p-Laplacian operator, defined by $\varphi_p(u) = |u|^{p-2}u$ and $1 < p < \infty$.

Our study focuses on some results concerning the first eigenvalue $\lambda_{1,m}$ of the problem (P_λ). More precisely, in this article, we investigate the simplicity of $\lambda_{1,m}$, the constant sign of the first eigenfunction associated with $\lambda_{1,m}$, the strict monotonicity characteristic concerning the weight m and sign change of any eigenfunction associated with $\lambda > \lambda_{1,m}$. Finally, we prove the existence and multiplicity of solutions for the partial discrete Dirichlet problem involving a nonlinearity f, in relation to the first eigenvalue $\lambda_{1,m}$. by using the critical point theory. Specifically, we develop a variational framework for the partial discrete Dirichlet problem and reduce the search for solutions to the search for critical points of the associated variational functional.

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Quasi-Einstein locally conformaly Kähler manifolds

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Keywords: Locally conformally Kähler manifolds, Quasi Einstein metrics, Vaisman manifolds, Einstein-Weyl structures, Hopf manifolds.

Abstract

We establish a fundamental equivalence between quasi-Einstein locally conformally Kähler (LCK) structures and Hermitian Einstein-Weyl structures. Leveraging this equivalence, we prove that any quasi-Einstein LCK manifold must be globally conformal to a Secondary Hopf manifold. This result leads to a complete and explicit classification of all quasi-Einstein Vaisman manifolds.

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Semigroup Approach to Semilinear Fractional Evolution Systems with Variable-Order Φ-Caputo Derivatives and Kernel Operators

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Keywords: Evolution equation, Φ-Caputo fractional derivative, variable-order derivative, kernel operator, fixed-point theorem.

Abstract (150–200 words)

This research focuses on a detailed investigation of the existence and uniqueness of mild solutions to initial value problems for semilinear fractional evolution systems involving a kernel operator and a variable-order Φ-Caputo derivative. Specifically, we derive the solution formula in terms of the semigroup generated by the resolvent and the Φ-function associated with the Caputo fractional derivative, using the generalized Laplace transform method along with the aid of certain probability density functions. To establish the existence of solutions, we utilize Krasnoselskii's fixed point theorem, while Banach's fixed point theorem is employed to confirm uniqueness. Finally, we illustrate the main results and their implications within the context of semigroups and variable-order fractional derivatives through a concrete example.

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Solving Fuzzy Fractional Differential Equations via Laplace Transform in the Sense of ψ-Caputo gH-Differentiability

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Keywords: Laplace Transform; Fuzzy Fractional Differential Equations; ψ-Caputo Derivative; gH-Differentiability; Fuzzy Calculus; Fractional Dynamics; Analytical Solution.

Abstract

This paper presents a novel approach for solving fuzzy linear fractional differential equations (FLFDEs) using Laplace transforms under ψ-Caputo-type generalized Hukuhara (gH)-differentiability. We extend the classical ψ-Caputo fractional derivative to the fuzzy context through gH-differentiability, which provides a more flexible framework for handling fuzzy-valued functions. The proposed method leverages fuzzy Laplace transforms to convert FLFDEs into algebraic equations, which are then solved numerically. We demonstrate the effectiveness of our approach through several examples, comparing the numerical solutions with exact solutions where available. The results show that our method provides accurate approximations while maintaining the fuzzy nature of the solutions. Potential applications in engineering and physics are discussed, along with computational considerations and limitations.

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Some Properties of the $\mathscr{F}_\kappa(I)$-limit Topology

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Keywords: Infinite cardinals, $\mathscr{F}_\kappa(I)$-limit, $\mathscr{F}_\kappa(I)$-limit topology, Topological properties.

Abstract. In this work, we study some properties of the $\mathscr{F}_\kappa(I)$-limit topology defined on the spectrum of a commutative ring. We begin by defining the $\mathscr{F}_\kappa(I)$-limit of a family of prime ideals, then introduce the notion of a closed set based on this construction. We show that these closed sets form a topology on the spectrum, called the $\mathscr{F}_\kappa(I)$-limit topology. Several concrete examples are presented, including the ring of holomorphic functions on an open subset of $\mathbb{C}$ and the ring of continuous functions from $\mathbb{R}$ to $\mathbb{R}$. Finally, we examine some topological properties of this topology.

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Spatio-Temporal Interpolation Method Applied to Remote Sensing: Evidence from the Moroccan Atlas Mountains

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Keywords: Spatio-Temporal Autoregressive Model, Interpolation, Remote Sensing Data, Normalized Difference Snow Index, Snow Cover Mapping

Abstract

This study presents a spatio-temporal interpolation approach for regular-grid NDSI (Normalized Difference Snow Index) pixels in the Moroccan Atlas Mountains using the quadrant spatio-temporal autoregressive (QSTAR) model. The method was evaluated through a two-step assessment to examine its stability under different climatic and topographic conditions. First, artificial gaps were introduced into three Moderate Resolution Imaging Spectroradiometer (MODIS) NDSI image clips representing high, moderate, and limited snow cover within the test area, supported by Monte Carlo simulations to avoid biased gap selection. From both classification and regression perspectives, the evaluation was conducted to assess the impact and accuracy of the interpolation. The results showed strong and stable performance, even with up to 50% missing pixels, with mean classification accuracy exceeding 97%, mean R^2 exceeds 0.78, and mean MAE range from 2.89% to 7.77%. Secondly, heterogeneity was evaluated across four topographically distinct regions by interpolating missing pixels and deriving the snow cover area for selected images. Compared with high-resolution Sentinel-2 data, which does not provide daily coverage, QSTAR showed strong agreement and generally outperformed the Elevation and Nearest Neighbor Spatio-Temporal (ENST) method, with lower errors and similarly high correlation across all regions. Overall, the QSTAR method is simple and fast in terms of structure and complexity, demonstrating strong and stable performance under varying climatic and topographic conditions, outperforming the ENST method and does not require the elevation variable to achieve high performance.

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Spectral Inclusion Relations for Exponentially Bounded C-Semigroups

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Keywords: C-semigroup, Kato operator, Saphar operator.

Abstract

In 1989 Ki Sik Ha [3], proved that if A is a generator of an exponentially bounded C-semigroup $(S_t)_{t\geq 0}$ in a Banach space, and let $T_t = C^{-1}S_t$, for all $t \geq 0$, then the spectral mapping theorem such as $e^{t\sigma(A)} \subset \sigma(T_t)$ and $e^{t\sigma_p(A)} \subset \sigma_p(T_t) \subset e^{t\sigma_p(A)} \cup \{0\}$, for all $t \geq 0$ hold. In the present work, we will extend the results of [3] for Saphar, essentially Saphar, Kato, and essentially Kato spectrum.

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Stability and numerical result of a thermoelastic Timoshenko suspension bridge with second sound

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Keywords: Suspension bridge, Timoshenko beam, second sound, Exponential stability, numerical analysis.

Abstract (150–200 words)
In this work, we study a mathematical analysis of a model representing a one-dimensional suspension bridge. The model takes into consideration the vibration of the bridge deck in the vertical plane modeled as an extensible thermoelastic beam. The main cable is modeled as an elastic string and is connected to the roadbed through a distributed system of linear elastic springs. The heat conduction is given by Cattaneo's law. We prove the existence and uniqueness of solutions of the system by using the semigroup theory. By introducing a number X_0 that characterizes the exponential decay, we prove that the corresponding semigroup associated to the system is exponentially stable if and only if $X_0 = 0$. Otherwise, we prove polynomial stability with an optimal rate. Finally, numerical analysis is performed using the finite element method for spatial discretization and the implicit Euler scheme for time integration. A priori error analysis and numerical simulation results are presented.

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Stochastic SEIR Optimal Control for Public Health Strategies

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Keywords: stochastic optimal control, SEIR model, epidemic modeling, mask-wearing, active testing, Pontryagin maximum principle, stochastic differential equations

Abstract
We analyze the effectiveness of two low-cost non-pharmaceutical interventions—mask-wearing and active testing/screening—for mitigating epidemic spread once transmission is already established. We develop a stochastic SEIR model in which these interventions appear as bounded control functions acting on transmission and detection/removal mechanisms. An adaptation of Pontryagin's maximum principle to stochastic systems is employed to derive the optimality conditions, and the resulting forward–backward system is solved numerically using a Forward–Backward Sweep Method coupled with a stochastic Runge–Kutta integrator. Numerical experiments across a range of basic reproduction numbers and noise intensities indicate that a coordinated deployment of mask-wearing and active testing substantially lowers peak prevalence and the cumulative exposed/infected burden under realistic budget constraints. The optimal policies typically follow bang–bang or singular–arc structures depending on parameter regimes and cost weights. These results highlight that, even in resource-limited settings, carefully timed and jointly optimized mask usage and active screening can yield significant public-health gains while maintaining manageable implementation costs.

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Study of a $p(x)$-biharmonic problem with a singular perturbation

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Keywords: Variational methods, singular problem, $p(\cdot)$-biharmonic operator,weak solutions, No-flux boundary conditions.

Abstract: Using the classical theorem of calculus of variations and the mointain pass type theorem, we show the existence and multiplicity of solution for p(x)-biharmonic problem involving Hardy type potential with no-flux boundary condition.

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The mechanical strength of rammed earth reinforced with straw

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Keywords: (rammed earth, strength, reinforced, straw fibers, CO2 emissions, mathematical models, numerical simulations)

Abstract

Earthen constructions are the oldest techniques used by humans to build their civilization, and several local materials are used to enhance their performance. However, since the end of the 19th century, people have converted their constructions into concrete, which consumes a crucial percentage of energy [1]. Because rammed earth emits fewer carbon emissions than other traditional materials, its use has gained popularity since the onset of climate change. Boosting its performance is mandatory to keep up with the needs of modern construction, especially since rammed earth is a brittle material with low tensile strength compared to conventional concrete [2], which can be reinforced with steel, unlike rammed earth. The latter can be reinforced with natural fibers, such as straw, which can enhance its tensile compressive and shear strength, especially as a local material with low CO2 emissions . Although earthen constructions are easy to set up, build, and maintain, they are too complex to define and analyze their features, as well as their mathematical models and numerical simulations [3], [4].

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Ulam-Hyers Stability and Existence Results for ϑ-Hilfer Hybrid Iterative Fractional Differential Equations in a Weighted Space

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Keywords: ϑ-Hilfer fractional derivative, Hybrid iterative functional differential equations, Fixed point, Weighted Space, Ulam-Hyers stability.

Abstract This paper investigates the existence, uniqueness, and stability of solutions for a class of ϑ-Hilfer hybrid iterative functional differential equations, which merge fractional calculus with iterative and hybrid differential equations. Using Dhage's theorem and fixed-point techniques, we establish rigorous existence and uniqueness results in the weighted space $\mathcal{D} = C_{2-z;\vartheta}([0, \mathcal{V}])$. Various forms of Ulam-Hyers stability are analyzed under suitable conditions. To validate the theoretical findings, we present an efficient numerical example, illustrated through a table and a graph.

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Weak Solution, Existence, Uniqueness, and Optimal Control for the Fractional Navier–Stokes Equations

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Abstract

This work focuses on the mathematical analysis of the *fractional* Navier–Stokes equations, which describe the motion of incompressible viscous fluids with anomalous diffusion effects modeled by fractional derivatives. We first introduce the concept of weak solutions and discuss their existence based on the classical results of Leray and Hopf, extended to the fractional setting. The question of uniqueness, which remains one of the most challenging open problems in fluid mechanics, is also addressed. Finally, we study an optimal control problem associated with the fractional Navier–Stokes system, highlighting existence results and the necessary optimality conditions.

Keywords: Fractional Navier–Stokes equations, weak solutions, existence, uniqueness, optimal control, partial differential equations.

1. Introduction

The Navier–Stokes equations form the cornerstone of fluid mechanics and play a crucial role in both theoretical and applied mathematics. Despite their apparent simplicity, the analysis of their solutions presents deep mathematical challenges. In particular, the questions of global existence and uniqueness of weak solutions in three dimensions remain open and are among the Millennium Prize Problems. The fractional variant introduces additional complexity but also offers refined modeling of turbulence and anomalous diffusion phenomena.

XFEM Simulation of Crack Propagation under Coupled Thermo-Mechanical Fields in Friction Stir Welded Aluminium Joints

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Keywords: Friction Stir Welding (FSW), Thermo-Mechanical Modeling, Residual Stresses, Crack Propagation, XFEM-Level Set Method

Abstract

Friction Stir Welding (FSW) is an advanced solid-state technique used to join lightweight metals (aluminium, copper, magnesium, steels) without melting, relying instead on frictional heat and intense plastic flow. Verma et al. [1] confirmed its growing industrial significance, while several authors [2-3] investigated microstructural evolution, joint design, and the role of rotational shear. Meng et al. [4] analyzed key practical challenges, including temperature control and defect formation. Recent studies have highlighted the thermal asymmetry between the advancing side (AS) and retreating side (RS), which strongly influences joint quality [5-8].

The present study proposes a fully coupled numerical approach to assess the combined influence of FSW parameters and temperature on crack propagation in a welded aluminum plate. An explicit finite element model developed in Abaqus accurately simulates the plunge, dwell, and traverse phases, and the resulting thermo-mechanical fields are integrated into a crack propagation analysis using the XFEM–Level Set method. The model incorporates complex residual stresses, spatial temperature gradients (293–700 K), and mixed-mode (I + II) fracture behavior. Results show that tensile residual stresses accelerate crack growth, while compressive stresses slow or suppress it. Optimizing key parameters (2.6–3.5 mm plunge depth; ~800 rpm rotation speed) helps reduce thermal gradients and residual stress concentrations, thereby improving the fracture resistance and structural integrity of FSW joints.

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