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Book of Abstracts

F2MDays
Franco-Moroccan Mathematics Days

Franco-Moroccan Mathematics Days (F2MDays'25)

Second Edition

Mathematics for everyone and everywhere

Faculty of Sciences - Tetouan

Abdelmalek Essaadi University

May 13-16, 2025

Synopsis

The Department of Mathematics at the Faculty of Sciences, Tétouan, Abdelmalek Essaadi University, is pleased to announce the organization of the second edition of the international congress Franco-Moroccan Mathematics Days (F2MDays'25).This event is jointly organized with the Laboratory of Analysis, Geometry and Applications (LAGA), Sorbonne Paris Nord University. It will take place from May 13 to 16, 2025, at the Faculty of Sciences, Tétouan.

This scientific congress provides researchers with the opportunity to explore the latest advancements in mathematical research. Through its workshops and plenary sessions, participants will have the chance to enhance their skills in scientific mediation and strengthen their understanding of complex mathematical concepts. Additionally, the congress promotes the dissemination of high-quality research, thereby contributing to the advancement of Mathematics worldwide. This scientific meeting will not only reinforce the bonds between the French and Moroccan mathematical communities but also will play a key role in advancing Mathematics on an international scale. The mathematics community is warmly invited to take part in this prestigious event. Outstanding contributions will be considered for publication in internationally indexed journals, as part of the call for papers open to mathematical researchers.

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Nour Eddine Alaa	UCA, Morocco
El Houssine Azroul	USMBA, Morocco
Mostafa Bendahmane	BU, France
Igor Chollet	USPN, France
Rachid El Harti	UH1, Morocco
Khalil Ezzinbi	UCA, Morocco
Houssain Kettani	AUI, Morocco
Olivier Lafitte	USPN, France
Lahcen Maniar	UCA, Morocco
Benoit Rittaud	USPN, France
Laurent Vivier	UPD, France
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Samir Tallay	UAE	Chihab Yazough	USMBA

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Part I

Keynote Speakers

1 On a Fractional Reaction-Diffusion System Applied to Image Restoration and Enhancement

Professor Noureddine Alaa

Laboratory LAMAI, Faculty of Sciences and Techniques, Cadi Ayyad University, Marrakesh, Morocco

Abstract

In this talk, we introduce a novel reaction-diffusion system governed by the fractional Laplacian for digital image restoration and contrast enhancement.

Our model employs a Sobolev-type fractional semi-norm, which offers several significant advantages: it preserves high-frequency edge features while simultaneously enhancing low-frequency texture details in smoother regions. The fractional Laplace operator in our formulation depends solely on pixel location and gray-level intensity.

By incorporating a reaction term into the model, we further improve contrast enhancement and overall image quality. Based on these features, we demonstrate that the proposed model is well-posed. As a first result, we establish the existence of a weak solution under the assumption that the reaction terms are bounded. Then, using an approximation approach, we prove the existence of a weak, non-negative SOLA (Solution Obtained as the Limit of Approximations) for the model.

Finally, numerical experiments show that our model outperforms existing approaches in the literature, particularly in image enhancement and denoising tasks.

2 Fractional Modeling of Complex Biological Dynamics: From Blood Cells to Epidemics

Professor El Houssine Azroul

Laboratory MAA, Faculty of Sciences Dhar El Mahraz, Sidi Mohamed Ben Abdellah University, Fez, Morocco

Abstract

Fractional calculus has emerged as a powerful tool for modeling complex biological systems, especially when memory and hereditary properties play a crucial role. In thistalk, we explore the impact of memory effects introduced via fractional derivatives in the study of three significant biological phenomena: the deformation of red blood cells under flow conditions, the spread of cassava disease in agricultural environments, and the dynamics of HIV infection within a host. By employing fractional-order models, we capture behaviors that are not observable through classical integer-order systems. Through analytical and numerical investigations, we demonstrate how incorporating memory leads to a richer and more accurate description of these biological processes. This interdisciplinary approach opens new pathways for understanding and predicting the dynamics of deformable particles and disease propagation in complex systems.

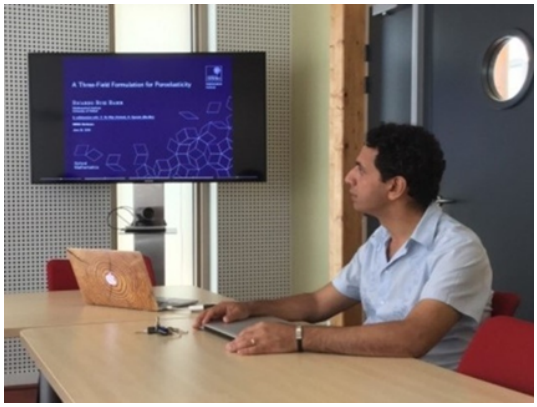
3 Stochastic Electromechanical Bidomain Model in Electrocardiology

Professor Mostafa Bendahmane

Institut de Mathématiques de Bordeaux, Université de Bordeaux, 33076 Bordeaux Cedex, France

Abstract

We analyze a system of nonlinear stochastic partial differential equations (SPDEs) of mixed elliptic-parabolic type that models the propagation of electric signals and their effect on the deformation of cardiac tissue. The system governs the dynamics of ionic quantities, intra and extra-cellular potentials, and linearized elasticity equations. We introduce a framework called the active strain decomposition, which factors the material gradient of deformation into an active (electrophysiology-dependent) part and an elastic (passive) part, to capture the coupling between muscle contraction, biochemical reactions, and electric activity. Under the assumption of linearized elastic behavior and a truncation of the nonlinear diffusivities, we propose a stochastic electromechanical bidomain model, and establish the existence of weak solutions for this model. To prove existence through the convergence of approximate solutions, we employ a stochastic compactness method in tandem with an auxiliary non-degenerate system and the Faedo-Galerkin method. We utilize a stochastic adaptation of de Rham's theorem to deduce the weak convergence of the pressure approximations.



4 Efficient Simulation of Quantum Circuits

Professor Igor Chollet

Institute of Computational and Data Sciences (ISCD), INRIA Alpines, Paris, France.

Abstract

This presentation is intended as an introduction to quantum computing. We will show how the mathematics of high-performance computing can be applied in this field. In particular, the challenge will be to present the algebraic structures involved in formulating quantum algorithms in circuit form and how these circuits can be classically simulated. We will present simple quantum algorithms to illustrate the discussion. Finally, we will outline how certain classical problems can be implemented on quantum architectures.

5 Crossed product Banach algebras associated with dynamical systems

Professor Rachid El Harti

Department of Mathematics and Computer Sciences, Faculty of Sciences and Techniques, University Hassan I, BP 577, Settat, Morocco

Abstract

From a locally compact group, a concrete Banach algebra, and an action of this group on this algebra, we construct an equally concrete algebra called Crossed Product Banach algebra associated with a dynamical system.
The study of this class of algebras plays a very important role in abstract harmonic analysis and representation theory. Moreover, we wonder when this class is Hermitian or amenable.

6 Reduction of Complexity for Partial Differential Equations, New Results and Open Problems

Professor Khalil Ezzinbi

Departement of Mathematics, Faculty of Sciences Semlalia, Cadi Ayyad University, Marrakesh, Morocco

Abstract

In this work, we prove the existence of a center manifold for some partial functional differential equations, whose linear part is not necessarily densely defined but satisfies the Hille-Yosida condition. The attractiveness of the center manifold is also shown when the unstable space is reduced to zero. We prove that the flow on the center manifold is completely determined by an ordinary differential equation in a finite dimensional space. In some critical cases, when the exponential stability is not possible, we prove that the uniform asymptotic stability of the equilibrium is completely determined by the uniform asymptotic stability of the reduced system on the center manifold. Keys words: Hille-Yosida operator, integral solution, semigroup, variation of constants formula, center manifold, attractiveness, reduced system, critical case, asymptotic stability, approximation.

7 Impact on Digitalization: Cybersecurity Threats and Emerging Issues

Professor Houssain Kettani

The Beacom College of Computer and Cyber Sciences Dakota State University, Madison, South Dakota, USA

Abstract

The rapid pace of digitalization has transformed industries, governments, and societies, enabling unprecedented levels of connectivity, automation, and data exchange. However, this digital evolution has also introduced a complex array of cybersecurity threats and emerging challenges.

This talk explores the multifaceted impact of digitalization on cybersecurity, highlighting how increased reliance on digital infrastructure has expanded the attack surface for malicious actors. Key issues include data breaches, ransomware attacks, vulnerabilities in Internet of Things (IoT) devices, and threats to critical infrastructure and higher education. Furthermore, this talk examines emerging concerns such as AI-driven cyberattacks, supply chain vulnerabilities, and regulatory inadequacies. By analyzing recent case studies and trends, the talk underscores the urgent need for adaptive cybersecurity frameworks, robust risk management strategies, and collaborative global governance to ensure secure and sustainable digital transformation.

8 Reproducing Kernels of Hilbert Spaces: PDE Analysis for Optimal Margin Separators in Learning

Professor Olivier Lafitte

LAGA, UMR 7539, Paris 13 University, Sorbonne Paris Cité, Villetaneuse, France

Abstract

The Kernel trick is one of the tools used for constructing non linear separators in learning (id is discriminate between two (or more) types in a large (size N) set of objects, elements, images characterized x_i where x_i has a large number (dimension d) of coordinates, pixels ...).
This amounts to finding the minimum under constraints of a quadratic function living in $\mathbb{R}^N$ in order to construct a separator as a linear combination of support vectors based on x_i.
We revisit under the eyes of PDEs this classical construction, and, instead of defining the Hilbert space associated with a given reproducing kernel (RKHS), we define the reproducing kernel of an Hilbert space, and observe that a wide class of Hilbert spaces commonly used in solving PDEs have a reproducing kernel.
In particular, for any integer m, up to a coefficient, all spaces $H^{m+1}(R^{2m})$ with the usual Sobolev norm have the same reproducing kernel $rK_1(r)$, and all spaces $H^{m+1}(R^{2m+1})$ have the same reproducing kernel e^{-r}, fundamental solution of the PDE associated with the Sobolev norm.

9 Logarithmic Convexity of Semigroups and Inverse Problems of Ornstein-Uhlenbeck Equation

Professor Lahcen Maniar

Cadi Ayyad University, Faculty of Sciences Semlalia LMDP, UMMISCO (IRD-UPMC)
B.P. 2390, Marrakesh, Morocco

Abstract

In this talk, we present some results on the logaritmic convexity estimate for anlytic semigroups. In the case 1/2-analytic semigroups, there is an explicit estimate. In the general case, we give a kind of explicit estimate. This estimate is used to study initial data and source inevrse problems for an observable abstract system. We illustrate our abstract result by an application to Ornstein-Uhlenbeck equations. Recently, we considered the case of non-analytical Ornstein-Uhlenbeck equation.

10 De Thalès aux Fractales : Pourquoi les Éléphants ne Ressemblent-t-ils pas aux Souris ?

Professor Benoit Rittaud

[1] Laboratory of Analysis, Geometry and Applications, University of Sorbonne Paris North, France.

Abstract

Le monde serait-il le même s'il etait plus grand, ou plus petit ? Le théorème de Thalés nous suggére que oui, et le grand philosophe et mathématicien Pascal avait été pris de vertige face aux conséquences logiques d'une telle éventualité. Mais Galilée avait déjà compris que les choses sont en réalité plus complexes, et expliqué pourquoi la préservation des proportions ne suffirait pas pour construire un monde de lilliputiens ou de géants. Si les éléphants ne ressemblent pas aux souris, c'est d'abord pour des raisons mathématiques qui tiennent à la notion de dimension. Généralisée au XXe siécle par Hausdorff, celle-ci est aujourd'hui au coeur du concept de fractale.

11 L'Algébre Linéaire en début d'Université - Espace de Travail Mathématique et Paradigmes

Professor Laurent Vivier

University of Paris Diderot, France

Abstract

Le cadre des Espaces de Travail Mathématique est une théorie didactique spécifiquement développée pour étudier le travail mathématique. On s'intéressera en particulier à la notion de paradigme, introduite au début des années 2000 pour la géométrie. Issues de recherches récentes, menées au Chili et en France, les paradigmes de l'algébre linéaire seront présentés pour l'étude didactique au début d'université.

12 A Comprehensive Study of Isogeometric Methods for Solving Partial Differential Equations

Professor Naji Yebari

Faculty of Science, University of Abdelmalek Essaadi, Tetouan, Morocco.

Abstract

This study presents a systematic investigation of isogeometric methods for solving both conventional and fractional-order partial differential equations (PDEs). The research is structured in two complementary parts. The first part develops isogeometric discretization techniques for classical PDEs, including the Poisson and convection-diffusion equations. We examine implementation challenges on complex geometries, with particular attention to multi-patch configurations and boundary condition treatment. For convection-dominated regimes, we employ the Streamline-Upwind Petrov-Galerkin (SUPG) stabilization method, demonstrating its effectiveness through simulations of strait flow dynamics in the Gibraltar region. The second part introduces novel numerical methods for time-fractional reaction-diffusion equations with Caputo derivatives, combining a new high-order temporal discretization scheme with isogeometric spatial approximations. We validate the method through numerical examples featuring constant and variable diffusion coefficients on complex geometries, and demonstrate its application to cardiac electrophysiology via spiral wave simulation using the FitzHugh-Nagumo model. Results show that the proposed methods maintain the geometric flexibility of isogeometric analysis while achieving improved accuracy and robustness, particularly for time-fractional problems requiring high-order approximations. This work establishes isogeometric methods as a powerful tool for both conventional and fractional PDEs, with demonstrated applications in fluid dynamics and cardiac modeling.

Part II

Participants

ID 1 On Galerkin spectral element method for solving Riesz fractional diffusion equation based on Legendre polynomials

Mouhssine Zakaria[1]

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Abstract

This paper presents a Galerkin spectral element method for solving a fractional diffusion equation, considering initial and boundary conditions. We construct a discrete scheme for time, employing the Crank-Nicolson method to approximate the Caputo fractional derivative on a uniform mesh. Then we introduce a Galerkin variational formulation to establish the unconditional stability of the scheme. Moreover, we apply the spectral element method based on Legendre polynomials in the space direction and obtain the fully discrete scheme. The error analysis of the fully discrete scheme is treated in L_2 sense. we present a computational analysis to deal with the Galerkin spectral element method, to compute the corresponding bilinear form, on the implementation process. Finally, we prove the effectiveness of the method through numerical experiments and some simulations using Matlab software.

Keywords: Fractional diffusion equation (FDE), Riesz derivative, Caputo derivative, Galerkin spectral element method, Legendre polynomials, stability, error estimates.

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ID 3 Integrating Machine Learning into Subdivision Schemes for Enhanced Geometric Modeling

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Abstract

This paper explores the optimization of subdivision schemes in geometric modeling through the integration of machine learning techniques. Traditional schemes, such as Chaikin, Catmull-Clark, or Loop, apply uniform refinement rules, which often overlook local geometric features, leading to unnecessary computations or loss of detail.

We propose an adaptive framework that enhances classical methods using learning-based strategies. In particular, models like MeshCNN and SubdivNet are evaluated for their ability to adjust subdivision dynamically based on mesh curvature and topological context. These AI-based approaches aim to reduce computational complexity while preserving surface fidelity.

Experimental comparisons highlight the improved performance of the optimized schemes in terms of accuracy, efficiency, and robustness. The findings suggest significant benefits for applications in computer graphics, medical imaging, and engineering design.

Keywords:

Subdivision schemes, geometric modeling, machine learning, MeshCNN, SubdivNet, adaptive refinement.

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ID 7 Zero-Divisors in Commutative Rings: A Graph-Theoretic Perspective

Khaireddin Assila [1,*] and Khalid El Ouartiti[1]

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Abstract

In the study of commutative algebra, zero-divisors play a pivotal role in understanding the internal structure and degeneration behavior of algebraic systems. A zero-divisor in a commutative ring R is a non-zero element $a \in R$ such that there exists another non-zero element $b \in R$ with $ab = 0$. The presence of such elements indicates a failure of the ring to behave like a domain and signals a rich and often intricate underlying ideal structure. These elements are not only algebra... This research presents a graph-theoretic framework for analyzing zero-divisors, by associating to each commutative ring a zero-divisor graph, denoted $\Gamma(R)$. In this graph, the vertices represent non-zero zero-divisors of the ring, and edges connect pairs (a, b) such that $ab = 0$. This approach transforms an algebraic structure into a combinatorial object, allowing us to apply techniques from graph theory to study rings in a new light.

Through this graphical lens, one can investigate a variety of structural properties of the ring: connectivity, cliques, girth, diameter, and chromatic number. These reflect, respectively, the interaction of annihilating elements, rich ideal-theoretic patterns, and partitioning into orthogonal substructures.

Our study gives special attention to Noetherian and Artinian rings, exploring how their algebraic finiteness conditions influence the topology of the zero-divisor graph. In Noetherian rings, maximal cliques often correspond to associated primes. In Artinian rings, the graph is finite and decomposable, which mirrors the ring's ideal structure.

Applications extend beyond algebra. In algebraic geometry, zero-divisor graphs reveal intersections of varieties. In cryptography, they suggest ways to build complex ring-based protocols. In network theory, they model redundancy and failure paths.

We also highlight future directions: matching graph invariants with algebraic properties, studying spectral behavior, and extending to noncommutative and graded settings.

This work offers a comprehensive framework for exploring zero-divisors through graph theory, bridging algebra, combinatorics, and applications in modern mathematics.

Keywords: Zero-divisors, Commutative rings, Zero-divisor graphs, Ring theory, Algebraic structures, Annihilators, Graph invariants, Cryptographic rings.

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ID 9 Existence of Renormalized Solutions for some noncoercive elliptic problem in a two-component domain with L^1 data

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Abstract

In this work, we will focus on studying a specific class of quasilinear elliptic equations with degenerate coercivity in a two-component domain, which is defined as follows:

$$\begin{cases} -\mathrm{div}(a(x,u_1,\nabla u_1)) + \mathcal{K}(x,\nabla u_1) + \lambda(x)|u_1|^{s-1}u_1 = f(x) & \text{in } \Omega_1, \\ -\mathrm{div}(a(x,u_2,\nabla u_2)) + \mathcal{K}(x,\nabla u_2) + \lambda(x)|u_2|^{s-1}u_2 = f(x) & \text{in } \Omega_2, \\ u_1 = 0 & \text{on } \partial\Omega, \\ a(x,u_1,\nabla u_1)\cdot\nu_1 = a(x,u_2,\nabla u_2)\cdot\nu_1 & \text{on } \Gamma, \\ a(x,u_1,\nabla u_1)\cdot\nu_1 = -h(x)|u_1-u_2|^{p-2}(u_1-u_2) & \text{on } \Gamma, \end{cases}$$

where Ω is a bounded open set of $\mathbb{R}^N$ ($N \geq 2$), with $\Omega = \Omega_1 \cup \Omega_2 \cup \Gamma$, where Ω_2 is an open set such that $\overline{\Omega_2} \subset \Omega$ with a Lipschitz boundary Γ and $\Omega_1 = \Omega \backslash \overline{\Omega_2}$, $\lambda(x) \geq \lambda_0, s \geq 1, 0 \leq \delta < 1$ and $f \in L^1(\Omega)$. We show the existence of a renormalized solutions for this class of equation, and we will conclude some regularity results.

Keywords: Quasilinear elliptic equations, non-coercive problems, Two-component domain, renormalized solutions.

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ID 10 Compatible Kähler structures on pseudo-Hermitian quadratic Lie algebras

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Abstract

We study Lie algebras endowed with a complex structure admitting, at the same time, a pseudo-Hermitian quadratic structure and a Kähler structure. These algebras have an invertible derivation that is skew-symmetric with respect to the quadratic structure and commutes with the complex structure. We propose several methods to construct such Lie algebras and use a generalized method of double extension to provide an inductive description of all of them. This double extension method allows us to prove that Lorentz-Hermitian quadratic Lie algebras cannot admit a Kähler structure for the same complex structure unless they are abelian. Additionally, we show that there is only one non-abelian Lie algebra of that kind for dimension less than or equal to 8 and prove that 2-step nilpotent ones with quadratic metrics of index 4 are necessarily either abelian or a trivial central extension of the aforementioned 8-dimensional Lie algebra.

Keywords: Pseudo-Hermitian Lie algebra, quadratic Lie algebra, Kählerian Lie algebra, symplectic Lie algebra, double extension.

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ID 11 Renormalized Solutions Of Elliptic Problems With Measure Data And Without Sign Condition

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Abstract

This study aims to establish the existence of renormalized solutions for the following nonlinear elliptic problems:

$$\begin{cases} A(u) - \operatorname{div} \Phi(x,u) + g(x,u,\nabla u) = \mu & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases} \tag{1}$$

where

- $\Omega \subset \mathbb{R}^N$ is a bounded Lipschitz domain with $N \geq 2$,
- $A(u) = -\operatorname{div} a(x,u,\nabla u)$ is a Leray–Lions type operator defined from $D(A) \subset W_0^1 L_{\mathcal{M}}(\Omega)$ into $W^{-1}L_{\bar{\mathcal{M}}}(\Omega)$.
- $\mathcal{M}$ and $\bar{\mathcal{M}}$ are a pair of complementary Musielak–Orlicz functions,
- the lower-order term Φ is a Carathéodory function,
- the nonlinearities $g : \Omega \times \mathbb{R} \times \mathbb{R}^N \to \mathbb{R}$ is a Carathéodory function,
- $\mu = f - \operatorname{div}(F)$ with $f \in L^1(\Omega)$ and $F \in E_{\bar{\mathcal{M}}}(\Omega)^N$.

The analysis is performed within the framework of Musielak spaces, allowing for measure data and nonlinearities without any sign condition. The Musielak function under consideration is assumed to satisfy the log-Hölder continuity condition.

Keywords: log-Hölder continuity, Nonlinear elliptic equation, Renormalized solution, Truncations..

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ID 12 An introduction to essential exact sequences

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Abstract

In module theory over a commutative ring, exact sequences offer a powerful tool for analyzing the relationships between modules. A sequence of modules and module homomorphisms $0 \to A \xrightarrow{f} B \xrightarrow{g} C \to 0$ is called essential exact (or e-exact) if $Ker(f) = 0$, $Im(f) \leq_e Ker(g)$ and $Im(g) \leq_e C$. In this presentation, we will explore the basic properties of essential exact sequences and we will present some interesting results related to these sequences, shedding light on their deeper algebraic and homological properties.

Keywords: Essential submodules, essential exact sequences, e-projective, e-exact functor.

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ID 13 Algebras satisfying $(xy)z = y(zx)$ and $(xy)z = \alpha(xz)y$ with $\alpha \in K$

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Abstract

Our main purpose is to study the possible properties of associativity, commutativity and nilpotency of some nonassociative and noncommutative algebra A satisfying both identities $(xy)z = y(zx)$ and $(xy)z = \alpha(xz)y$ with $\alpha \in K$. Indeed, by making a bond with the concept of nilpotency, we prove that such algebras are nilpotent of index ≤ 3 if $\alpha \in K - \{-1, 1\}$ and 4-nice for $\alpha = 1$. We also show that A is nilpotent of index ≤ 4 when $\alpha = -1$.

Keywords: Nonassociative algebras, nice algebras, cyclic algebras, nilpotent algebras.

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ID 14 Algebraic structure of algebras satisfying $x^2x^3 = \omega(x)x^4$

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Abstract

This paper concerns the algebraic structure of weighted algebras satisfying the ω-polynomial identity $x^2x^3 = \omega(x)x^4$. Assuming there is an idempotent, we study the structure of these algebras through Peirce's decomposition. The idempotent change is also examined. Finally, we study the connection with train algebras.

Keywords: Idempotent, Peirce decomposition, Polynomial identity, Train algebra.

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ID 15 On the first eigenvalue of the $p(\cdot)$-Laplacian problem with Robin boundary conditions

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Abstract

This paper focuses on the analysis and numerical approximation of the first eigenvalue problem for the $p(\cdot)$-Laplacian with Robin boundary conditions. Under appropriate assumptions on the right-hand side function f and the variable exponent p, we establish the existence of a solution and derive relevant solution estimates. For numerical approximation, we develop an algorithm combining the finite element method with the quasi-Newton method. Finally, we validate the effectiveness of our approach through various test cases.

Keywords: $p(\cdot)$-Laplacian, Sobolev spaces, variable exponent, eigenvalue problem, finite element.

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ID 16 Entropy Solution for Some Nonlinear Parabolic Problems in Musielak Spaces with L^1 Data

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Abstract

In this study , we deal with the existence result for nonlinear parabolic equations of the form:

$$\begin{cases} \frac{\partial u}{\partial t} + Au - divg(x,t,u) = f - divF & \text{in } \Omega_T \\ u(x,0) = u_0(x) & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega \mathrm{X}(0,T) \end{cases}$$

where $A(u) = -div(a(x,t,u,\nabla u)$ is a Leary-Lions type operator defined on the inhomogeneous Orlicz-Sobolev space $W_0^{1,x}L_\varphi(\mathbf{\Omega}_T)$, φ is a Musielak function, $g(x,t,u)$ is a Carathéodory function, the second term f *in* $L^{\mathbf{1}}(\mathbf{\Omega}_T)$. We estabilsh the existence result of entropy solution in the setting of Musielak-Orlicz spaces.

Keywords: Nonlinear parabolic problems, Musielak-Orlicz spaces, Entropy solution, Existence.

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ID 17 Nonlinear elliptic problem without monotonicity condition in Generalized Sobolev spaces

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Abstract

In the present paper we prove some existence results of entropy solution for nonlinear degenerate elliptic problems of the form $Bv + H(x, v_n) = f$, in Musielak-Orlicz-Sobolev spaces, where $B(v) = -\text{div}\,(b(x, v, \nabla v))$ is a Leray-Lions, operator defined form the musielak-Orlicz-sobolev spaces $W_0^1 L_\Psi(\Omega)$ into its dual$f \in L^1(\Omega)$, and no monotonicity strict condition is assumed on the function $b(x, s, \xi)$, The tool we use to overcome this difficulty is to investigate some techniques introduced by Minty's lemma.

Keywords: Elliptic problem; Entropy solutions; Musielak-Orlicz-Sobolev spaces, Compact imbedding, Δ_2-condition.

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ID 19 Generic coordinate systems in two variables over a principal ideal domain

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Abstract

Given a ring R and $n \geq 1$, we write $A = R^{[n]}$ to mean that A is isomorphic to the polynomial R-algebra in n variables. By a coordinate system of $A = R^{[n]}$ we mean a sequence $x = x_1, \ldots, x_n$ that generates A as an R-algebra. When R is an integral domain, and K is its quotient field, a sequence $y = y_1, \ldots, y_n$ in A is said to be a generic coordinate system of A if its image under the canonical homomorphism $A \longrightarrow K \otimes_R A = K^{[n]}$ is a coordinate system of $K \otimes_R A$.

In this talk we present our main result in [1], which gives a natural construction of the generic coordinate systems in two variables over a principal ideal domain R. As an application we prove that for every locally nilpotent R-derivation ξ of $A = R^{[2]}$ the automorphism $\exp(\xi)$ is 1-stably tame in an appropriate coordinate system of A. This shows that the well-known result due to Smith [1], asserting that the Nagata automorphism is 1-stably tame, actually holds in full generality.

Keywords: Generic coordinate system, Locally nilpotent derivation, Tame automorphism.

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ID 20 Meir-Keeler Contraction in Probabilistic Controlled Generalized Metric Spaces

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Abstract

In this study, Meir-Keeler contraction is introduced in the context of probabilistic controlled generalized metric spaceS. Without requiring the Hausdorff property, we prove new fixed point theorem under this extended condition and some examples are given. To show the efficacy of our approach, a number of illustrative instances and comparisons with previous finding are offered.

Keywords: Probabilistic controlled generalized metric space, Hausdorff property, Fixed point, Meir-keeler contraction.

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ID 21 Congruence Modulo n and Minimal Polynomial: A Bridge Between High School and Linear Algebra in Undergraduate Education

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Abstract

This work proposes a structured introduction to the minimal polynomial by leveraging the structural similarities between modular arithmetic in $\mathbf{Z}/n\mathbf{Z}$ (covered in high school) and polynomial rings. We present the minimal polynomial through three complementary definitions, designed to reduce abstraction:
• Definition via the ideal of annihilating polynomials: A constructive analogy between residue classes modulo n (arising from $n\mathbf{Z}$) and the ideal $\{P \in \mathbf{K}[X] \mid P(A) = 0\}$.
• Definition by minimal degree: A generalization of the minimal order in group theory, where n is the smallest annihilating integer in $\mathbf{Z}/n\mathbf{Z}$.
• Definition by divisibility: An extension of the principle "if n divides a, then $a \equiv 0 \mod n$" to polynomials, where every annihilating polynomial is a multiple of the minimal polynomial. Building on the work of Tall (2013) and Harel & Tall (1991), we clarify how each definition corresponds to a distinct cognitive register, while acknowledging certain limitations. The research of Zazkis & Liljedahl (2004) on multiple representations informs our approach, where each definition anchors in a specific learning register:
• Algebraic register (ideal): Exploits the functional analogy $n \leftrightarrow \mu_A$.
• Matrix register (minimal degree): Relies on concrete examples of diagonalization in dimension 2.
• Operational register (divisibility): Uses Euclidean division algorithms inspired by modular arithmetic. This approach avoids conceptual dispersion by:
• Clearly separating the study of ideals (abstract) from that of the minimal polynomial (operational).
• Using modular congruences as a guiding metaphor rather than as a formal model.

Keywords: minimal polynomial, congruence modulo n, high school mathematics, undergraduate level.

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ID 22 On uniqueness results for some fixed point theorems

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Abstract

In fixed point theory, one of the most important results is due to Krasnosel'skii [7] (see also, [12, 15]), who motivated by an observation that inversion of a perturbed differential operator may yield the sum of a compact and contraction mappings proved a general fixed point theorem to cover this situation. It asserts that, if $\mathcal{M}$ is a nonempty open, bounded and convex subset of a Banach X and A and B are two mappings from $\overline{\mathcal{M}}$ into X such that $A\overline{\mathcal{M}} + B\overline{\mathcal{M}} \subset \overline{\mathcal{M}}$, A is continuous on $\overline{\mathcal{M}}$ and $A\overline{\mathcal{M}}$ is relatively compact and B is a contractions mapping, then $A + B$ has at least one fixed point in $\overline{\mathcal{M}}$. Since then, there have appeared an important literature contributing generalizations or modifications of the Krasnosel'skii fixed point theorem and their applications (see, for example, [1, 4, 8, 9, 10] and the numerous references therein).

All these papers give us conditions guaranteeing the existence of fixed points. A natural question is to ask about additional assumptions on the mappings that the fixed point equation has a unique solution. In [6], Kellogg showed that a compact mapping $F : \overline{\mathcal{M}} \to \overline{\mathcal{M}}$ has a unique fixed point if the following conditions are satisfied:

a. F is continuously Fréchet differentiable in $\mathcal{M}$ and 1 is not an eigenvalue of $F'(x)$ for each $x \in \mathcal{M}$.

b. For each $x \in \partial\mathcal{M}$, $x \neq F(x)$.

Kellogg's theorem is extended by Talman [14] to the class of α-set contractions when $\alpha < 1$. In [13], Smith and Stuart showed that the result of Kellogg and its extension by Talman remain valid provided that the set $\{x \in \mathcal{M}, 1 \text{ is an eigenvalue of } F'(x)\}$ has no accumulation points in $\mathcal{M}$; the other assumptions are the same. Also, Kellogg's result is used by Shih and Wu [11] to prove the global asymptotic stability in the Schauder fixed point.

The main purpose of this talk is to establish the uniqueness in the Krasnosel'skii fixed point theorem when $B \in \mathcal{L}(X)$ and $\|B^k\|_{\mathcal{L}(X)} < 1$ for some integer $k \geq 1$. We are also interested to the study of the global asymptotic stability of the fixed point in the sense of the Belitskii-Lyubich conjecture [2, p. 41]. Our results are illustrated by an example.

Keywords: Fixed point theorems, compact map, uniqueness.

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ID 23 On the existence of renomalized solution for some nonlinear parabolic problems in Musielak-Orlicz spaces

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Abstract

In this paper we will prove in Musielak–Orlicz spaces, the existence of renomalized solution for nonlinear parabolic problems of Leray-Lions type, in the case where the Musielak–Orlicz function M doesn't satisfy the Δ_2-condition while the right hand side f belongs to $L^1(Q_T)$.

Keywords: Musielak-Orlicz space, Nonlinear parabolic problems, Renormalized solution, Existence.

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ID 24 Exact Solutions for Finite-State Birth-Death Processes: A Matrix-Theoretic Approach and Generalizations

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Abstract

In this paper, we will consider the case of Birth and Death Process with Finished Number of States, which is always justified by taking the number of states to be very high.

We have found the deterministic solution (distribution) of Kolmogorov differential equations of the birth and death process with a finite number of states, depending only on the eigenvalues and powers of the tridiagonal matrix A.

And finally we define and study the general linear birth and death process "LBDGP", as a Kendall process by taking

$\lambda_k = \lambda f(t)$ and $\mu_k = \mu f(t)$.

Keywords: Birth and Death Process, Matrix, Vandermonde matrix, Diagonalisation, Exponentiel of Matrix, Kolmogorov differential equations.

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ID 25 Solving quadratic equations with complex coefficients & determining the second root for any complex number

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Abstract

This paper presents a definitive solution for expressing the second root ($z^{1/2}$) of any complex number z as a function of z and $\Delta^{1/2}$ as a function of Δ in the context of quadratic equations with complex coefficients. This research has resulted in two direct algorithms and associated software. These algorithms are not only accurate but also exceptionally fast, providing a powerful tool for efficiently determining the second root of any complex number and solving quadratic equations with complex coefficients. This innovative approach addresses a long-standing challenge in the field, significantly contributing to the accuracy and speed of calculations in complex coefficient scenarios either manually or using a programmable computing machine such as smart phones or computers...

Keywords: Complex numbers, Equations of the second degree, Algorithm, The second root.

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ID 26 Existence and uniqueness of solutions to some nonlinear L_φ-elliptic problems

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Abstract

In the present paper, we focus on studying the nonlinear elliptic problem defined as follows

$$\begin{cases} -\operatorname{div}\left(a(x,u,\nabla u)\right) + g(x,u) = \mu - \operatorname{div}\left(\phi(x,u)\right) & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases} \tag{2}$$

where Ω is a bounded open domain of $\mathbb{R}^N$ $(N \geq 2)$, the nonlinear term $g(x,u)$ satisfies the sign condition, for the right-hand side $\mu = f - \operatorname{div}(F)$ with $f \in L^1(\Omega)$ and $F \in (E_{\bar{\varphi}}(\Omega))^N$ and $\phi(x,u)$ is a nonlinear term that satisfy some growth conditions. We prove the existence and uniqueness of renormalized solutions for the nonlinear elliptic problem (2) in the framework of Musielak-Orlicz Sobolev spaces.

Keywords: Nonlinear elliptic equation, Renormalized solutions, Musielak-Orlicz Sobolev spaces.

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ID 27 Entropy solutions for some elliptic unilateral problems with degenerate coercivity

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Abstract

We consider the following nonlinear degenerate and non-coercive elliptic problem:

$$\begin{cases} -\sum_{1}^{N} D^i a_i(x,u,\nabla u) + g(x,u,\nabla u) = f - \sum_{1}^{N} D^i \phi_i(x,u) & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

where Ω is an open bounded set of $\mathbb{R}^N$ ($N \geq 2$). The Carathéodory functions $a_i(x,s,\xi)$ satisfy a degenerate ellipticity condition, and the lower-order term $g(x,u,\nabla u)$ obeys controlled growth conditions. The data f belongs to $L^1(\Omega)$, and $\phi_i(x,s)$ is Carathéodory function with appropriate structural assumptions. We demonstrate the existence of entropy solutions for the unilateral problem associated with the non-coercive elliptic equations, and we will conclude some regularity results.

Keywords: Nonlinear elliptic equations, non-coercive problems, entropy solutions, obstacle problems.

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ID 28 Study some nonlineair elliptic equations in sobolev space with variable exponent and L^1 data

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Abstract

In this work, we have treated the nonlinear elliptic problem whose is defined as:

$$\begin{cases} -div\ a(x,u,\nabla u) + g(x,u,\nabla u) = f & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases} \tag{3}$$

where Ω is a bounded open set of $\mathbb{R}^N$ $(N \geq 2)$; and $f \in L^1(\Omega)$ the lower term g is a Carathéodory function does not satisfy the sign condition. We demonstrate the existence of entropy solutions for the problem (3), and we will conclude some regularity results.

Keywords: Nonlinear elliptic equations, entropy solutions, variable exponent.

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ID 30 On the automorphism group of generic a^1-fibrations over the affine line

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Abstract

Danielewski surfaces were introduced in [3] as a counterexample to the Zariski Cancellation Problem over algebraically closed fields. These are affine algebraic surfaces embedded in the affine 3-space $\mathbb{A}^3_{\mathbb{C}}$ and defined by an equation of the form

$$x^n z - q(y) = 0,$$

where $n \in \mathbb{N}^\star$ and $q(y) \in \mathbb{C}[y]$ has degree at least two. Since then, several Danielewski-type surfaces have been introduced and studied in many different contexts, see e.g., [4, 5, 2, 6, 9, 1, 8, 7], in particular the automorphism groups of their coordinate rings were described. In fact, a Danielewski-type surface $\mathcal{S}$ is a particular case of an affine surface endowed with an $\mathbb{A}^1$-fibration, i.e., a regular map $\mathcal{S} \longrightarrow \mathbb{A}^1$ whose general fiber in an affine line.

In this talk, given an algebraically closed field K of characteristic zero, we propose a purely algebraic method to describe the K-automorphism group of an affine surface endowed with an $\mathbb{A}^1$-fibration. Specifically, we consider finitely generated faithfully flat $K[x]$-algebras A such that

$$K(x) \otimes_{K[x]} A = K(x)^{[1]}$$

where $K(x)^{[1]}$ stands for the polynomial $K(x)$-algebra in one variable. We study the group $\mathrm{Aut}_K(A, K[x])$ of K-automorphisms of A that preserve $K[x]$.

The $K[x]-$algebra A can be endowed with locally nilpotent $K[x]$-derivations. We first prove that, the set of such derivations, denoted by $LND_{K[x]}(A)$, is a free $K[x]$-module of rank one. This leads to the construction of a natural group homomorphism

$$\psi : \mathrm{Aut}_K(A, K[x]) \longrightarrow \mathbb{T},$$

where $\mathbb{T} = K^* \times K^*$ is the two-dimensional algebraic torus. The kernel of ψ is the subgroup $\mathrm{SAut}_K(A)$ of exponential K-automorphisms of A, yielding the short exact sequence One of our main results asserts that this sequence is split exact, implying that the group $\mathrm{Aut}_K(A, K[x])$ is the inner semidirect product of $\mathrm{SAut}(A)$ and an algebraic subgroup of $\mathbb{T}$. Moreover, we establish that this subgroup exhibits only five structural possibilities. Finally, in the case of a Danielielewski-type surface defined by $c(x)z - q(x, y) = 0$, we present an algorithm that determines precisely which one of these five possibilities occurs in terms of the input data $c(x)$ and $q(x, y)$.

Keywords: Danielewski-type surface, Locally nilpotent derivation.

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ID 31 Entropy solutions for some quasilinear and non-coercive Neumann $p(x)-$elliptic equation

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Abstract

In this paper, we study of the following quasilinear and non-coercive elliptic problem

$$\begin{cases} -\mathrm{div}(\dfrac{a(x,|\nabla u|)\nabla u}{(1+|u|)^{\lambda(x)}}) + |u|^{p(x)-2}u = f(x,u) & \text{in } \Omega \\ \dfrac{a(x,|\nabla u|)\nabla u}{(1+|u|)^{\lambda(x)}}.\eta = g & \text{on } \partial\Omega, \end{cases}$$

where $1 < p(x) < N$ and $0 \leq \lambda(x) \leq \min(1, p(x)-1)$. we study the existence and regularity of entropy solutions for L^1-data in Sobolev spaces with variable exponents.

Keywords: Sobolev spaces with variable exponent, Neumann boundary conditions, entropy solutions, non-coercive problems.

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ID 33 Unilateral problem associated to the quasilinear elliptic equation in anisotropic weighted Sobolev spaces

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Abstract

In this paper, we will study the following class of non-coercive quasilinear elliptic equations

$$\begin{cases} -\sum_{i=1}^{N} D^i(a_i(x,u,\nabla u)) = f(u) + \rho\dfrac{|u|^{q-1}u}{|x|^{p_m}} & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

where Ω is bounded open set of $\mathbb{R}^N$ $(N \geq 2)$ with $\partial\Omega$ with Lipschitz boundary. We show the existence of entropy solutions for this non-coercive unilateral elliptic equation in the anisotropic weighted Sobolev spaces, and we will conclude some regularity results.

Keywords: Anisotropic weighted Sobolev spaces, non-coercive problems, entropy solutions, obstacle problems.

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ID 34 Mathematical Modeling of High-Temperature Dependent Thermo-Elastic Composites Using a Micromechanical Method

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Abstract

In this work, the micromechanical modeling of the effective high temperature dependent behavior of thermo-elastic composite materials is analyzed. The modeling is based on the micro-to-macro transition inclusion problem, employing temperature-dependent localization tensors. Green's tensors are developed to derive temperature dependent integral equations related to Eshelby's tensors and micromechanical approaches. The effective behavior at high temperatures is determined using micromechanical methods and is presented for various inclusion volume fractions, shapes, and types of reinforced composites.

Keywords: Mathematical modeling, Elliptic integral equation, Temperature-dependent properties, Micromechanical methods, Nonlinear thermal response

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ID 36 A Comparative Study of Ordinary and Partial Differential Equations Resolution Using Artificial Neural Networks and Physics-Informed Neural Networks

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Abstract

The resolution of differential equations, both ordinary and partial, plays a fundamental role in various fields of applied mathematics, physics, and engineering. Traditional numerical methods, such as the finite difference method and the finite element method, have been widely employed for this purpose. However, in recent years, artificial intelligence-based approaches have gained increasing attention, particularly artificial neural networks and physics-informed neural networks.

This study presents a comparative investigation of these two neural network-based methods for solving differential equations. Artificial neural networks provide a data-driven approach where solutions are learned from training datasets, whereas physics-informed neural networks incorporate the underlying physical laws into the training process to enhance accuracy and generalization. We analyze their performance in terms of accuracy, computational efficiency, and adaptability to complex boundary conditions. The comparison is conducted through selected benchmark problems involving ordinary and partial differential equations, with results assessed against classical numerical solutions.

The findings of this research aim to highlight the advantages and limitations of each method and provide insights into their applicability to different types of differential equations. This study contributes to the ongoing development of efficient and reliable machine learning techniques for solving mathematical and engineering problems.

Keywords: Neural Network-Based Differential Equation Solvers, Physics-Informed Neural Networks, Machine Learning.

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ID 37 Existence and uniqueness of renormalised solutions for parabolic Dirichlet problem with measure

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Abstract

In this paper, we consider the following class of nonlinear parabolic equations with Dirichlet conditions

$$\begin{cases} \dfrac{\partial b(u)}{\partial t} - \operatorname{div}(a(x,t,|\nabla u|)\nabla u) + |u|^{p(x)-2}u = f - div(g) & \text{in} \quad \Omega \times [0,T] \\ u(t=0) = u_0 & \text{in} \quad \Omega \times [0,T] \\ u(x,t) = 0 & \text{on} \quad \partial\Omega \times (0,T) \end{cases}$$

where Ω is a bounded open domain of $\mathbb{R}^N (N \geq 2)$ and $T > 0$. Assuming that f belongs to $L^1(Q_T)$ and g is an element of $(L^{p'(\cdot)}(Q_T))^N$ and the operator a verifies some conditions. We prove the existence and uniqueness of renormalised solutions.

Keywords: Renormalised solutions, parabolic equation, existence and uniqueness, Sobolev spaces with variable exponent, Dirichlet conditions.

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ID 39 The Impact of Student Behavioral Engagement on Mathematics Performance in Adaptive Learning Systems: A Statistical and Machine Learning Approach

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Abstract

Adaptive learning systems have emerged as the cornerstone of personalized education in the field of mathematics, dynamically adjusting the instructional content according to the peculiarities of each learner's profile. Parallelly, these systems are often underutilizing behavioral engagement data like accuracy, response time, and task completion patterns to predict academic achievement. This research focuses on understanding the interplay between behavioral engagement and learning outcomes, employing interaction data from the ALIN adaptive learning system.

Initially, Pearsons correlation coefficients and independent-sample t-tests were computed to measure the linear relationships and possible differences between raw behavioral indicators and students' final test performances. The results showed a weak or non-significant relation at these levels, implying that these engagement variables, when taken as raw measures of engagement, may not sufficiently capture the academic progression.

The above triggers a systematic feature-engineering process with the aim of creating some higher-level indicators such as: accuracy rate, average time per problem, and right answers per minute. These new variables are better correlated with learning gains, assessed with a new correlation analysis. The refined variables obtained are then passed to train and evaluate regression models, such as Linear Regression, Random Forest, XGBoost, K-Nearest Neighbors, and Support Vector Regression, with the Linear Regression model producing the best performance with $R = 0.48$ and $RMSE = 5.35$, underscoring the value of statistically informed feature design.

This study demonstrates the complementary roles of statistical analysis and machine learning in the extraction of educational data. While statistical techniques reveal the limitations of raw indicators and perform feature selection, machine learning models, in turn, take advantage of engineered features to accurately predict academic improvement. Therefore, these results constitute a foundation upon which behavior-aware adaptive learning systems can be developed to support data-driven personalization beyond mere content adaptation.

Keywords: Adaptive Learning, Mathematics Education, Student Behavior, Learning Engagement, Statistical Analysis, Machine Learning, Pedagogical Innovation

ID 40 On the Numerical Range of Composition Operators : A Case Study in $\mathcal{H}^2$

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Abstract

In this paper, we investigate the numerical range of composition operators on the Hardy space $\mathcal{H}^2$. Although the exact determination of this range remains an open problem, we introduce an approximation approach that sheds light on its geometric structure and fundamental spectral properties. In particular, we focus on the case where the composition symbol φ is an automorphism of the unit disk, analyzing the impact of elementary transformations; rotations, translations, dilations, and inversions, on the numerical range. Our analysis, supported by several examples and case studies, offers novel insights into the spectral behavior of composition operators within a functional framework.

Keywords: Composition operators, Hardy space, Geometric transformations, spectrum, Numerical Range.

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ID 41 Fixed Point Theorems in Probabilistic Metric Spaces and Novel Contractions

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Abstract

Probabilistic Metric Spaces (PMS) provide a generalization of classical metric spaces by incorporating probabilistic structures, making them a fundamental tool in various mathematical and applied fields. Fixed point theorems in PMS play a crucial role in proving the existence and uniqueness of solutions to numerous problems in analysis and optimization.

Over time, research has led to the development of Probabilistic b-Metric Spaces, which extend PMS by relaxing the triangle inequality through a scaling factor, allowing for greater flexibility in distance measurement. This generalization has enriched fixed point theory and expanded its range of applications.

Further advancements have introduced Controlled Strong Probabilistic Metric Spaces, where additional control functions refine the metric properties, providing a more structured framework for studying fixed points under probabilistic settings. These refinements have contributed to a deeper understanding of contraction principles and their implications.

A key focus of this study is contraction mappings that ensure the existence and uniqueness of fixed points. While classical contractions impose strict conditions, we introduce a novel type of contraction that significantly relaxes these constraints while still guaranteeing fixed point results. This new contraction strengthens the applicability of fixed point theory by broadening the conditions under which such results hold, thus contributing to the theoretical advancement of probabilistic metric spaces.

Keywords: Controlled Strong Probabilistic Metric Spaces, Fixed point, Contraction mapping.

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ID 43 Existence and uniqueness of renormalized solution for some quasilinear and non-coercive elliptic problems

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Abstract

The present paper focuses on studying of the elliptic problem given by

$$\begin{cases} -\sum_{i=1}^{N} D^i a_i(x,u,\nabla u) = f - \sum_{i=1}^{N} D^i \phi_i(x,u) & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega \end{cases} \tag{4}$$

where $f \in L^1(\Omega)$. We study the existence and uniqueness of renormalized solution for the non-coercive elliptic problem (4) in the anisotropic weighted Sobolev spaces.

Keywords: Renormalized solution, existence and uniqueness, degenerate coercive, quasilinear elliptic equation, anisotropic weighted Sobolev spaces.

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ID 44 Deep Neural Network-Based Discrete Gradient Flow Approximations for High-Dimensional Evolution PDEs

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Abstract

We investigate the numerical approximation of initial-boundary value problems governed by time-dependent partial differential equations (PDEs) using deep neural networks (DNNs) [1], [1], [2]. The proposed method employs discrete gradient flow approximations based on non-standard Dirichlet energies, designed for problems with essential boundary conditions [4]. We construct Galerkin-type numerical methods, often referred to as Nitsche-type methods [5]. Additionally, we explore a second class of discrete gradient flows for time-dependent PDEs with non-essential boundary conditions [4]. The numerical discretization is achieved through a sequence of residual-type DNNs, corresponding to implicit time-stepping. Finally, we present numerical experiments that demonstrate the performance and effectiveness of our approach, particularly for higher spatial dimensions.

Keywords: PDEs, Evolution, Artificial Intelligence, Deep Nitsche's method, Numerical analysis

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ID 45 Existence of Weak Solutions for $(\mathbf{p}(x), \mathbf{q}(x))$-Laplacian-like Systems

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Abstract

In this work, we study the existence of at least one weak solution for $(p(x), q(x))$-Laplacian-like systems. Our result is obtained using the theory of topological degree and the theory of Sobolev spaces with variable exponents.

Keywords: $(\mathbf{p}(x), \mathbf{q}(x))$-Laplacian-like system , Topological degree , Variable exponent Sobolev spaces .

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ID 46 Enhancing BEMD Decomposition with Adaptive Compact Support for Radial Basis Functions

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Abstract

Bidimensional Empirical Mode Decomposition (BEMD) is a powerful tool for analyzing non-stationary and non-linear signals, particularly in image processing applications such as denoising, compression, and watermarking. However, its computational cost remains a major challenge, primarily due to the extrema interpolation step. Although compactly supported radial basis functions (CSRBFs) have been introduced to reduce complexity, the selection of their support size significantly impacts the quality of decomposition, especially since BEMD operates iteratively, with varying extrema distributions at each step.

This paper proposes an adaptive hierarchical strategy to determine optimal CSRBF support sizes throughout the BEMD process. The initial support size is computed based on nearest-neighbor distances among extrema, while subsequent sizes are adjusted dynamically to account for the progressive reduction in extrema across iterations. Our approach aims to balance computational efficiency with decomposition accuracy. Experimental results demonstrate the effectiveness of the method in reducing run-time while preserving the quality of the extracted Intrinsic Mode Functions (IMFs).

Keywords: Decomposition BEMD, CSRBF functions, Time-frequency analysis, Intrinsic Multimodal functions (IMFs).

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ID 48 Nonconvex stochastic optimal control for a biological wastewater treatment model

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Abstract

In this paper, we propose a nonconvex mathematical model describing the process of biodegradation of organic pollutants by means of fungi. These fungi utilize glucose to support their metabolism and growth in the presence of white noise. The study we're interested deals with an optimal control problem consisting in the minimization of nutrient and the maximization of dilution. The control strategy entails using the dilution rate of the reactor, D, and the glucose inflow C_{in} as controls, by modulating the inflow rate and the quantity of glucose introduced into the reactor. This research focuses on three key aspects. Firstly, we establish the existence and uniqueness of solutions to the dynamical system, which serves as a fundamental step laying the groundwork for subsequent analyses and applications. Secondly, since the dynamic is nonconvex with respect to the controls, we delve into the Hamilton-Jacobi-Bellman (HJB) equation and its viscosity solution, providing insights into the existence of an optimal control and the value function. Lastly, we confirm our theoretical findings through numerical simulations.

Keywords: Biological wastewater treatment, nonconvex Stochastic optimal control, Stochastic HJB equation, Viscosity solution.

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ID 49 Renormalized solutions for a class of non-coercive elliptic problems in Musielak-Orlicz Spaces

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Abstract

In this paper, we investigate the existence and certain regularity properties of renormalized solutions within the framework of Musielak-Orlicz spaces for the following non-coercive quasilinear elliptic problem:

$$\begin{cases} -\operatorname{div} a(x,u,\nabla u) = f - \operatorname{div} \phi(x,u) & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

where $a(x,s,\xi)$ is a Carathéodory function that satisfies the degenerate coercivity condition, $\phi(x,s)$ is a Carathéodory function satisfying only one growth condition, and the datum f belonging to $L^1(\Omega)$.

Keywords: Quasilinear elliptic problem, non-coercive operator, renormalized solutions, Musielak-Orlicz-Sobolev spaces.

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ID 50 Integrating Quantile Regression LSTM with Robust Optimization for Blood Supply Chain Management During Disasters

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Abstract

Blood supply chain (BSC) management during disasters presents significant challenges due to demand uncertainty, time-critical operations, and resource limitations. This paper presents an innovative approach that combines robust optimization (RO) and artificial intelligence to enhance the BSC within a bi-objective optimization framework. In addition, we integrate quantile regression long short-term memory (QR-LSTM) neural networks to dynamically estimate demand uncertainty intervals during disaster scenarios. Indeed, traditional approaches to BSC either use deterministic demand assumptions or employ fixed safety margins, both of which fail to capture the complex uncertainty patterns in disaster situations. Our approach leverages historical blood usage data to generate asymmetric prediction intervals that inform (RO) models, enabling more precise protection against shortages while avoiding excessive conservatism. The robust counterpart formulation incorporates a dynamic budget of uncertainty that adapts based on forecast confidence, allowing different levels of protection across time periods and blood products. We employ the ϵ-constraint method to generate the robust Pareto frontier that captures the trade-off between cost and response time objectives under uncertainty. Computational experiments using disaster-inspired scenarios demonstrate that our approach achieves higher service levels (96.2% vs. 78.5% for deterministic models), while maintaining competitive operational costs. The robust Pareto front reveals distinct operational regions offering decision-makers transparent trade-offs between cost efficiency and system responsiveness, with practical solutions clustered in the mid-range region.

Keywords: Blood supply chain, Quantile regression LSTM, Robust optimization, Humanitarian logistics, Multi-objective optimization.

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ID 51 Solving Uncertain Journeys in the Probabilistic TSP Using Social Algorithms: A Comparative Study

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Abstract

This paper addresses the Probabilistic Traveling Salesman Problem (PTSP) [1], an extension of the classical Traveling Salesman Problem that incorporates uncertainty in customer visitation through probabilistic presence. The objective is to minimize the expected total travel cost under these stochastic conditions. We evaluate and compare three social-inspired metaheuristic algorithms—Cuckoo Search (CS) [2], Social Spider Algorithm (SSA) [3], and Particle Swarm Optimization (PSO) [4] for their efficacy in solving PTSP. Leveraging their inherent strengths in population-based search mechanisms and stochastic exploration, we analyze their performance across benchmark instances. Results demonstrate that all three algorithms exhibit robust potential for addressing PTSP, with distinct advantages observed in specific scenarios: CS excels in diversification, SSA balances exploration-exploitation trade-offs, and PSO converges efficiently. The study underscores the adaptability of social metaheuristics for probabilistic optimization, particularly in handling complex cost expectations. We conclude that hybridizing these algorithms or fine-tuning their parameters could further enhance their performance, offering promising avenues for future research in stochastic routing and related combinatorial optimization challenges.

Keywords: Artificial Bee Colony, Probabilistic Traveling Salesman Problem, swarm intelligence, local search.

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ID 52 Generalization of Chika's divisibility mapping

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Abstract

The creation of a rule, criterion, or test for divisibility by a prime number is an ancient and challenging problem in elementary mathematics. In 2019, a 12-year-old Nigerian boy, Chika Ofili, proposed a divisibility test for 7 based on a new class of numbers associated with this prime number (see [2]; [3]). His approach relies on a specific arithmetic transformation that allows checking divisibility by 7 without using the traditional Euclidean division.

In this paper, we study the generalization of Chika numbers to other prime numbers and explore their applications to a new divisibility theorem. We establish fundamental properties of this method and demonstrate its validity for a broader set of prime numbers. Furthermore, we compare this new test with some classical divisibility methods proposed in [1] and [4], analyzing their efficiency and ease of application. Finally, we discuss the theoretical and pedagogical implications of this approach in teaching divisibility rules.

Keywords: Chika numbers; Prime numbers; Divisibility theorems, Divisibility test.

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ID 53 A Modified Deep Finite Volume Methods

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Abstract

Partial Differential Equations (PDEs) provide a fundamental mathematical tool for modeling a variety of physical and engineering phenomena. However, since analytical solutions for PDE's can be challenging and, in some cases, unattainable, numerical methods have become the primary approach for solving PDEs. Recently, Deep Neural Networks (DNNs) have emerged as an alternative method for obtaining approximate solutions. Among these DNN-based approaches, Physics-Informed Neural Networks (PINNs)[1] have achieved significant advancements in solving differential equations. PINNs integrate physical knowledge into the neural network loss function through pointwise residual sampling. However, this strong-form definition of the loss function fails to approximate non-smooth solutions accurately. To address this, we propose combining the strong and weak forms inspired from element finite method [2] in the cost function definition, with the contribution of each part being adjusted automatically. To validate the performance of this approach, we conduct several experiments, including one-dimensional and two-dimensional equations.

Keywords: Physics-informed neural networks, Deep finite element method, Adaptive weithing.

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ID 54 Application of a deep learning-based recurrent neural network for PM10 air pollution prediction: the TANGIER case study

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Abstract

The environment and human health are both greatly impacted by air pollution, making it a serious issue since it contributes to climate change by degrading ecosystems, reducing biodiversity, and weakening the ozone layer. It increases sadly respiratory and cardiovascular problems and raises the risk of cancer. Air pollution in Tangier City is increasingly linked to several forms of pollutants, among these particulate matter (PM10). Therefore, it is essential to accurately anticipate levels of this pollutant in order to reduce risks to health [1]. There are two primary goals for this study. First, it uses two artificial neural network (ANN) models: simple RNN and Long Short-Term Memory (LSTM) architecture to forecast daily PM10 concentrations. Every experiment looks at the relationship between predictors and the success of models using a different set of input data [1]. The study also looks at whether the LSTM model can generate reliable predictions without stationary time series data [2]. Performance was assessed using a variety of metrics, such as mean square error (MSE), root mean square error (RMSE), mean absolute error (MAE), and the index of agreement. The results reveal the effectiveness of the two algorithms, with the LSTM model demonstrating superior predictive power for PM10 concentrations and avoiding the need for a stationary time series in order to produce accurate forecasts.

Keywords: Artificial Neural Network, Air quality forecasting, Long Short-Term Memory (LSTM), Particulate matter (PM10), Air pollution, recurrent neural networks (RNN)

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ID 55 Hybrid Modeling for Predictiong Nitrate Contamination in Groundwater Using Linear Regression, Markov Chain, and Artificial Neural Networks.

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Abstract

Nitrate contamination in groundwater represents a major environmental and public health issue on a global scale. In our study, we focus on predicting water quality in the Oued Inaouene watershed.

To achieve this goal, we propose a hybrid predictive model that combines three approaches: Linear Regression, Markov Chains, and Artificial Neural Networks, in order to improve the accuracy and robustness of nitrate concentration forecasting.

We assess the effectiveness of these models using performance metrics such as R, MAE, and AI. The results show a noticeable improvement in prediction performance when Artificial Neural Networks are integrated into the hybrid approach.

Keywords: water quality, artificial neural networks, linear regression, markov chain, nitrate prediction.

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ID 57 Improving PINNs by Integrating Vanilla PINNs with the Deep Finite Element Method

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Abstract

Partial Differential Equations (PDEs) provide a fundamental mathematical tool for modeling a variety of physical and engineering phenomena. However, since analytical solutions for PDE's can be challenging and, in some cases, unattainable, numerical methods have become the primary approach for solving PDEs. Recently, Deep Neural Networks (DNNs) have emerged as an alternative method for obtaining approximate solutions. Among these DNN-based approaches, Physics-Informed Neural Networks (PINNs)[1] have achieved significant advancements in solving differential equations. PINNs integrate physical knowledge into the neural network loss function through pointwise residual sampling. However, this strong-form definition of the loss function fails to approximate non-smooth solutions accurately. To address this, we propose combining the strong and weak forms inspired from element finite method [2] in the cost function definition, with the contribution of each part being adjusted automatically. To validate the performance of this approach, we conduct several experiments, including one-dimensional and two-dimensional equations.

Keywords: Physics-informed neural networks, Deep finite element method, Adaptive weithing.

References

[1] Raissi, M., Perdikaris, P., & Karniadakis, G. E. Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. In Journal of Computational physics, 378 (2019), 686-707.

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ID 58 Applications of Artificial Intelligence to design a control for Nonlinear Systems

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Abstract

Mathematical biology is a rapidly expanding field, offering innovative and exciting perspectives. Gradually, mathematical models have established themselves as valuable tools for predicting the health impacts of various interventions. Thus, these models have become essential for understanding the dynamics of epidemics and developing control strategies. However, we have observed that mathematical methods do not always suffice to provide an explicit expression of control for managing all situations, due to the complexity of interactions in biological systems and the uncertainties associated with infection spread. Therefore, we have integrated artificial intelligence to design these controls using artificial neural networks. These networks must be capable of effectively replacing the role of controls in different situations. In this work, we will explore an approach consisting of creating an artificial neural network and training it on labeled data so that it can be able to replace the role of control in other nonlinear systems, whether their expression is explicitly determined or not yet.

Keywords: Epidemiology, Nonlinear Systems, Infected individuals, Artificial Intelligence, Neural Networks, Artificial Control.

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ID 59 On class of the mean-reversion non-homogeneous stochastic models with with a non-homogeneous, multifactorial drift function

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Abstract

Stochastic models largely used to describe commodity prices have proved not to be suitable to present the dynamic behavior and time-related nature of commodity markets. Indeed, fluctuations of returns are described by non-Gaussian and heterogeneous characteristics, which requires the choice of properly adjusted models. The mean objective of this study is to develop stochastic continuous model to describe commodity price by introduce two type of extensions into both parts of price dynamic: deterministic and stochastic parts.

Keywords: Commodity prices, Stochastic Models, Mean-reversion, Long-term Predictions, Non-Homogeneous features. a stable market with minimal external shocks. This reflects a market stability in equilibrium, where supply and demand are balanced, and external factors have limited impact. Over time, the distance between the two curves increases, suggesting structural changes in the market

References

ID 60 Nonlinear variationnel parabolic inequalities with lower order term in Orlicz-Sobolev spaces

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Abstract

In the work we are interested in the existence of entropy solutions for nonlinear variationnel parabolic inequalities associated to the parabolic equation of the following type :

$$\frac{\partial u}{\partial t} - \operatorname{div}\ a(x,t,u,\nabla u) - \operatorname{div}\Phi(x,t,u) = f \quad \text{in } Q_T = \Omega \times (0,T),$$

where $-\operatorname{div}\Big(a(x,t,u,\nabla u)\Big)$ is a Leray-Lions operator, the lower order term Φ satisfies a generalized natural growth condition described by the appropriate Orlicz function M, $f \in W^{-1,x}E_{\overline{M}}(Q_T)$ and No growth restriction is assumed neither on M nor on its complementary $\overline{M}$, therefore, the solution in this context is natural.

Keywords: Entropy solution, Natural growth, Unilateral parabolic problem, Orlicz-Sobolev spaces .

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ID 61 Nonlinear elliptic problem without monotonicity condition in Generalized Sobolev spaces

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Abstract

In the present paper we prove some existence results of entropy solution for nonlinear degenerate elliptic problems of the form $Bv + H(x, v_n) = f$, in Musielak-Orlicz-Sobolev spaces, where $B(v) = -\text{div}\,(b(x, v, \nabla v))$ is a Leray-Lions, operator defined form the musielak-Orlicz-sobolev spaces $W_0^1 L_\Psi(\Omega)$ into its dual$f \in L^1(\Omega)$, and no monotonicity strict condition is assumed on the function $b(x, s, \xi)$, The tool we use to overcome this difficulty is to investigate some techniques introduced by Minty's lemma.

Keywords: Elliptic problem; Entropy solutions; Musielak-Orlicz-Sobolev spaces, Compact imbedding, Δ_2-condition.

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ID 63 A study of some positive operators on Banach spaces

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Abstract

Positive theory plays an important role in economics by providing a scientific approach to understanding economic behavior and developing economic models that can be used to make informed decisions. One of the most used operator in operator theory is the Dunford-Pettis operator, which is a linear operator on Banach spaces that satisfy a certain property, namely that they map weakly convergent sequences to norm convergent sequences. Many new operators were defined on the basis of this famous operator in functional analysis field.

We study the weak*Dunford Pettis operator which is derived from the concept of Dunford Pettis and we conclude some new results

Keywords: Dunford Pettis, Banach lattices, linear operator

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ID 65 On a nonlinear parabolic problem in Musielak-Orlicz-Sobolev spaces

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Abstract

In this study, we prove an entropy solutions to some nonlinear parabolic inequalities with L^1-data. The proof is based on the penalization methods.

Keywords: Entropy solutions, Musielak-Orlicz-Sobolev spaces,Parabolic inequalities.

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ID 66 Mountain Gazelle Optimizer method for incomplete pairwise comparison matrix

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Abstract

The Analytic Hierarchy Process (AHP) is a widely used decision-making strategy based on pairwise comparison matrices to acquire priority vectors. However, incomplete pairwise matrices with missing values are a critical issue, which can undermine the effectiveness of the strategy. The work in this paper presents the use of the Mountain Gazelle Optimizer (MGO), a newly developed metaheuristic inspired by the adaptive behavior of mountain gazelles, in filling in the missing values in incomplete pairwise comparison matrices in the AHP strategy. The strategy aims at minimizing the consistency index (CI) of the reconstructed matrix so that its consistency is at acceptable levels. Through a series of experiments with synthetic data sets as well as real data sets, the performance of MGO is compared with traditional estimation strategies as well as other optimization algorithms. The results indicate that MGO presents higher precision and consistency, hence its robustness and efficiency in the handling of incomplete matrices. The work presents the promising use of the Mountain Gazelle Optimizer as a reliable strategy for the treatment of incomplete data problems in AHP, hence its extended application in multi-criteria decision-making in uncertain environments.

Keywords: Mountain Gazelle Optimizer (MGO), AHP Method, Incomplete pairwise comparison matrix

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ID 70 On Representation Numbers by quaternary quadratic forms

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Abstract

In this paper, we compute explicit the number of integers represented by certain positive-definite, integral, non-diagonal quaternary quadratic forms, namely:

$$x^2+y^2+z^2+3t^2+xy+xt,$$
$$x^2+y^2+2z^2+2t^2+xt+yt+2zt,$$

and

$$x^2+y^2+z^2+8t^2+xy+xz,$$
$$x^2+y^2+2z^2+3t^2+xt+yt+2zt,$$
$$x^2+y^2+2z^2+3t^2+xy+xt.$$

Our approach relies on the theory of modular forms and the use of theta functions of level 32, with discriminants 32 and 64 respectively.

Keywords: Number of representation, genus of quaternary quadratic forms, Dedekind eta function, eta quotients, theta functions, modular forms, cusp forms.

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ID 71 Controlled generalised fusion frame on Hilbert C*-modules

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Abstract

A Hilbert C*-module H generalizes a Hilbert space by replacing the field of complex numbers $\mathbb{C}$ with a C*-algebra $\mathcal{A}$. The inner product is extended to a mapping $\langle \cdot, \cdot \rangle$ from $H \times H$ to $\mathcal{A}$, satisfying certain properties analogous to those in a classical Hilbert space.

The theory of frames in Hilbert spaces has proven to be a powerful tool in signal processing, data analysis, and operator theory. Classical frames provide a way of decomposing elements of a Hilbert space into a sum of basis-like vectors, even in cases where an orthonormal basis may not exist. This concept can be generalized to fusion frames, which are particularly useful when working with more complex structures, such as C*-modules.

In this presentation, we introduce several definitions and characterizations of (P, Q)-controlled K-generalized fusion frames in Hilbert C*-modules, drawing motivation from classical frame theory and its generalization to operator algebras. These fusion frames are a natural extension of classical frames to the context of C*-modules, allowing for a broader range of applications, particularly in quantum information theory and noncommutative geometry. We focus on their structural properties, which provide insight into the interplay between the module structure and frame theory.

Keywords: Hilbert C^*-Modules,Frames,g-Fusion Frames, K-g-Fusion Frames, Controlled K-g-Fusion Frames.

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ID 72 Deep Learning Techniques for Brain Tumor Detection and Classification Based on Metaheuristics

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Abstract

This research investigates the application of deep learning techniques for the detection and classification of brain tumors. By combining convolutional neural networks (CNNs) with the Grey Wolf Optimizer (GWO) and Genetic Algorithm (GA), this project seeks to enhance classification accuracy for various brain tumor types, including gliomas, meningiomas, pituitary tumors, and healthy cases. Utilizing a dataset of MRI images, our results demonstrate robust performance, as evidenced by high precision, recall, and ROC-AUC metrics. This study underscores the promising role of bio-inspired algorithms in medical image classification, paving the way for improved diagnostic tools in healthcare.

Keywords: Brain tumor, Detection, Classification, Deep learning, Medical imaging, Metaheuristics, GWO, GA.

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ID 74 Stability analysis of advanced multi-quadratic mappings via Lipschitz conditions

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Abstract

It is well known that the problem of the stability of homomorphisms of metric groups (in other words, the Cauchy functional equation) was posed by Ulam [2] in 1940 (a year later, its solution in the case of Banach spaces was presented by Hyers [1]). Since then the Ulam type stability of various objects (including functional, difference and differential equations, isometries, operators, groups, C^*-algebras, etc.). In Lipschitz spaces, the notion of stability was introduced by Tabor [1]. In this work, we discuss the general solution of some classes of functional equations, and then prove the stability problem of the same functional equation according to Lipschitz criteria. Some important consequences are also presented.

Keywords: Stability, Multi-quadratic mapping, Symmetric left invariant mean, Lipschitz spaces.

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ID 75 Dynamics of a stochastic SEIR model with a saturated incidence rate driven by Lévy noise

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Abstract

In this manuscript, we examine a stochastic framework characterizing a susceptible-exposed-infectious-recovered (SEIR) epidemic model incorporating a saturated incidence rate influenced by Lévy jumps. Our objective is to investigate the dynamical behavior of a system comprising three stochastic differential equations. Initially, we establish comprehensive criteria for the existence and uniqueness of positive solutions to the stochastic differential system commencing from a positive initial condition through the construction of a suitable Lyapunov function, subsequently deriving sufficient conditions for both the extinction and persistence of the infectious disease in an average sense. Ultimately, a thorough discussion and numerical simulations are provided to substantiate the findings obtained.

Keywords: SEIR model; Itô's formula; extinction; Lévy noise, Euler scheme

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ID 76 Existence and Uniqueness of Solutions for a Fully Nonlinear Elliptic Equation with Geophysical Applications to Fluid Flows

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Abstract

This study focuses on the mathematical analysis of radial solutions to fully nonlinear elliptic equations

$$\begin{cases} -div(|\nabla u|^{p-2}\nabla u) = g(|x|)f(|x|, u, x.\nabla u), & x \in \Omega, \\ \alpha u + \beta \frac{\partial u}{\partial n} = 0, & x \in \partial\Omega, \\ \lim\limits_{|x|\to+\infty} u(x) = 0. \end{cases}$$

where $\Omega = \{x \in \mathbb{R}^N : |x| > r_0 > 0\}$, $p > 1$, $N \geq 1$, $g : [r_0, +\infty) \to \mathbb{R}^+$ and $f : [r_0, +\infty) \times \mathbb{R} \times \mathbb{R} \to \mathbb{R}$ are continuous. This equation has significant interest due to its critical role in modeling geophysical fluid flows, where understanding the behavior of solutions is essential for both theoretical and practical applications. Using the Leray–Schauder fixed point theorem as a cornerstone of our analysis, we establish rigorous results concerning the existence of solutions. Additionally, we introduce novel techniques to demonstrate the uniqueness of solutions under appropriate conditions on f and g. Furthermore, we complement our theoretical findings with carefully constructed examples.

Keywords: Leray−Schauder fixed point, exterior domain, radial solution, nonlinear boundary conditions, geophysical fluid flows.

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ID 77 Existence and Uniqueness of Solutions for a Fully Nonlinear Elliptic Equation with Geophysical Applications to Fluid Flows

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Abstract

Unbalanced classification problems are common in many real-life applications. In this paper, we propose a hybrid SMOTE-PSO-SVM method, an oversampling technique that integrates Particle Swarm Optimization (PSO) and Support Vector Machines (SVM) with a modified SMOTE architecture. We use K-means clustering to identify the strong centers of minority class and leverage PSO to dynamically optimize critical parameters. Then, the SVM fitness function is formulated as an optimization problem and solved using PSO to determine the optimal features. An evaluation on a different dataset shows that the hybrid SMOTE-PSO-SVM method outperforms six state-of-the- art oversampling techniques, achieving superior AUC scores (averaging +7.2%) across ten diverse classifiers, while maintaining strong performance in terms of precision, recall, and F1-score.

Keywords: Support vector machine, Unbalanced problem, Particle Swarm Optimization, Diabetes.

ID 78 A generalization of the Nash equilibrium solution

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Abstract

The concept of Nash equilibrium is crucial in game theory, particularly in non-competitive games. It enables all players, who may have different strategies, to achieve an optimal expected payoff. This scenario ensures that no player has an incentive to alter their strategy. In this paper, we introduce a generalization of the Nash equilibrium solution. Additionally, we present a generalization related to Sanver's (2006) Proposition 4.1. To generalize the concept of Nash implementation solution, we start by defining a multi-valued outcome function $G : S \to 2^X - \emptyset$. We also introduce the concept of the freedom to compare two solutions, which are represented as two sets according to Sen's (1993) axiom. Additionally, we use Sen's (1993) axiom to present a generalized version of Proposition 4.1 from Sanver (2006). This method enables us to pinpoint the necessary and sufficient conditions for implementing a multi-valued social choice correspondence within this generalized framework, and generalizing Sanver's (2006) Proposition 4.1. The concept of Nash equilibrium emphasizes that all players can maximize their benefits, fostering a win-win situation for everyone involved. By introducing the idea of freedom within this concept, we promote individual freedom in the market mechanism.

Keywords: Nash Equilibrium, Generalization of the Nash Equilibrium solution, Multi-valued functions, Social choice correspondence, Game form.

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ID 80 Existence and uniqueness of solutions for some anisotropic quasilinear parabolic problem with measure data

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Abstract

This paper is devoted to study the existence and uniqueness of renormalized solution for some degenerated quasilinear parabolic problem of the type

$$\begin{cases} \dfrac{\partial u}{\partial t} - \displaystyle\sum_{i=1}^{N} D^i(a_i(x,u)|D^i u|^{p_i-2}D^i u) + |u|^{p_0-2}u = f - \mathrm{div}F & \text{in } Q_T, \\ u = 0 & \text{on } \Sigma_T, \\ u(x,0) = u_0 & \text{in } \Omega \end{cases} \tag{5}$$

in the anisotropic Sobolev space, where the Carathéodory functions $a_i(x,s)$ satisfying only some conditions, and the data $\mu = f - \mathrm{div}F$ such that $f \in L^1(\Omega)$ and $f \in \prod_{i=1}^{N} L^{p_i'}(\Omega)$. Moreover, we conclude some regularity results.

Keywords: Anisotropic parabolic Sobolev spaces, non-coercive quasilinear parabolic equation, renormalized solutions.

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ID 81 On The Study Of Some Nonlinear Unilateral Problems In Orlicz Spaces

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Abstract

In this paper, we prove the existence of solution for the following unilateral problem

$$\begin{cases} -\operatorname{div} a(x,u,\nabla u) - div\,\Phi(x,u) = \mu & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega \end{cases}$$

Where the lower order term Φ satisfy some the natural growth condition.
The right-hand side μ belongs to $L^1(\Omega) + W^{-1}E_{\overline{M}}(\Omega)$.In Orlicz spaces.

Keywords: unilateral problem Orlicz spaces natural growth condition.

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ID 82 Feature Selection in Granular Ball Support Vector Machines using DC Programming

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Abstract

Feature selection is a crucial optimization challenge in the field of supervised pattern classification. It involves selecting a subset of available features that effectively capture the essential characteristics of the data. In supervised pattern classification, choosing the right set of features is critical for developing compact and highly accurate classifiers. Granular Ball Support Vector Machine (GB-SVM) has emerged as an efficient and adaptive approach for improving classification performance and computational efficiency by leveraging the concept of granular structures in the feature space. This method refines the traditional SVM framework by introducing a set of granular balls, which allows for better handling of complex decision boundaries and provides flexibility in dealing with variability within the data. This paper presents a novel feature selection approach directly minimizing the classifier performance in the context of granular ball SVM. To address our optimization problem, we employ Difference of Convex (DC) functions programming, a versatile and powerful framework designed for solving non-convex continuous optimization problems. Numerical experiments performed on several data sets show the potential of the proposed method.

Keywords: Feature selection, Granular Ball Support Vector Machine (GB-SVM), DC Programming, Non-convex optimization.

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ID 85 Existence of Solutions for Mathematical Models in Geophysical Fluid Flowse

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Abstract

In this paper, we investigate the existence of radial solutions for a class of elliptic equations in exterior domains. This study is motivated by the relevance of such equations to geophysical fluid flows. Specifically, we consider the following problem

$$\begin{cases} -\mathrm{div}(|\nabla u|^{p-2}\nabla u) = \omega(|x|)f(|x|, u, x\cdot\nabla u), & x \in \Omega, \\ \frac{\partial u}{\partial n} = 0, & x \in \partial\Omega, \\ \lim\limits_{|x|\to\infty} u(x) = 0, \end{cases}$$

where $\Omega = \{x \in \mathbb{R}^N : |x| > r_0 > 0\}$ is the exterior domain, $N > p > 1$, and $\frac{\partial u}{\partial n}$ is the outward normal derivative of u on $\partial\Omega$. The functions ω and f are continuous and satisfy certain conditions to be specified later. By employing the Leray–Schauder fixed point theorem, we establish the existence of solutions and present rigorous results for these nonlinear problems. Furthermore, we provide some examples to confirm our theoretical results and emphasize their practical relevance.

Keywords: Radial solution, Exterior domain, Gradient term, Existence of Solutions .

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ID 86 On Skew Cyclic DNA codes over $\mathbb{F}_4[v]/ < v^4 - v >$

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Abstract

In this paper, we describe a particular class of skew cyclic codes over the ring $\mathbb{F}_4[v]/ < v^4 - v >$ and determine their structure. This allows us to characterize reversible DNA codes and reversible complement DNA codes over this ring. We also explore the Gray images of these skew cyclic codes over this ring.

Keywords: Skew cyclic codes, reversible codes, reversible complement code, DNA codes

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ID 87 Asymptotic Behavior Of Large Solutions Of A Nonlinear Elliptic Equation

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Abstract

In this paper, we study the nonlinear elliptic equation

$$\triangle_p u = g(x)f(u) \quad \text{in} \quad \mathbb{R}^N$$

where $\triangle_p u = div.\left(|\nabla u|^{p-2}\nabla u\right)$, $N > 3$, $p \geq 2$, g and f fulfill the required assumptions. We give existence results and describe the asymptotic behavior of large solutions near infinity.

Keywords: nonlinear elliptic equation, large solutions, existence of solutions, asmptotic behavior.

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ID 88 Existence of entropy solutions for some nonlinear elliptic unilateral problems in non-reflexive Orlicz-Sobolev spaces

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Abstract

We prove the existence results in the setting of the non-reflexive Orlicz-Sobolev spaces $W_0^1 L_M(\Omega)$ for the unilateral problem associated with the following equation:

$$-\operatorname{div} \mathcal{A}(x, u, \nabla u) - \operatorname{div} \Phi(x, u) + \mathcal{H}(x, u, \nabla u) = \mu \quad \text{in } \Omega$$

where $\mu = f - \operatorname{div}(F)$ is a measure in $L^1(\Omega) + E_{\bar{M}}(\Omega)$, $\mathcal{H}(x, u, \nabla u)$ a nonlinear term that satisfies a controlled growth condition, and Φ fulfills only a natural growth condition. No restriction is assumed either on M or on its conjugate $\overline{M}$.

Keywords: Nonlinear Obstacle Problem, Natural Growth, Gradient Dependent Nonlinearities , Modular convergence , Non-Reflexive space

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ID 91 Application of Machine Learning for Forest Fire Prediction: Optimization and Risk Assessment

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Abstract

This study consists in solving the problem of forest fire prediction in Morocco by proposing a model based on supervised Machine Learning techniques[1]. Forest fires, one of the greatest risks to the environment in regions with extreme climatic conditions, are modeled using mathematical techniques from large sets of meteorological and climatic data. It is made to identify the probability of fire incidence accurately using supervised, optimized models. Several algorithms were tested, such as Logistic Regression, Decision Tree, Random Forest, XGBoost, LightGBM, and CatBoost. Hyperparameter optimisation[2] was performed via GridSearchCV, achieving an accuracy of 99.13% with the XGBoost model. The high accuracy was further validated using confusion matrices and F1 scores to assess generalization capacity and reduce overfitting concerns. In addition, the importance of the variables was studied and it was established that temperature and soil moisture are key factors. The data set used covers multiple regions in Morocco and is derived from satellite and meteorological sources; however, generalization beyond this geographic context requires further evaluation. Finally, a fire risk index based on a regression approach was proposed to anticipate critical areas.

Keywords: Forest Fire, Machine Learning,Supervised Models ,Hyperparameter Optimization .

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ID 92 An algebraic and trigonometric tension B-spline collocation method to solve time-dependent singularly perturbed convection-diffusion problems

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Abstract

In this paper, we present a new numerical method for solving singularly perturbed, time-dependent parabolic convection-diffusion problems via a collocation method with Uniform Algebraic Trigonometric tension B-splines of the fourth order (UAT tension B-splines). We use the Crank-Nicolson method to discretize the temporal variable on uniform mesh and the UAT tension B-splines collocation approach to discretize the spatial variable with piecewise uniform Shishkin mesh. Furthermore, we analyze the stability and convergence properties of the method. To demonstrate its efficacy, we compare our proposed approach against various benchmark problems from the existing literature.

Keywords: Singularly Perturbed, Boundary value problems, Shishkin mesh, Crank-Nicolson method, Algebraic trigonometric Spline.

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ID 93 Visual Cryptography: Secure Image Sharing and Its Practical Implications

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Abstract

This paper presents a comprehensive overview of visual cryptography (VC), with a particular emphasis on its application to binary, grayscale, and color images. It explores the development of visual cryptographic schemes (VCS) using both combinatorial and algebraic techniques, highlighting their contributions to improving pixel expansion and contrast optimization. The study delves into various approaches aimed at enhancing the efficiency of VCS, specifically focusing on pixel expansion and contrast enhancement, which are crucial for ensuring the clarity and security of decrypted images. Additionally, the paper examines the potential use of visual cryptography in authentication systems, emphasizing its role in safeguarding sensitive data through visual methods. The analysis emphasizes the adaptability of VCS in both theoretical and practical contexts, providing promising solutions for secure image sharing and identity verification.

Keywords: Visual Cryptography, Pixel Expansion, Contrast.

ID 95 A generalization of annihilator condition for modules and their extensions

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Abstract

In this work, we will introduce the concept of Property (*a.c.*) for modules, which is a generalization of Property (*a.c.*) for rings. A module is said to satisfy Property (*a.c.*) if the right annihilator of every finitely generated submodule equals to the right annihilator of a right cyclic submodule. We study several modules having this property. Moreover, we investigate Property (*a.c.*) for many extensions as skew polynomial modules, skew power series modules and matrix modules.

Keywords: Property (*a.c.*), p.q-Baer mosules, Annihilator condition, σ-skew quasi-Armendariz modules

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ID 96 About the class of Null almost L- and Null almost M-weakly compact operators on Banach lattices

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Abstract

The subject of this work is mainly concerned with the functional analysis, more precisely, in the field of the theory of positive operators on Banach lattices. And the aim is to study the relationship between the class of Null almost L-weakly compact (resp. Null almost M-weakly compact) operators and other classes of operators like almost L-weakly compact (resp. almost M-weakly), compact, almost Dunford-Pettis, weak Dunford-Pettis.

Keywords: Banach lattice, Null almost M-weakly compact operator, Null almost L-weakly compact operator, almost Dunford-Pettis, Order continuous norm.

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ID 97 Derivations in 3-Jordan algebras

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Abstract

In this project, we study the Lie algebra of derivations of a commutative algebra verifying the identity $(x^3y)x - x^3(xy) = 0$, known as the 3-Jordan algebra. We give a characterization of these derivations. We also show a necessary and sufficient condition for the ideals defined in the paper "A Variety containing jordan and pseudo-composition algebras" to be d-invariant. We conclude our study by investigating low-dimensional 3-Jordan algebras which are dimensionally nilpotent.

Keywords: Derivation, Invariant ideal, Dimensionally nilpotent algebra.

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ID 98 On some nonlinear elliptic equations with measurable boundary conditions in Anisotropic weighted Sobolev spaces

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Abstract

The novelty of this note is to establish existence result for the following anisotropic elliptic equation

$$-\operatorname{div} B(x,\vartheta,\nabla\vartheta) + H(x,\vartheta) = f - \operatorname{div} F$$

where the datum $f \in L^1(\Omega)$ and $F \in \prod_{i=1}^{N} L^{p_i'}(\Omega, w_i^*)$ and $H(x,\vartheta) \in L^1(\Omega)$. Furthermore only the large monotonicity conditions will be assumed on $B(x,s,\xi)$. To overcome this difficulty we will use the approach of Minty's lemma in the anisotropic weighted Sobolev spaces.

Keywords: Anisotropic, weighted Sobolev spaces, elliptic problem, Entropy solutions, Measure data,Truncation.

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Musielak-Orlicz-Sobolev Spaces, Journal of Mathematical Physics, Analysis, Geometry 2022, Vol. 18, No. 3, pp. 1-18.

ID 99 An advanced finite volume scheme on general meshes for the two-dimensional multi-layer shallow water equations

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Abstract

The multi-layer shallow water system with friction (6) is widely used to model geophysical flows involving free surface dynamics, such as tides, dam breaks, storms, and tsunamis [?, ?]. First introduced in [?], this system of PDEs has been extensively studied and extended in several works, including [?, ?, ?].

Numerical solutions for such models present challenges due to their non-linear structure, irregular source terms, complex layer interactions, and computational constraints. This study focuses on the two-dimensional version of the system, incorporating a topography source term. We propose a finite volume method on unstructured meshes composed of triangles and quadrilaterals and develop a simple and accurate homogeneous solver based on a predictor-corrector scheme with the method of characteristics.

The Finite Volume Characteristics (FVC) method, initially introduced in [?, ?] for one-dimensional problems, was later extended to the multidimensional case by Ziggaf et al. [?, ?], with a general formulation suited for complex geometries. Here, we further extend the FVC scheme to two dimensions while ensuring a well-balanced discretization for non-homogeneous cases. This ensures lake at rest equilibrium and accounts for layer exchanges and wind effects.

The governing equations of the multi-layer shallow water model are given by:

$$\begin{cases} \partial_t h_\theta + \nabla \cdot (h_\theta \mathrm{u}) = 0 \\ \\ \partial_t h_\theta \mathrm{u}_\theta + \nabla \cdot (h \mathrm{u}_\theta \otimes \mathrm{u}_\theta) + g h_\theta \mathrm{grad}(h) = -g h_\theta \mathrm{grad} Z - \kappa_\theta \delta_{1\theta} \mathrm{u}_\theta + F_\theta, \end{cases} \tag{6}$$

where θ represents the layer index, and the unknowns are the water height in each layer, h_θ, such that $h = \sum_{\theta=1}^{N} h_\theta$, and the velocity vector $\mathrm{u}_\theta = (u_\theta, v_\theta)^T$.

The source term F_θ is given by:

$$F_\theta = \mathcal{F}_u + \mathcal{F}_b + \mathcal{F}_w + \mathcal{F}_\mu, \quad \theta = 1, 2, \ldots, N,$$

where $\mathcal{F}_u$ represents momentum exchange between vertically discretized layers. The terms $\mathcal{F}_b$, $\mathcal{F}_w$, and $\mathcal{F}_\mu$ correspond to bed friction, wind-driven forcing, and internal friction, respectively. Finally, we validate our approach through benchmark tests, showing good agreement with other numerical methods and experimental results.

Keywords: FVC scheme, multi-layer shallow water model, unstructured mesh, well-balanced scheme.

ID 101 From Groups to Groupoids: The Structure of Wide Transitive Subgroupoid Posets

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Abstract

In this work, we review key tools and results related to lattices of subgroups, deliberately avoiding the highly specialized and abstract language of category theory. Instead, we emphasize clarity by enriching the discussion with examples, making the subject accessible to mathematicians with minimal background. We introduce and investigate the posets of subgroupoids of transitive groupoids, leveraging a correspondence between groups and transitive groupoids to explore their lattice-theoretic properties, along with some homotopy-theoretic considerations. Our approach extends classical results from finite groups to the more general and nuanced setting of finite groupoid posets.

Keywords: Transitive groupoid, Wide subgroupoid, Poset of Subgroupoids, Homotopy type of a poset

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ID 102 Asymptotic Analysis of Radial Solutions of a Nonlinear Equation with Singular Term

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Abstract

In this paper, we study the radial solutions of the nonlinear elliptic equation with singular term

$$\Delta_p U + \alpha x.\nabla U - \beta|x|^{\gamma}|U|^{q-1}U = 0, \quad \text{in} \quad \mathbb{R}^N,$$

where $p > 2$, $q \geq 1$, $N \geq 1$, $\alpha > 0$, $\beta > 0$ and $\gamma < 0$.
We establish the global existence of solutions and provide a detailed description of the asymptotic behavior of positive solutions near infinity.

Keywords: Elliptic equation, Entire solutions, Positive solutions, Asymptotic behavior.

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ID 103 The Form near Infinity of Radial Solutions of a p-Laplacian Equation with Singular Coefficient

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Abstract

In this paper, we examine the radial solutions to the nonlinear elliptic equation with singular coefficient

$$\Delta_p U - \alpha x.\nabla U + \frac{|U|^{q-1}U}{|x|^2} = 0, \quad \text{in} \quad \mathbb{R}^N,$$

where $p > 2$, $q \geq 1$, $N \geq 1$, and $\alpha > 0$.
We focus on the existence of global solutions and provide a characterization of the asymptotic behavior of positive solutions.

Keywords: Nonlinear elliptic equation, Singular coefficient, Global existence, Asymptotic behavior.

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ID 105 On the Diophantine equation $(p^n)^x + (3^m p + 2)^y = z^2$ where p, $3^m p + 2$ are prime numbers

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Abstract

In this paper, we give methods to find the Diophantine equation $(p^n)^x+(3^m p+2)^y = z^2$ in $\mathbb{N}$ where $p \geq 3$ and $3^m p+2$ are prime integers. To do this, we use the congruent method, and we prove that this equation has no nonnegative solutions if $p > 3$. In the case $p = 3$, we will found that this equation has no solutions if $m > 1$. For this case $m = 1$, we use the elliptic curves, we further will found that this equation has a unique solution is $(x, y, z) = (5, 4, 122)$ if $n = 1$.

Keywords: Diophantine equation, elliptic curve, factor method.

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ID 106 Asymptotic Behavior of a Nonlinear p-Laplacian Equation with Convection and Reaction Terms

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Abstract

The aim of this paper is to study a nonlinear p-Laplacian equation with convection and reaction terms. The prototype equation is given by

$$\operatorname{div}(|\nabla U|^{p-2}\nabla U) + \lambda x \nabla(|U|^{q-1}U) + \theta U = 0 \quad \text{in} \quad \mathbb{R}^N,$$

where $p > 2,\ q > 1,\ N \geq 1,\ \lambda > 0$ and $\theta > 0$. We establish the existence of entire radial solutions and prove that these solutions are strictly positive under appropriate conditions. Furthermore, we analyze the structure of these solutions and investigate their asymptotic behavior near infinity.

Keywords: Entire solution, radial solution, asymptotic behavior, existence of positive solutions.

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ID 107 Singular Solutions of a p-Laplacian Equation with a Source Term Exhibiting Mixed Power-Law Nonlinearity

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Abstract

In this paper, we study the existence and asymptotic behavior of positive radial solutions defined on $B(0,R)$ with $R>0$ for the equation

$$\Delta_p u + f(u) = 0, \qquad \text{on } B(0,R),$$

where $\Delta_p u = \operatorname{div}(|\nabla u|^{p-2}\nabla u)$ is the p-Laplacian with $p>2$, and the nonlinear source term is given by

$$f(u) = u^q - u^{-\delta}.$$

We consider radial solutions satisfying the initial conditions $u(0)=a>0$ and $u'(0)=0$, and we focus on the analysis of singular solutions for which $u(r)\to 0$ as $r\to R$.

By employing scaling arguments and comparison principles, we establish sufficient conditions on the exponents q and δ ensuring the existence of singular solutions that vanish at a finite radius. Furthermore, we analyze their asymptotic behavior near the singularity and derive explicit asymptotic expansions.

Keywords: Radial solution, Singular solution, Asymptotic behavior, Power-Law Nonlinearity.

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ID 108 Graph-based Kolmogorov Arnold Networks: A Survey and New Perspectives

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Abstract

Graph Neural Networks (GNNs) have emerged as a transformative paradigm in machine learning and artificial intelligence, achieving an impressive success in representation learning and demonstrating remarkable success across diverse domains. In this paper, we aim to provide a systematic and comprehensive review of recent research works on GNN-based KAN (Kolmogorov Arnold Networks) architecture, a neural network model inspired by the Kolmogorov-Arnold representation theorem. Recently KANs have demonstrated the ability to provide flexible and interpretable representations of high-dimensional functions, contrasting traditional neural networks through the use of learnable, spline-parameterized functions rather than fixed activation functions. Moreover, we explore how KAN-enhanced GNNs leverage external knowledge to improve performance in tasks such as node classification, link prediction, and graph classification. Finally, we discuss the contrasting key challenges of GNNs-based KAN methods in graph learning tasks, and state some research gap for future directions.

Keywords: Deep learning, Graph neural networks, Graph Representation Learning, Kolmogorov-Arnold Networks.

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ID 109 The "Data Processing and Organization" A comfortable habitat for teaching mathematical modeling in primary schools in Morocco

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Abstract

In this article, we are testing the hypothesis that the field of "Data Processing and Organization" represents a comfortable niche for teaching and learning mathematical modeling at the primary level in the Moroccan education system. We started from the following question: What is the ecology of "mathematical modeling" knowledge in the new Moroccan curriculum at the primary level?

We seek to characterize the institutional relationship of the knowledge "mathematical modeling" in the new curriculum of July 2021. To do this, we relied on an analysis of the Pedagogical Guidelines (OP) and also the textbook of the 6st-year primary Moroccan students (Age 11 to 12) called "MON LABO EN MATHEMATIQUES" based on the Anthropological Theory of the Didactic (ATD) developed by Chevallard (1999) and the praxeological approach which models mathematical activity.

We were able to identify the existence of an institutional relationship between the knowledge "Mathematical Modeling" and the institution "the new primary curriculum." We also found different places that constitute the habitats of this knowledge and examined its activities in the field of "data processing and organization" as a comfortable niche for teaching mathematical modeling at the primary level. This study leads to perspectives for the teaching and learning of mathematical modeling in other school levels such as middle school or high school or even higher education and also in other fields such as measurement, geometry, numbers and calculation.

Keywords: Mathematics modeling, The Anthropological Theory of the Didactic, Ecology of knowledge, Praxeology.

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ID 110 Asymptotic Behavior and Blow-Up Solutions of a Singular Parabolic Equation

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Abstract

In this paper we study the self-similar solutions for a nonlinear singular parabolic equation of the form:

$$(E): \qquad v_t(x,t) = (v^l)_{xx}(x,t) - |x|^r v^{-s}(x,t), \quad x \in \mathbb{R},\ t > 0,$$

where $l > 1$, $r > 1$ and $s > 0$. While prior work focused on the existence of solutions. The present study provides a more detailed analysis of the solutions behavior near both the origin and infinity. In particular, we identify conditions under which solutions exhibit non-monotonic behavior, and we determine the exact asymptotic limit.

Keywords: Singular parabolic equation, Self-similar solutions, Blow-up solutions, Asymptotic behavior, Non-monotonic solutions, Existence of solutions.

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ID 111 Méthode des volumes finis et résolution numérique d'un modèle de Black-Scholes en finance

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Abstract

In this paper, we study the numerical solution of the Black-Scholes equation, a fundamental model in mathematical finance for option pricing. We adopt the finite volume method, an approach well-suited for parabolic partial differential equations, ensuring flux conservation and improved accuracy in numerical approximations. After discretizing the spatial and temporal domains, we formulate the problem in matrix form and implement an explicit Euler scheme. Stability and convergence analysis demonstrate that the method provides reliable results under certain discretization step conditions. Numerical results illustrate the evolution of option prices and validate the efficiency of the proposed method. This approach thus offers a robust alternative to classical finite difference and finite element methods in computational finance.

Keywords: FiniteVolume Method, Stochastic differential equation, Black-Scholes Model.

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ID 112 A Hybrid Classification Model Based on the Hidden Markov model and Generalized Inverse method

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Abstract

In this paper, we investigate the properties of a generalized Inverse to improve the performance of an HMM-based classifier. The learning process is devoted to showing how a generalized inverse can be used in the theoretical development of the posterior probabilities of HMM model. In particular, it is demonstrated that the fundamental observation equation, presented as a rectangular matrix, can be aggregated using a derived form of the generalized inverse. We also examine the effect that different procedures for calculating the generalized inverse have on the performance of the developed models. We illustrate the proposed method using numerical experiments and an analysis of the obtained results.

Keywords: Hidden Markov Markov, Classification, Supervised learning ,Generalized inverse .

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ID 115 Local derivations of $\mathbb{K}[x][y, \sigma, \delta]$

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Abstract

In this paper, we study local derivations in algebras of type $\mathbb{K}[x][y, \sigma, \delta]$, where σ is an automorphism and δ a σ-derivation. We prove that, in many cases, any local derivation is a derivation.

Keywords: Derivation, Kadison algebra, local derivation, Ore extension.

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ID 116 Radial blow-up standing solutions for the semilinear wave equation

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Abstract

We consider the following semilinear wave equation with subconformal power nonlinearity in dimension N:

$$\partial_t^2 U = \Delta U + |U|^{p-1}U,$$

where $p > 1$ and if $N \geq 2$ then $p \leq 1 + \frac{4}{N-1}$. We are able construct a radial blow-up solution which converges, in similarity variables, to a soliton near $(r_0, T(r_0))$ for a given $r_0 > 0$, where $T(r_0)$ is the local blow-up time. For this purpose, we use a modulation technique allowing us to kill the nonnegative modes of the linearized operator of the equation around the soliton, in similarity variables. We will also use some energy estimates from the one dimensional case, with a new idea to control of some additional term we have in our case. Combining all this with topological argument, we are able to trap our error in some shrinking set for well chosen initial data.

Keywords: wave equation, blow-up, blow-up profile, similarity variables.

References

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ID 119 Hybrid Machine learning and Deep Learning with GARCH-family models for forecasting volatiliteis : Application in Islamic equities

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Abstract

A larger body of empirical research has been seeking alternative assets that can provide diversification benefits. Recently, Islamic finance emerged as a new trend that has started to attract the attention of academics and investors across the world through its non-conventional instruments. Several studies have indicated that Islamic equities act as safe havens and provide diversification benefits to investors. The conservative nature of Sharia principles makes Islamic financial assets natural hedging instruments against crises, as they show negative or weak correlation during turbulent market conditions, as they prohibit speculating and the receipt and payment of interests. Thus, theoretically, Islamic equities should differ fundamentally from conventional equities. The findings of a profund systematic review conducted in this article by using a combination of Machine Learning and Deep leraning with GARCH–family models as feature extractors and a symmetric model in which conditional variance is determined based on squared values of both residuals and conditional variances from previous periods, combined with technical analysis indicators to construct models and automated trading systems, including artificial intelligence or training algorithms to generate better volatility forecasts. Results indicate that Sharia equities are relatively more stable than conventional ones and are found to serve as a reliable hedge and safe haven asset class during shocks. We also reveal that investors can achieve diversification benefits and lower their downside risk by adding Islamic equities to their portfolios. This research identified the general trends in the current literature, highlights research gaps that require further more study, and offers suggestions for future research on Islamic equities as a new kind of ethical finance.

Keywords: Islamic equity, compliant stocks, Islamic finance, GARCH-family models, Deep Learning, Machine Learning.

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ID 120 Balancing Communication In Equity Markets Under Heterogeneous Beliefs: A Novel Agent-Based Modeling Approach

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Abstract

Price dynamics and market efficiency are shaped by the interaction between diverse opinions of investors and the flow of information in financial markets, which operate as intricate adaptive systems constantly adjusting to new information. Traditional asset pricing models do not to account for the role of communication and beliefs' diversity and therefore often fail to predict market fluctuations. This study develops an Agent-Based Model (ABM) to explore the effect of varying levels of communication on price stability, volatility, and market efficiency. Inspired by previous models in behavioral finance and network theory, our framework integrates Bayesian updating, stochastic processes, and machine learning techniques to simulate belief evolution and trading behavior. We employ agent-based simulations and simulated maximum likelihood estimation (SMLE) to calibrate the model using real and artificial market equity data. Additionally, we incorporate dynamic stochastic modeling to analyze how communication structures affect market behavior. Our study aims to bridge the gap between heterogeneous agent models and empirical validation, offering insights for regulatory policies, market stability, and information dissemination strategies. The findings are expected to reveal a critical balance between information flow and market efficiency, highlighting conditions under which increased communication improves price discovery or amplifies speculation and bubbles. This research contributes to the growing literature on agent-based financial modeling and provides a novel methodological approach to understanding market behavior under heterogeneous beliefs.

Keywords: Communication, Heterogeneous beliefs, share price and equity market, agent-based model, stochastic processes, and machine learning.

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ID 121 Neural Approaches for Forecasting Cryptocurrency Volatility in particular Stablecoin Efficiency

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Abstract

The high-volatility character of cryptocurrencies makes it difficult for investors to gain stable returns or maintain value. In order to avoid changes in price during the payment process, investors hope for fair payment and unlike traditional cryptocurrencies. Stablecoins refer to a cryptocurrency that is pegged to the value of an underlying non-volatile or less volatile asset or currencies. Stablecoins could maintain value and hedge risk for other volatile assets. The finding indicates also that Stablecoins can be used as an inexpensive and direct payment network because some crypto-exchange accept only Stablecoins as a medium of exchange. Furthermore, Stablecoins facilitate the exchange between fiat currencies and cryptocurrencies, therefore, avoiding excessive price fluctuations and act as a bridge between fiat currency and cryptocurrencies.Stablecoins refer to a cryptocurrency that is pegged to the value of an underlying non-volatile or less volatile asset or currencies.Stablecoins minimize the requirement for recurrent exchange among fiat currencies and cryptocurrencies, and the circulation of fiat currencies and frequent banking transactions. Stablecoins will be the requisite infrastructure in the ecosystem payment. Although different cryptocurrencies have different architectures for optimal performance, the results confirmed that performance is degraded when the neural network goes too deep. In the case of neural network models, recurrent networks have been able to capture time dependencies. In contrast, their LSTM successors have solved the stability problem during optimisation. Thus, combining both models will enhance the predictive capabilities of the indi vidual models in forecasting the volatility of cryptocurrencies. Furthermore, the error rate of almost all the artificial neural network architectures presented was lower than that of the existing time-series model. As a result of predicting the log-return price of each cryptocurrency using an artificial neural network model built in various architectural forms, the prediction result of the artificial neural network-based time-series prediction model showed less error.

Keywords: Stablecoins, cryptocurrencies, Machine Learning, Neural Network.

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ID 122 Optimal Control and Viscosity solutions of HJB equation modelling a wastewater treatment problem

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Abstract

We are interested by the optimal control of awastewater treatment problem, consisting in degradation of the pollutant by bacteria using the dissolved oxygen. The control variables represent the dissolved oxygen, The ratio between the recycled flow rate and the influent flow rate and the aeration rate. Therefore, we study the invariance and dissipation. Also, we prove the existence of an optimal control. Next, using the viscosity solution of Hamilton Jacobi Bellman , we establish that the value function is the unique viscosity solution of this equation, which characterize the optimal control.

Keywords: Wastewater treatment, Dynamical system, Invariance , Dissipation, Optimal control, Hamilton Jacobi Bellmen, viscosity solution of HJB.

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ID 123 The 2-class group of certain imaginary triquadratic fields

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Abstract

The investigation of $\mathbf{C}l_2(k)$ was the subject of many intensive studies which lead to several important results. This investigation began with quadratic fields through Gauss's genus theory, extended to certain biquadratic fields under specific conditions, and was eventually developed further to include triquadratic fields.In this work, we focus on the case of triquadratic fields under specific conditions.

Let $p \equiv 1 \pmod 4$ and $q \equiv 3 \pmod 8$ be two primes such that $q \geq 5$ and $\left(\frac{p}{q}\right) = -1$. The purpose of this presentation is to investigate the $2-$rank of the class group of fields of the form $\mathbb{K} = \mathbb{Q}(\sqrt{p}, \sqrt{-q}, \sqrt{d})$, furthermore, we determine families of these fields whose 2-class groups are cyclic, of type $(2, 2)$, $(2, 4)$ and $(2, 2, 2)$.

Keywords: Imaginary triquadratic number fields, 2-Class group, 2-Rank.

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ID 124 On the study of some quasilinear elliptic equation in weighted anisotropic elliptic problems

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Abstract

In this paper, we consider the following nonlinear weighted anisotropic elliptic problem of the type:

$$\begin{cases} -\sum_{i=1}^{N} D^i\big(a_i(x,u,\nabla u)\big) + |u|^{p_0-2}u\sigma = f(x) & \text{in} \quad \Omega, \\ u = 0 & \text{on} \quad \partial\Omega, \end{cases}$$

where the right-hand side $f(x)$ is assumed to be in $L^1(\Omega)$ and σ is weighted function. We prove the existence of entropy solutions for our nonlinear elliptic equation in the weighted anisotropic Sobolev spaces, and we conclude some regularity results.

Keywords: Entropy solution, weighted anisotropic Sobolev spaces, nonlinear elliptic equations, $L1-$data.

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ID 127 Weighted Sp-Pseudo S-Asymptotically Periodic Solutions For Some Systems Of Nonlinear Integral Equations

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Abstract

This work is concerned with the existence of positive weighted pseudo S-asymptotically periodicsolution in Stepanov-like sense for some systems of nonlinear delay integral equations. In this context, we will first be interested in establishing a suitable composition theorem, and then some existing results concerning the S-asymptotic periodicity in the scalar case are developed here for the vector case. We point out that, in this paper, we adopt some changes in the definitions, which, although slight, are necessary to accomplish the work.

Keywords: Weighted Sp-pseudo S-asymptotic periodicity, S-asymptotic periodicity, Systems of nonlinear delay integral equations.

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ID 130 The Teaching of Problem Solving and its Impact on Students' Performance in Solving Problems in Mathematics: An Experimental Study

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Abstract

Problem solving plays an important role in the acquisition of cognitive and metacognitive strategies that are essential in everyday life by involving a series of processes. These skills are not acquired by themselves but require a stimulating teaching-learning environment. The aim of this article is to evaluate the impact of integrating problem solving as a teaching object, as a distinct didactic component, rather than as a learning tool.

The participants in this study were 66 secondary school students who were randomly assigned to one of two groups: an experimental group that received instruction using problem solving as an object according to Polya's approach, and a control group that received traditional instruction. Both groups took a problem-solving pre- and post-test. The results showed that the experimental group outperformed the control group on the post-test, as well as showing a significant improvement (sig = 0.0) in their skills compared to their pre-test scores. In addition, Polya skill scores and grades for both groups were highly correlated (r=0.959 for control group; r=0.966 for experimental group with $\alpha < 0.01$), showing that high or low marks obtained reflected very significantly their ability to generate cognitive and metacognitive processes during problem solving.

Keywords: Problem solving, Skills, Teaching mathematics, Learning, Evaluation.

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ID 131 Produits de Blaschke, ensembles de niveaux et conjecture de Crouzeix

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Abstract

Cette présentation est motivée par l'étude de la conjecture de Crouzeix appliquée aux compressions de l'opérateur shift, lorsque le symbole est un produit de Blaschke fini. Dans ce contexte, Pamela Gorkin et Kelly Bickel posent une version adaptée de la conjecture, appelée conjecture de Crouzeix pour les ensembles de niveaux (Level Set Crouzeix conjecture ou LSC conjecture), portant sur le comportement des ensembles de niveaux des produits de Blaschke finis. Cette présentation explore cette conjecture dans plusieurs cas particuliers, en se concentrant principalement sur les produits de Blaschke finis sans points critiques. Dans ce cadre, l'analyse géométrique des images numériques des compressions du shift a permis à Pamela Gorkin et Kelly Bickel de confirmer la validité de cette conjecture pour des degrés faibles (notamment pour n=3, n=4 et n=5). Si le temps le permet, cette présentation expliquera également comment ces résultats géométriques offrent de nouvelles perspectives sur la conjecture de Crouzeix pour les shifts compressés associés. Ce travail est issu d'une collaboration entre Pamela Gorkin et Kelly Bickel.

Keywords: Produit de Blaschke finis, Conjecture de Crouzeix,LSC, Les compressions du décalage .

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ID 132 Statistical Inference for Multi-Parameter Lognormal Diffusion Processes

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Abstract

Stochastic diffusion processes, especially the lognormal diffusion model, play a key role in modeling dynamic systems across disciplines such as finance, biology, and engineering. Although the two-parameter lognormal diffusion is extensively studied, generalized formulations (with three or four parameters) provide enhanced flexibility to model real-world data features, including skewness and distributional shifts. However, statistical inference for these extended models presents significant challenges, particularly due to their complex likelihood structures and potential identifiability issues.

The aim of this work is to study the multi-parameter lognormal diffusion process and the statistical inference methods used to estimate its parameters.

Keywords: Diffusion process, Multi-Parameter Lognormal Diffusion, Statistical inference.

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ID 133 Quartic points on $\mathcal{C}_a : y^7 = x^a (x-1)^a$

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Abstract

The goal of this work is to give a parametrization of the set of quartic points on the family of quotients of the Fermat curve of degree 7 of equation $\mathcal{C}_a : y^7 = x^a (x-1)^a$ where $a \in \{1, 2, 3\}$. We use the Mordell-Weil group, the Riemann-Roch spaces and birational morphisms to give this parametrization.

Keywords: Fermat quotients curve,birational morphism, quartic points.

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ID 134 On Discriminant and Separability of Commutative Algebras

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Abstract

In this work we use the power tool of the relative discriminant to study the separability of some finitely generated projective R-algebras over a commutative ring R. More precisely, we prove that if R is residually perfect (i.e., R/I is a perfect field for any maximal ideal I in R) and A is a finitely generated projective R-algebra of constant rank over R then A is separable over R if and only if all maximal ideals of R are unramified in A. Further, we establish some properties of separability of a composite of finitely generated R-algebras and we use the tower formula of the discriminant to prove the transitivity of separability of a tower of extensions of finitely generated algebras. Some applications on strongly graded algebras over a graded principal ideal ring, are given.

ID 135 Cloture integrale d'un anneau gradué

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Abstract

Le thème développé dans cette intervention entre dans le cadre de ce que l'on pourrait appeler "Algèbre commutative graduée". Les techniques utilisées diffèrent des techniques existantes car nous restons dans le contexte gradué, c'est-à-dire que nous établissons une théorie sur les anneaux gradués en partant de l'étude des corps gradués. L'objectif est d'étude de la cloture intégrale d'un anneau gradué commutatif intègre gradué par un monoide symplifiable et sans torsion.

ID 136 Commutativity and generalized derivations in prime ring involving symmetric elements

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Abstract

In this paper, we explore the commutativity of a prime ring $(R, *)$ equipped with an involution of the second kind. Specifically, we examine the influence of a generalized derivation G associated with a derivation d on the structure of the ring. Under certain conditions involving these mappings and their interactions with symmetric elements, we establish criteria that ensure the ring exhibits commutativity.

Keywords: Generalized derivation, Derivation, involution, prime ring, symmetric element.

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ID 137 A Comparative Analysis of Residual-Based and Reconstruction-Based A Posteriori Error Estimators

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Abstract

The aim of this talk is to compare two types of a posteriori error estimation, considering several approximations. It is about the classical residual error estimations [4, 1] and the estimations based on reconstruction [3, 2].
The idea of a posteriori error estimates based on the reconstruction of the equilibrated potential and/or equilibrated flux goes back to the Prager-Synge equality for the Poisson equation $-\Delta p = f$. This identity is valid for all $v \in H_0^1(\Omega)$ and all $\mathbf{u} \in H(\text{div }, \Omega)$ such that div $\mathbf{u} + f = 0$, and given by

$$\|\mathbf{u} - \nabla v\|_{0,\Omega}^2 = \|\mathbf{u} - \nabla p\|_{0,\Omega}^2 + \|\nabla p - \nabla v\|_{0,\Omega}^2.$$

It follows that, to obtain such estimate, we need to reconstruct a so-called equilibrated flux; $\mathbf{u} \in H(\text{div }; \Omega)$ satisfying the equilibrium condition div $\mathbf{u} + f = 0$ and such that $\mathbf{u} - \nabla p$ is as small as possible, and/or reconstruct a potential v in $H_0^1(\Omega)$.
In all cases, to have an estimate, which is said "by reconstruction", it is necessary to have at the end an equilibrated, flux and potential. Now, the question is: is it better to work with a numerical method that allows us to have an equilibrated quantities and in this case there is no need to reconstruct, or else, do we use a method where, we do not have an equilibrated solutions such as the Discontinuous Galerkin method, and in this case it is necessary to reconstruct the two variables? By using various finite elements methods, for a diffusion problem, we will first compare, these various estimates by reconstructions, then we compare them with the classical residual estimates where no reconstruction is required.

Keywords: Comparison, a posteriori error estimation, reconstruction, residual.

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ID 138 Mathematical modelling and numerical simulation of urban inundation

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Abstract

Urban flooding is a growing concern in Morocco as a consequence of rising urban population and climate change induced increases in heavy rainfall. For instance, our previous works [1, 1] have shown that the north of Morocco is expected to experience severe scenarios of floods in terms of their frequencies and strengths. Our aim in the present study is to develop easy-to-implement and fast simulation tools to cope with these challenges. We propose a set of shallow water equations for modelling inundation floods in large urban areas accounting for different hydraulics and hydrology processes. The shallow water equations including rainfall and effects of urban topography forms a hyperbolic system of conservation laws with stiff source terms. In general, the numerical solution of this system is very challenging and many methods from computational fluids dynamics fail to accurately resolve the flow features. Therefore, we introduce in this study a class of finite element methods for the numerical solution including interaction between water and structures such as buildings. Computational techniques used for sampling the hydrographs and resolving the boundary conditions are also discussed in the current works. We consider both two-dimensional and three-dimensional problems and numerical results are presented for different case studies.

Keywords: Mathematical modelling, Numerical simulation, Urban inundation, Shallow water equations, Finite element method.

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ID 139 The vaccination strategy within the nonlinear dynamics of fractional model of herpes simplex virus (HSV) transmission

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Abstract

This paper introduces a new fractional mathematical model for the herpes virus, integrating vaccination dynamics into population-level transmission. We provide a detailed analysis of the model's biological and mathematical characteristics, including an investigation of equilibrium states both the disease-free equilibrium (DFE) and the endemic equilibrium (EE) and their stability in relation to the basic reproduction number R_0. A sensitivity analysis is also conducted to assess how key parameters affect disease spread, emphasizing the critical role of vaccination in curbing herpes transmission. To support our theoretical conclusions, we present numerical simulations illustrating how vaccination reduces the prevalence of infected and exposed individuals. Our findings underscore the effectiveness of vaccination as a key strategy for controlling herpes outbreaks and alleviating its public health impact.

Keywords: HSV-1, HSV-2, Basic reproduction number, Study of the stability, Numerical scheme, Fractional Caputo derivative.

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ID 140 Modeling the Dynamics of Tuberculosis Using the Caputo Fractional Derivative: Memory Effects in Disease Transmission

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Abstract

Tuberculosis (TB) remains a significant global health challenge, requiring advanced mathematical approaches to better understand its transmission and control. In this study, we develop a fractional-order model of TB dynamics based on the Caputo derivative, which incorporates memory effects inherent in biological processes. The fractional framework enables the modeling of past states influencing the current disease dynamics, thus offering a more realistic description than classical integer-order models. Using numerical simulations, we analyze the impact of the fractional order on the spread of tuberculosis, demonstrating how memory effects influence the persistence and control of the disease. The results reveal that fractional-order models can capture complex dynamics and offer deeper insights into long-term disease behavior, making them valuable tools for public health planning and intervention strategies.

Keywords: Fractional Calculus, Memory Effects, Caputo fractional derivative, Epidemiological Modeling, Tuberculosis.

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ID 141 A Mathematical Insight into Zika Virus Transmission Dynamics

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Abstract

In this study, we develop a new mathematical model to describe the transmission dynamics of the Zika virus, accounting for interactions between humans and mosquitoes. We analyze the feasibility region of the system and determine the equilibrium points, followed by an investigation of their stability. The existence and uniqueness of the solution are established through fixed-point theory. To approximate the solution, we employ a standard numerical method. Numerical simulations are provided to illustrate the model's dynamics and support the theoretical findings.

Keywords: Zika virus, Mathematical modeling, Human-mosquito interaction, Numerical simulation

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ID 142 Elliptic Equations on Two-Component Structures: Renormalized Solutions under Robin Boundary Conditions

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Abstract

In this paper, we consider the degenerated quasilinear elliptic equation with nonhomogeneous Robin boundary conditions of the form :

$$\begin{cases} -\text{div}\,(a(x,u_1,\nabla u_1)) = f(x) & \text{in } \Omega_1, \\ -\text{div}\,(a(x,u_2,\nabla u_2)) = f(x) & \text{in } \Omega_2, \\ u = 0 & \text{in } \partial\Omega, \\ a(x,u_1,\nabla u_1)\nu_1 = a(x,u_2,\nabla u_2)\nu_1 & \text{in } \Gamma, \\ a(x,u_1,\nabla u_1)\nu_1 = -h(x)|u_1-u_2|^{p-2}(u_1-u_2) & \text{in } \Gamma, \end{cases} \tag{7}$$

where Ω is an open bounded and connected subset of $\mathbb{R}^N$ ($N \geq 2$), with a Lipschitz boundary $\partial\Omega$., such that Ω is decomposed as $\Omega_1 \cup \Omega_2 \cup \Gamma$, where Ω_2 is an open subset included in Ω, and $\Omega_1 = \Omega \cap \overline{(\Omega \setminus \Omega_2)}$ and $\Gamma = \partial\Omega_2 \cap \Omega$. Moreover, we assume that $f \in L^1(\Omega_1 \cup \Omega_2)$ and $\phi(x,s)$ is a Carathéodory function that verifying only some growth condition. we study the existence of renormalized solutions for this class of quasilinear equations, Also, we conclude some regularity results.

Keywords: Quasilinear elliptic equations, Non-coercive problems, Two-component domains, Renormalized solutions.

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ID 143 Topological degree approach to nonlocal Kirchhoff-type problem with Dirichlet boundary conditions

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Abstract

In the present study, we examine a Kirchhoff-type problem involving the generalized integro-differential operator with a singular kernel. Utilizing the topological degree, we investigate the existence of weak solutions to the nonlocal problems described above, subject to Dirichlet boundary conditions.

Keywords: generalized fractional Sobolev space with variable exponent, topological degree theory, nonlocal Kirchhoff-type problem

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ID 144 Deep learning for microvascular imaging in diabetes-related foot ulcers

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Abstract

Artificial intelligence (AI) has emerged as a transformative tool in medical imaging, particularly in the diagnosis and management of chronic conditions. Recent advances in deep learning have enabled high-precision analysis of microvascular imaging data, offering new insights into diabetes-related complications. This paper explores the role of AI in processing microvascular images—such as optical coherence tomography angiography (OCTA), infrared thermography, and capillaroscopy—to detect, assess, and predict the progression of foot ulcers in diabetic patients.

Diabetic foot ulcers (DFUs), affecting 25% of diabetes patients and frequently leading to amputations, are strongly linked to microvascular dysfunction. This paper investigates AI-driven approaches for early detection of microvascular impairment to prevent DFU development, reviews deep learning models like U-Net and vision transformers for analyzing tissue perfusion patterns, and explores multimodal AI techniques combining OCTA and thermal imaging for enhanced diagnostics. It also provides a comparative assessment of current methods, discussing their performance, dataset limitations, and clinical utility, while outlining future research directions focused on improving AI interpretability and real-world implementation in resource-limited settings.

Keywords: Diabetic foot ulcers, Artificial intelligence, Deep learning, microvascular imaging

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ID 145 A Genetic-Grey Wolf Hybrid Approach for Feature Selection in Arabic Text Analysis

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Abstract

The application of meta-heuristic approaches to Arabic texts remains limited, due to the complexity of the language's parsing and derivation rules, its rich morphology, and its elaborate grammatical structures. In this research, we propose an innovative architecture for processing Arabic documents, using Grey Wolf Optimization (GWO) combined with the genetic algorithm. The method is divided into four distinct phases: Term weighting: Based on the TF-IDF, this step evaluates the frequency and relevance of terms in documents and classes. Feature selection: The Genetic Grey Wolf Optimization (GGWO) algorithm is used to reduce the dimensionality of the data and identify the most significant features for modeling. Classification: An adapted version of the Firefly algorithm is used to assign documents to predefined classes, via an optimized objective function. Comparative evaluation: The performances of the different approaches are analyzed and compared. The experiments were conducted on two reference corpora, with a comparative study of the term weighting systems. The results demonstrate that the GGWO-Firefly hybrid approach outperforms traditional statistical algorithms in terms of accuracy and efficiency.

Keywords: Grey Wolf Optimization; genetic algorithm; Text classification; Firefly Algorithm; Feature Selection.

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ID 146 Fractional-Order Modeling of Dengue Infection Dynamics: Homotypic Reinfection, Stability, and Numerical Validation

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Abstract

Dengue fever, caused by four antigenically distinct serotypes, remains a global health threat, with current models relying on assumptions of lifelong homotypic immunity that recent evidence challenges. To address this gap, we propose a fractional-order within-host model of dengue infection dynamics, incorporating memory effects and non-local interactions inherent to immune response variability. By replacing classical derivatives with Caputo fractional operators, our framework captures anomalous viral diffusion, antibody-dependent enhancement (ADE), and waning immunity critical for homotypic reinfection scenarios. We derive the basic reproduction number $\mathcal{R}_0$ via next-generation matrix methods adapted to fractional systems and identify infection-free and endemic equilibrium points. Stability analyses, guided by Matignon's theorem, reveal the sensitivity of equilibria to fractional-order parameter α, which quantify immune memory retention and viral clearance dynamics. Numerical validation using the Adams-Bashforth-Moulton scheme demonstrates that the fractional model better aligns with empirical viral load and IgG/IgM antibody data compared to integer-order counterparts, particularly in predicting long-term reinfection risks.

Our results underscore the epidemiological relevance of homotypic reinfections, suggesting that fractional-order dynamics significantly influence dengue transmissibility even when $\mathcal{R}_0 < 1$. This work provides a novel mathematical foundation for reevaluating disease control strategies, including vaccine booster timing and serotype-specific immunity management.

Keywords: Fractional Caputo derivative, Basic reproduction number ($\mathcal{R}_0$), Stability analysis, Dengue serotype reinfection, Adams-Bashforth-Moulton method

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ID 148 Some methods for solving partial differential equations with neural networks

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Abstract

Neural networks are increasingly used to construct numerical solution methods for partial differential equations. In this expository review, we introduce and contrast three important recent approaches attractive in their simplicity and their suitability for high-dimensional problems: physics-informed neural networks, methods based on the Feynman-Kac formula and methods based on the solution of backward stochastic differential equations.

Keywords: backward differential equation, curse of dimensionality, neural networks, partial differential equation, PINN.

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ID 149 The Teaching of Problem Solving and its Impact on Students' Performance in Solving Problems in Mathematics: An Experimental Study

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Abstract

This study examines the sequential integration of entanglement-enhanced quantum error-correcting codes (EAQECCs) constructed from cyclic codes over structured rings $\mathcal{R}$. We rigorously assess how the hierarchical arrangement (inner, intermediate, outer) of multi-stage concatenation impacts key metrics, including entanglement resource utilization, logical failure rates, and pseudo-threshold behavior. By demonstrating that cyclic codes over $\mathcal{R}$, when refined to saturate classical bounds (Griesmer, Plotkin, Singleton), generate EAQECCs that achieve quantum optimality, we derive explicit code families with certifiable performance limits. The algebraic versatility of $\mathcal{R}$, paired with multi-tiered redundancy, amplifies error resilience and fault tolerance, offering a systematic architecture for scalable quantum protocols in computation and communication.

Keywords: Problem solving, Skills, Teaching mathematics, Learning, Evaluation.

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ID 150 Some results on simple-separable modules

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Abstract

A module M over a ring is called simple-separable if every simple submodule of M is contained in a finitely generated direct summand of M. While a direct sum of any family of simple-separable modules is shown to be always simple-separable, we prove that a direct summand of a simple-separable module does not inherit the proprety, in general. It is also shown that an injective module M over a right noetherian ring is simple-separable if and only if $M = M_1 \oplus M_2$ such that M_1 is separable and M_2 has no zero socle. The structure of simple-separable abelian groups is completely described.

Keywords: Separable module, simple-separable module, V-ring, π-V-ring.

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