BİRUNİ UNIVERSITY
"Future of Science"

(Hybrid) International Conference on Nonlinear Science and Complexity (ICNSC23) July 10-15 2023, Istanbul-Turkey

Abstracts Book

Editors
Mustafa Bayram
Aydın Seçer

(Hybrid) International Conference on Nonlinear Science and Complexity ($\mathcal{ICNSC}$23) July 10-15, 2023, Istanbul-Turkey

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Prof. Dr. Mustafa Bayram
Prof. Dr. Aydın Seçer

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Participant Statistics

217 participants from 44 different countries attended the conference, 38 of them from Turkey and the others from abroad, so 82% participants are foreigners and 18% participants are Turkish.

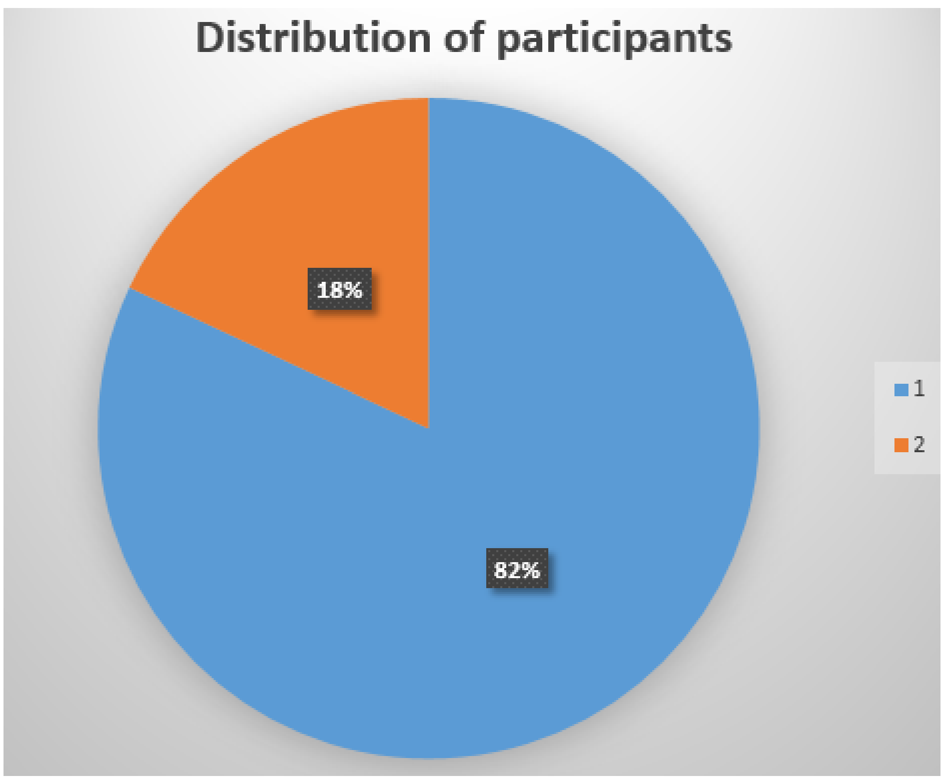

Figure 1: 1. Foreign participants, 2. Turkish participants

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MESSAGE FROM CHAIRMAN

It was with great pleasure that we welcomed you to the "International Conference on Nonlinear Science and Complexity, 2023". This conference, which took place in Istanbul, Turkey from July 10-15, 2023, was a hybrid event presented by Biruni University. With a significant turnout of scientists from 44 countries and a total of 207 papers presented, we gathered to discuss the most recent developments, discoveries, and progress in Nonlinear Science and Complexity.

Our aim was to delve into the fundamental and frontier theories that act as the backbone of modern science and technology. We hoped to instigate further research interest and explorations into this exciting field. The conference placed a spotlight on the foundational theories and principles, analytical and symbolic approaches, and computational techniques in nonlinear physical science and mathematics. A diverse range of topics was addressed, from nonlinear dynamical systems, nonlinear electronic circuits, and classical and fractional differential equations to nonlinear dynamics in fields such as biology and engineering. We also explored complexity in areas like physics, chemistry, and biomedicine, neurodynamics, social dynamics, data-driven dynamical systems, and mathematical methods in artificial intelligence, among others.

As the number of applications from around the world increased, we faced the challenging task of selecting and categorizing abstracts from numerous participants. We did our utmost to accommodate a wide range of speakers, creating an environment conducive to rich, engaging interactions and exchanges.

We were also delighted to offer a range of social activities including an excursion boat trip and a city tour, providing an excellent opportunity for participants to engage in informal discussions and networking. We were particularly heartened by the robust participation from young researchers, whose presentations contributed significantly to the conference.

The talks covered a wide range of mathematics and its applications such as analysis, algebra, statistics, computer mathematics, discrete mathematics, geometry, and engineering, as well as their use in modeling. We believed that this richness provided the basis for interdisciplinary collaborations.

We want to express our sincere thanks to some key individuals who contributed significantly to the conference's success. Albert Luo and Lev Ostrovsky, your participation and efforts were truly appreciated. The same goes for Dumitru Baleanu, Aydin Secer, Tuğçem Partal, Neslihan Ozdemir, Melih Cinar, Handenur Esen, and Ismail Onder, along with all our colleagues who worked tirelessly for the organization of the conference. In addition, we acknowledged the support and guidance of the chairman of the board of trustees of Biruni University and Prof. Dr. Adnan Yüksel, the Rector of Biruni University, our host institution. We were also grateful to all the plenary speakers who kindly accepted our invitation and dedicated their time to sharing their ideas during the conference.

Our heartfelt appreciation extended to all members of the organizing committee. If any individual or contribution has been unintentionally overlooked or forgotten, we hope for their kind understanding. We sincerely thanked all who put their effort into making this occasion possible.

We were delighted to welcome each and every one of you to this conference. We hope it was an enjoyable and productive experience and look forward to meeting again on future occasions.

Sincerely Yours,
Prof. Dr. Mustafa Bayram,
Conference Chair

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Yury Stepanyants (Australia)
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AWARDEE PRESENTATIONS

Characterization of a continuous phase transition in a chaotic system

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Abstract: Some characteristics of scaling invariance are discussed for a transition from integrability to nonintegrability in a class of dynamical systems described by a two-dimensional, nonlinear, and area preserving mapping. The dynamical variables are action I and angle θ and the angle diverges in the limit of vanishingly action. The transition is controlled by a parameter ϵ is closely related to the order parameter. A scaling invariance observed for the average squared action along the chaotic sea gives evidence that the transition observed from integrability to nonintegrability is equivalent to a second order, also called continuous, phase transition since when the order parameter approaches zero at the same time the response of the order parameter to the conjugate field (susceptibility) diverges. This investigation allows application to a wide class of systems and transitions, including transition from limited to unlimited chaotic diffusion in dissipative systems and also in a transition from limited to unlimited Fermi acceleration in time dependent billiard systems.

Keywords: Phase transitions, Scaling laws, Scaling invariance

Mathematics Subject Classification: 05.45.-a

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New Trends in Fractional Nonlinear Dynamics and Control

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Abstract: Fractional calculus is focussing on the study of fractional order integral and derivative operators over real or complex domains and their applications [1-3].In my talk, I will present some new trends in the field of fractional nonlinear dynamics and control. Illustrative examples will be given to justify the theoretically presented approaches.

Keywords: Fractional calculus, Nonlinear dynamics, Control

Mathematics Subject Classification: 35R11

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Geometric variational methods: molecules, garden hoses, sponges, figure skating, data science, and everything in between

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Abstract: Variational methods have formed the foundation of classical mechanics for several hundred years. In this lecture, I will show how the applications of variational principles, coupled with some ideas from geometry, can solve a wide variety of seemingly disconnected problems using the same mathematical approach. After a general and gentle introduction, I will illustrate this method on the examples of modeling figure skating (a system with nonholonomic constraint) and fluid-structure interactions applied to porous media containing incompressible fluid (two media coupled through the incompressibility constraint). I will also discuss the limitations of these methods, i.e., what progress can be achieved by algorithmic thinking alone and at what point ingenuity and creativity must take over. I will also outline the further potential of the method by briefly mentioning new applications of these methods to computations based on physics-based neural networks.

Keywords: Variational methods, modeling, fluid-structure interactions, conservation laws, nonholonomic mechanics

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Chaos and Complexity

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Abstract: Never in the annals of science and technology has emerged a field so broad and so multi-disciplinary as nonlinear chaotic and complex dynamics. The history of chaotic dynamics started with James Clerk Maxwell in the mid-eighteen century, while a Professor at the present University of Aberdeen. Maxwell was working, among many other things, on the theory of ideal gases. He, as you may know, is perhaps best remembered for his contribution to electromagnetism, the famous Maxwell's equations. He lived at the time in which the intellectual world was fascinated with the concept of a predictable, clockwork Universe. Yet he had the independence of mind not to agree with this scientifically accepted paradigm, both in his scientific and in his philosophical writings. Maxwell was the first person to understand systems having intrinsic unpredictability, which is the hallmark of chaos. In his own words "...when an infinitely small variation in the present state may bring about a finite difference in the state of the system in a finite time, ...the condition renders impossible the prediction of future events...". This realisation has had broad scientific and philosophical implications for the understanding of natural and man-made systems. By following the tradition of nonlinear dynamics even further, complexity lends the systems not only to be unpredictable, but they are made up of many states that are interrelated in a complicated manner with the emergence of both ordered and random behaviours. As chaos, it fosters and promotes multi-disciplinary interactions across both organisational lines and traditional disciplinary boundaries.

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Edge of Chaos: The Holy Grail of Complexity

Leon Chua

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Abstract: Edge of Chaos is a sexy jargon promoted, exploited, and abused by numerous scientists and luminaries engaged in complexity theory for more than 3 decades , all ending in vain. In this innaugural talk , I will define and present the Edge of Chaos criteria , a mathematical method that I conceived and proved rigorously for calculating the parameter domain where complex phenomena may emerge.
To demonstrate the predictive power of my edge-of-chaos criteria, I will present the definitive resolution of 3 classic unsolved problems, namely, the 71-year-old Turing instability phenomenon, the 49-year old Smale Paradox, and the 242-year old Galvani's All-or-none enigma .
I will conclude my talk by identifying the edge-of-chaos criteria as the complement of the second law of thermodynamics where entropy may decrease over time.

Machine Learning for Predicting the Chaotic Dynamics of Terrestrial Climate and Weather

Edward Ott

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Abstract: We first review basic ideas on machine learning (ML) for prediction of very large, heterogeneous, spatiotemporally chaotic systems, focusing on a hybrid scheme for combining ML with conventional numerical modeling and on a technique for convolutional parallelization employing many , spatially distributed ML units. We then discuss the differences between climate and weather prediction, emphasizing their respective nonstationary and stationary characters, and report on recent advances from our current work.

Essentially 2d nonlinear evolution equations and collapses in free-surface boundary layers

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Abstract: The overwhelming majority of nonlinear evolution equations used in various branches of science are one-dimensional, i.e. reprersent (1+1)d differential equations. Here, to describe dynamics of 3d longwave perturbations in various free-surface boundary layers, we present a way of asymptotic derivation of essentially two-dimensional nonlinear evolution equations with pseudo-differential (rather than differential) operators. The equations are derived by making use of the small parameters in the distinguished limit: nonlinearity is in balance with dispersion and dissipative effects. In each case the dispersion might be due to different factors (e.g. finite wavelength, weak stratification in the boundary layer, stratification, rotation outside the boundary layer). The key feature of the novel evolution equations is that these factors enter the equation in additive way: they can sum up. Thus. we get almost infinite variety of combinations of different (2+1)d novel evolution equations which describe dynamics of coherent structures in boundary layers. We specify conditions for these patterns to collapse, i.e. to form a point singularity in finite time. We describe the collapses analytically taking weakly stratified boundary layers as an example. We coclude by discussing open questions and perspectives.

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PLENARY AND INVITED SPEAKERS PRESENTATIONS

Stability, Periodic Points, and Bifurcations in Generalized Fractional Maps

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Abstract: Generalized fractional maps are discrete Volterra equations of convolution type with the asymptotically power-law kernels [1, 2, 3]. This definition encompasses most of the defined in literature discrete fractional and fractional difference equations/maps. For those maps, we derived conditions of asymptotic stability for fixed points [4] and equations defining asymptotically periodic points and bifurcation points [2, 3, 5]. As examples, we applied our results to the investigation of the fractional/fractional difference logistic and standard maps. We present arguments to support our conjecture that the Feigenbaum number δ exists in fractional systems and has the same value, $\delta = 4.6692016$, as in the regular maps [5].

Keywords: Generalized fractional maps, Periodic points, Stability, Bifurcations, Transition to chaos

Mathematics Subject Classification: 26A33, 47H99, 34A99, 37G15, 70K50, 39A70

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Conformal gauge transformations of the vortex field statistics in optical turbulence

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Abstract: The concept of gauge transformations (developed in the geometry of the Yang- Mills fields) is applied to the proof of the conformal invariance of the statistical curves of zero vorticity in the case of an inverse energy cascade in the wave optical turbulence, which is studied in the framework of the hydrodynamic approximation (M.D. Bustamante, S.V. Nazarenko in [Phys. Rev. E. 92, 2015]) of the two-dimensional nonlinear Schrödinger equation (NLS) for the weighted velocity field $\mathbf{u}$. In this case, the multipoint probability density functions (PDF) of the vortex fields $\Omega = \nabla \times \mathbf{u}$ satisfy the infinite chain of Langren- Monin-Novikov (LMN) equations (statistical form of the Euler equations). Equations are considered under an external forcing in the form of white Gaussian noise and the large-scale friction, which leads to the statistical stationarity of the PDF. Basic result: the gauge transformations are local, conformal invariantly transform the n-point statistics of the curve of zero vorticity.

Keywords:2D wave optical turbulence, gage transformation, conformal symmetry, Lundgren-Monin-Novikov (LMN) equations, Polyakov conjecture

Mathematics Subject Classification: 76F20, 35B06

Solitary Waves in the Cylindrical Kadomtsev–Petviashvili Equation

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Abstract: We present exact solutions in the form of solitary waves in the cylindrical Kadomtsev–Petviashvili (cKP) equation (alias Johnson equation) which describes nonlinear wave processes in dispersive media. This equation is formally belonging to the class of completely integrable systems; however, its exact solutions were not studied in detail albeit some particular solutions are known. We show that this equation has relationships with the Korteweg–de Vries and plane Kadomtsev–Petviashvili equations. Using these relationships, we construct wide classes of exact solutions representing cylindrically diverging solitary waves and compact solitary waves called lumps. We demonstrate interesting properties of lumps solutions specific for the cylindrical geometry. Exact solutions describing normal and anomalous lump interactions are found and will be graphically illustrated.

Keywords: Cylindrical Kadomtsev–Petviashvili equation, nonlinear waves, completely integrable systems, exact solutions, solitary waves, lumps

Mathematics Subject Classification: 35R11

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Pulse Phenomena and Dynamics for Impulsive Differential Systems with the State-dependent Impulses

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Abstract: It is well known that transient phenomenon is universal in the field of natural science and engineering. So that the impulsive dynamical systems have provided mathematical models. In recent years, the study for such systems has experienced a significant development including a series of basic theories and stability criteria. Up to now, these results mostly focus on systems with fixed impulses and few takes the state-dependent impulses into account. In this talk, we investigate the pulse phenomena and dynamics for impulsive differential systems with the state-dependent impulses from discontinuous dynamical point of view. In order to analyze and predict the precise motion of the flow once experienced a collision with the impulsive surface, we use the mapping structure, which introduces the switching plane and the generic mappings. We give the conception of flow collision impulsive surface of impulsive differential systems and get some types of the collision through the generic mapping structures. We also study the global periodic flow of impulsive differential systems with dependent state pulses in some pulsating cases.

Keywords: Pulse phenomena, Impulsive differential systems, Collision

Detecting Chaos

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Abstract: There are several analytical and numerical methods to detect chaotic behavior in a nonlinear dynamical system. This talk will present three numerical methods to detect chaos: The Lyapunov Characteristic Exponents, the Smaller Alignment Index, and the Converse KAM Method. By comparing the three methods, we will show the advantages and disadvantages of each method and discuss their limits.

Keywords: Lyapunov Characteristic Exponents, Smaller Alignment Index, Converse KAM method.

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Applications of the General Integral Transforms with Different Kernels

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Abstract: In this work, we investigate the general informations about fractional differential equations and integral transforms. We present some special functions. We discuss some different transforms such as Laplace, Sumudu, Elzaki, Natural, Aboodh, α-İntegral Laplace, Pourreza, Mohand, Sawi, Kamal and G-transform and the basic properties of these transforms. We present the integral transforms and applications of Mittag-Leffler function. We demonstrate the simulations by some figures.

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Do we need large numbers?

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Abstract: Positive numbers which are significantly larger than those typically used/required in everyday life appear frequently in fields such as mathematics, cosmology, cryptography, and statistical mechanics. In particular, large numbers have immense applicability in science and technology, especially with the advent of silicon technology based high-speed digital computers. In this lecture we shall give many examples in diverse fields where large numbers cannot be avoided.

Keywords: Large Numbers, Real World Applications, Puzzles.

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Complex nonlinear behavior of elasticity in structured media

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Abstract: Numerous laboratory experiments and field observations demonstrate that in media with a complex structure, the dynamic elastic response is characterized by (i) strong elastic nonlinearity, (ii) stress-strain hysteresis, and (iii) a long-time recovery back to the original state ("slow dynamics"). This behavior was observed in many materials, such as metals, glass beads, and, most typically, in geomaterials such as rock. Earlier (see [1, 2] and references therein) we proposed a physical model of granular materials with an inter-grain contact potential that includes adhesion and an elastic (Hertz) force. After an initial impact, the recovery occurs irreversibly, with hysteresis, whereas some contacts remain in the "excited," metastable state, and then slowly (commonly logarithmically in time) return to the initial state due to thermal processes. The latter, slow stage is described by an Arrhenius-type equation commonly used for chemical reactions. In this presentation, the state of the problem is outlined, and new developments are discussed. Particularly, the data of logarithmic soil recovery which can take years after strong earthquakes, are discussed and described using the theory. In conclusion, some yet unsolved problems are indicated.

Keywords: Strong nonlinearity, Hysteresis, Long-time relaxation, Arrhenius equation, Earthquakes

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$q-$Deformed and $\alpha-$parametrized hyperbolic tangent function based Banach space valued multivariate multi layer neural network approximations

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Abstract: Here we study the multivariate quantitative approximation of Banach space valued continuous multivariate functions on a box or RN, N E N, by the multivariate normalized, quasi-interpolation, Kantorovich type and quadrature type neural network operators. We investigate also the case of approximation by iterated multilayer neural network operators of the last four types. These approximations are achieved by establishing multi-dimensional Jackson type inequalities involving the multivariate modulus of continuity of the engaged function or its partial derivatives. Our multi-variate operators are defined by using a multidimensional density function induced by a q-deformed and A-parametrized hyperbolic tangent function, which is a sigmoid function. The approximations are pointwise and uniform. The related feed-forward neural network is with one or multi hidden layers.

Information Thermodynamics of Finite-Tape Ratchet System

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Abstract: We demonstrate the paradigm of information thermodynamics through an explicit example of a ratcheting mechanism with a finite tape, a heat reservoir, and a work reservoir. While this finite-tape ratchet system can support the operational regime of an engine or eraser, it cannot sustain these thermodynamic functionalities indefinitely due to eventual equilibration as the tape reaches its finite information capacity. Nonetheless, cumulative work can be accrued or expended through successive tape scans. We prove that the ratchet obeys the Information Processing Second Law at both its transient phase and stationary state. Through two ratchet designs, we illustrate the stochastic thermodynamics that underlie the operation of the ratchet system with its tendency to converge to an equilibrium or a non-equilibrium stationary state. Furthermore, we show how the ratchet harnesses correlation to accumulate more work by having a longer time constant to reach the steady state.

Keywords: Nonequilibrium physics, Maxwell demon, Ratchet system, Stochastic thermodynamics, Complex system.

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Exploring the Complexity of Physical Systems: Basin Entropy and Wada Basins

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Abstract: In nonlinear dynamics, basins of attraction are defined as the set of points that, taken as initial conditions, lead the system to a specific attractor. This notion appears in a broad range of applications where multistability is present, which is a common situation in neuroscience, economy, astronomy, ecology, and other disciplines. Nonlinear systems often give rise to fractal boundaries in phase space, hindering predictability. When a single boundary separates three or more different basins of attraction, we call them Wada basins. Usually, Wada basins have been considered even more unpredictable than fractal basins. However, this particular unpredictability has not been fully unveiled until the introduction of the concept of basin entropy. The basin entropy provides a quantitative measure of how unpredictable a basin is. With the help of several paradigmatic dynamical systems, we illustrate how to identify the ingredients that hinder the prediction of the final state. The basin entropy together with two new tests of the Wada property have been applied to some physical systems such as experiments of chaotic scattering of cold atoms, models of shadows of binary black holes, and classical and relativistic chaotic scattering associated to the Hénon-Heiles Hamiltonian system in astrophysics.

Keywords: Complexity, Fractal structures, Basin entropy, Wada basins.

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Finite-Time Divergence in Discrete Maps of Matrices - Theory and Applications

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Abstract: This talk will cover an important aspect of discrete chaotic systems when the nodal complexity is increased by expanding the dimension of the scalar variables. It will be demonstrated that a multidimensional discrete chaotic map can diverge even if the eigenvalues of the matrix of initial conditions are located in the convergence domain of the corresponding scalar discrete map. Complex fractal patterns representing spatio-temporal divergence in the extended Kaneko model, novel image hiding schemes based on finite-time divergence of coupled map lattices, spiral waves of divergence, intermittent bursting in fractional logistic map of matrices will be used to illustrate counter-intuitive properties of coupled discrete maps of nilpotent matrices.

Keywords: Iterative Map, Divergence, Nilpotent Matrix.

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Numerical Solutions for Quantum Inclusions with Simulation

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Abstract: What has highlighted the role of these quantum calculations in recent modeling and research is undoubtedly the possibility of using a computer to calculate different values of quantum fractional derivative and integral operators in discrete spaces. With the daily expansion of computational extension packages in different software and the need to have better approximations with the least error in modeling and interpreting natural phenomena that will experience multiple shocks at certain times, differential inclusions and quantum calculations could be considered serious attention of researchers.

Keywords: Fractional Quantum, Inclusion problems, Numerical Solution, Simulation

Mathematics Subject Classifications: 34A08; 34K60.

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On the solvability of some systems of integro-differential equations with concentrated sources

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Abstract: The article is devoted to the existence of solutions of a system of integro-differential equations in the case of the normal diffusion and the influx/efflux terms proportional to the Dirac delta function. The proof of the existence of solutions relies on a fixed point technique. We use the solvability conditions for the non-Fredholm elliptic operators in unbounded domains.

Keywords: : Integro-differential systems, Dirac delta function, Non-Fredholm operators, Sobolev spaces.

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Some properties of intuitionistic fuzzy theory and using in initial value problems

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Abstract: In this study, firstly we examine the historical development of binary logic to multi valued logic (fuzzy logic and intuitionistic logic). After that we give some properties of intuitionistic logic, Zadeh's extension principle. Finally we solved a second order intuitionistic initial value problem by using Zadeh's extension principle.

Keywords: : Intuitionistic fuzzy sets, Intuitionistic fuzzy number valued functions, Zadeh's extension principle, Intuitionistic fuzzy initial value problem.

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LCSs-based Hidden Structures in Complicated Unsteady Fluid Flows and Their Applications in Flow Control

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Abstract: High aerodynamic performance is of fundamental importance in turbo-machinery, aircrafts etc., and it is found that there exists some singular phenomena and unsteady flow could induce some positive effects, such as nonlinear high lift. However, how to understand the phenomenon and control them are still open problems. Indeed, the traditional Eulerian description is no longer available to describe the singular behaviors, which are related to mass/momentum transports and mixing. From viewpoint of dynamic system, unsteady flow is one dissipative dynamic system, there exits global attractor, one of invariant manifolds. In particular, the initial study shows that there exist intrinsic spatiotemporal structures in complex unsteady flows, and their topology properties have significant influences on the flow performance. However, due to the complexity of unsteady flow, the quantitative description and analytical approach of the "intrinsic properties" or "genes" of the unsteady flow have always been a difficult problem in fluid dynamics and there is no a specified method. Hence, it is important to study the intrinsic flow structures in unsteady flows and their controlling. Under such background and with nonlinear dynamics, Hyperbolic, Elliptic and Parabolic Lagrangian Coherent Structures (LCSs), with invariant spatiotemporal properties in a period, are developed to describe and analyze the complex flow structures in unsteady flows, and some numerical methods following nonlinear dynamics are given in capturing LCSs. Interestingly, Hyperbolic LCSs can be used to describe separation flow, Elliptic LCSs are available for describing vortex in a fine way, and Parabolic LCSs can describe the shear flow. Importantly, it is found that some hidden structures based on LCSs, which govern the flow performances, can be captured, in comparison with the flow structures in Eulerian Frame. Further, some fine structures and properties in LCSs of complex unsteady flows, such as topology structures of energy transport, are investigated with LCSs method and Lobe dynamics presented, and hence can be used to control or regulate the complex unsteady separation flow in a new way. Finally, as a verification of the above discussions, some examples relevant to unsteady separation flows are presented to illustrate the feasibility and advantages of the LCSs-based analytic method. As the results, the methods based on complete intrinsic Lagrangian Coherent Structures could describe and analyze the flow structures and dynamics of complex unsteady flows quantitatively, and further control the flow with one new and accurate method.

Keywords: Lagrangian Coherent Structure, Unsteady Fluid Flow, Vortex, Nonlinear Dynamic system.

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Competing Bifurcations of a Vibroimpact Pair

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Abstract: The presentation is focused on the analysis of a VI impact pair, which is an illustrative representative of non-smooth dynamical systems [1]. Such a system was proposed to be used as an energy harvesting device consisting of a ball travelling freely inside a harmonically excited capsule. Both sides of this capsule are covered by dielectric elastomer with compliant electrodes, organising a variable capacitance capacitor. Deformation of the elastomer leads to changes in capacitance and therefore ability to harvest energy. The considered vibroimpact system can be studied exactly analytically using maps. This allows us to study smooth and non-smooth bifurcations and their interplay in a canonical model of an impact pair While the sequences of bifurcations have been studied extensively in single-degree-of-freedom impacting models, there are limited results for two-degree-offreedom impacting systems such as the impact pair. Using an exact analytical solution between the impacts and the stability analysis, we obtain sequences of period doubling and fold bifurcations together with grazing bifurcations. Using this analysis, we identify the bifurcations on unstable or unphysical solutions branches, which we term ghost bifurcations. The presentation addresses the mystery of why sometimes we observe grazing and sometimes PD transitions, and how the ghost bifurcations, not observed numerically or experimentally, can influence the birth or death of complex behaviours [2]. We also discuss the influence of asymmetric values of the restitution coefficients and targeted energy transfer in such systems.

Keywords: Grazing, Period-doubling, Vibroimpact, Energy Harvetsing.

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A Normalized Fractional Gradient Algorithm for Nonlinear Input-Output Error Systems

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Abstract: We propose a new auxiliary model based normalized variable initial value FLMS (AM-NVIV-FLMS) algorithm for input nonlinear output error (INOE) system identification. AM-NVIV-FLMS algorithm is accurate, convergent, robust and reliable for INOE system identification. The numerical results agree with the significance and efficacy of the proposed scheme.

Keywords: Nonlinear systems, Auxiliary model, Fractional Calculus, Adaptive algorithms.

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Discrete Implicit Maps for Predicting Periodic Motions

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Abstract: Analytical prediction of periodic motions in nonlinear systems has long been of interest. The recent promoted discrete implicit maps has been proven to be one of the most efficient methods so far. Such method employ discrete maps based on discretization of the physical model and uses mapping structure to represent different periodic motions. Such mapping structure then lead to a set of discrete governing equations that can be used to analytically predict the periodic motions. Due to the complexity of the system, computational methods are then adopted to solve such equations numerically in computer programs. Analytical bifurcation trees can then be obtained for various periodic motions, while the stability and bifurcation conditions are obtained from eigenvalue of the corresponding Jacobian matrix. Predictions of the trajectories for any periodic motions can also be achieved using such techique.

Keywords: Discrete Maps, Periodic Motions, Bifurcation.

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Some Applications of Existence of Fixed Points in Nonlinear Science

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Abstract: The existence of a fixed point plays a significant role in nonlinear science as many real-world problems can be reformulated as a problem of finding a fixed point of nonlinear maps. It is a century when Banach provided the primary metric fixed point result and evidenced that each contraction in a complete metric space has a unique fixed point. However, in some situations, the fixed point of a map may not be unique. Non-unique fixed points of a discontinuous self-map perform an significant role in fixed point theory. Because if the fixed point is not unique then the set of non-unique fixed points may include a circle, a disc, an ellipse, an elliptic disc, or a hyperbola, and may have several applications in Biology, Neural Networks, Economics, Artificial Intelligence, and so on. The geometry of fixed points performs a remarkable role in real-world problems. In this talk, we discuss some applications of the existence of a fixed point and fixed figures to nonlinear science.

On offset boosting in chaotic system

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Abstract: Offset boosting is an important issue for chaos control due to its broadband property and polarity control. There are two main approaches to realize offset boosting. One is resort to parameter introducing where an offset booster realizes attractor boosting. The other one is by the means of periodic function or absolute value function where any self-reproduced or doubled attractors with diverse offset are extracted out by a specific initial condition. The former also provides a unique window for observing multistability and the latter gives the direction for constructing desired multistability.

Dynamics and bifurcations of product-quadratic nonlinear systems

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Abstract: In this paper, nonlinear dynamics of dynamical systems possessing bivariate quadratic vector fields is discussed. The bivariate quadratic vector field is a product of two different-variable univariate functions in two directions. The dynamical systems with two crossing-variable product bivariate vector fields are presented, and the corresponding global dynamics of such dynamical systems is discussed. The hyperbolic and hyperbolic-secant flows with directrix flows are discussed for the first time. From the infinite-equilibriums, the inflection sink (or source) bifurcation is presented for the switching of hyperbolic flow and saddles with hyperbolic-secant flow and sink (or source). Parabola-saddle bifurcations are for the switching of saddle and hyperbolic-secant flow with center and hyperbolic flow, which is called the saddle-center switching bifurcation. Inflection diagonal-saddle bifurcations are presented for the switching of the network of saddle and sink (or saddle and source) with hyperbolic and hyperbolic-secant flows. This paper gives a different view to discuss dynamical systems from which the complicated behaviors in nonlinear dynamical systems may be discovered.

Choosing embedding lag and why it matters

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Abstract: Takens' theorem guarantees a faithful embedding of a deterministic nonlinear dynamical system from time series data under fairly generic conditions. Embedding, in this way, is the foundation of nonlinear time series analysis and modeling. Since the 1980s many methods have been proposed to estimate the time between observations to provide to an embedding - the embedding lag. The basic premise is that time intervals should insure independence but not irrelevance. Almost all methods to choose this lag are based on the application of some heuristic to this premise. I will review some of the more interesting ones and introduce a new topologically well-founded way of doing the same. The method I describe is based on using concepts from persistent homology and topological data analysis to ensure that one achieves the "best" attractor for the given data.

Mathematical birth of early after depolarizations in cardiomyocytes: fast-slow and bifurcation analysis

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Abstract: In this talk we analyze the dynamical mechanisms underlying the formation of arrhythmogenic early afterdepolarizations (EADs) in two mathematical models of cardiac cellular electrophysiology: the Sato et al. biophysically detailed model of a rabbit ventricular myocyte of dimension 27 and a reduced version of the Luo-Rudy mammalian myocyte model of dimension 3. Based on a comparison of the two models, with detailed bifurcation analysis using continuation techniques in the simple model and numerical explorations in the complex model, we propose a conjectured scheme. We will show that in the most relevant parametric region the change, on EADs, is organized by a hysteresis loop and especial orbits, called "canards" in dynamical systems community, that generates two stable orbits, with and without EAD. It is noteworthy how a standard 1-fast—2-slow decomposition fails to properly describe some dynamical properties of the system. Instead, we combine and refine this approach by further separating the 2 slow variables according to their respective time scales. All these phenomena allow us to propose a dynamical systems conjecture of a global scheme of creation of EADs. This theoretical scheme fits well with electrophysiological experimental data on EAD generation and hysteresis phenomena.

Keywords: Bifurcations, Fast-slow, Cardiac dynamics.

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Route towards chaos in a modified FitzHugh-Nagumo neuron

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Abstract: The study of brain-inspired neurons is of great significance for the development of artificial intelligence and the treatment of diseases. This paper is devoted to investigating the analytical solutions of the modified FitzHugh-Nagumo neuron model with external electric fields through the discrete mapping method and further studies the memristive neuron using analytical method which can provide a new perspective to the study of complex motions of the neuron. The bifurcation trees of period-m motions are presented through the implicit discrete mapping method in FHN neuron system, and the stable and unstable orbits, which cannot study through the traditional numerical method, are calculated. The bifurcations and stability of the periodic orbits are determined via eigenvalues. The spiking firing of neurons can be observed through the discrete nodes in phase portraits and time histories of membrane potential. Moreover, the antimonotonicity of the improved FitzHugh-Nagumo neuron model is reported with varying controlled parameters. In the end, hardware experiments are designed via Field Programmable Gate Array to verify stable and unstable periodic motions obtained by the analytical method.

New Challenges in Fractional Calculus

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Abstract: Entire functions have played an important role in the descriptions of the complex phenomenon. Fractional calculus has been successfully applied to model the complexity in the field of physics. The target of this report is to show two entire functions associated with the Mittag-Leffler function, which are considered as entire Fourier sine and cosine integrals. We consider them as the special solutions for the time-fractional diffusion equation within the Caputo fractional derivative. We guess that they have the real zeros in the entire complex plane. The special cases for them are related to the well-known conjectures in the analytic number theory. The result was accepted for publication in Fractals [1].

Keywords: Caputo fractional derivative, Entire function, Mittag-Leffler function, Time-fractional diffusion equation, Fourier sine integral, Fourier cosine integral, Analytic number theory.

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On Λ-fractional fields and mechanics

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Abstract: Pointing out that Λ-fractional analysis is the unique fractional calculus theory including mathematically acceptable fractional derivatives, variational calculus for Λ-fractional analysis is established. Since Λ-fractional analysis is a non-local procedure, global extremals are only accepted. That means the extremals should satisfy not only the Euler–Lagrange equation, but also the additional Weierstrass-Erdmann corner conditions. Hence non-local stability criteria are introduced. The proposed variational procedure is applied to any branch of physics, mechanics, biomechanics, etc. The present analysis is applied to Λ-fractional refraction of light and in the Λ-fractional deformation of an axially extended bar and upon the bending problem of a cantilever beam.

Keywords: Λ-fractional derivative; Λ-fractional space; initial space; fractional stress; fractional deformation; fractional strain; local stability; global stability; coexistence of phases.

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High-dimensional continua of equilibrium states in globally coupled ensembles of oscillators

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Abstract: Global coupling in the ensemble of oscillators implies that all elements are subjected to the action of the same common field, and this can drastically reduce the number of effective degrees of freedom. We consider the situations in which the number of parameters defining the action of the global fields is smaller than the overall number of ensemble elements. In the phase spaces of such ensembles, high-dimensional continua composed of the equilibrium states can generically arise. Commonly, existence of these quiescent continua is not related to symmetries. Taking as examples the special cases of the globally coupled Kuramoto oscillators and active rotators, we demonstrate that under the sufficiently strong repulsive coupling a system of *N* units can feature a (*N*–2)- or (*N*–3)-dimensional manifold of the states of rest. In presence of permutational symmetries, such continua of steady states are attracting or repelling as a whole; in general, however, their stability with respect to transversal perturbations varies in the course of the motion along the manifold. The proposed mechanism does not require that all elements in the ensemble are identical: a strong global field is able to counteract diversity among the ensemble units and bring the temporal evolution to a halt.

Keywords: Coupled oscillators, invariant manifolds.

On an origami structure of period-1 motions to homoclinic orbits in the Rössler system

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Abstract: In this talk, an origami structure of period-1 motions to spiral homoclinic orbits in parameter space of the Rössler system will be presented. The edge folds of the origami structure are generated by the saddle-node bifurcations. For each edge, there are two layers to form the origami structure. On one layer of the origami structure, there is a pair of period-doubling bifurcations inducing periodic motions from period-1 to period-2n motions (n = 1, 2, . . . ,1). On such a layer, the unstable period-1 motion goes to the homoclinic orbits with a mapping eigenvalue approaching negative infinity. However, on the corresponding adjacent layers, no period-doubling bifurcations exist, and the unstable period-1 motion goes to the homoclinic orbit with a mapping eigenvalue approaching positive infinity. To determine the origami structure of the period-1 motions to homoclinic orbits, the implicit map of the Rössler system is developed through the discretization of the corresponding differential equations. The Poincare mapping section can be selected arbitrarily. Before construction of the origami structure, the bifurcation diagram of periodic motions varying with one parameter is developed, and trajectories of stable periodic motions on the bifurcation diagram to homoclinic orbits are illustrated. Finally, the origami structures of period-1 motions to homoclinic orbits are developed through a few layers. This study provides the mathematical mechanisms of period-1 motions to homoclinic orbits, which help one better understand the complexity of periodic motions near the corresponding homoclinic orbit. There are two types of infinitely many homoclinic orbits in the Rössler system, and the corresponding mapping structures of the homoclinic orbits possess positive and negative infinity large eigenvalues. Such infinitely many homoclinic orbits are induced through unstable periodic motions with positive and negative eigenvalues accordingly.

Efficient and Brute-Force Numerical Algorithms for Computing Basins of Attraction: Analyzing Dynamical Systems with Different Complexity using Julia and Matlab

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Abstract: The investigation focuses on the behavior of pendulums subject to kinematic excitation without elastic elements, but with an additional mass suspension connected to a fixed base via a spring [1]. The study compares a simple vertically excited pendulum with a single mass to a more complex dual-mass pendulum coupled to a Maxwell element. The structural complexity of both systems is assessed, and their sensitivity to varying initial conditions is analyzed using basins of attraction computed in Matlab and Julia [2]. Within the framework of the analyzed dynamical systems, numerical methods for computing basins of attraction are explored and evaluated. The basin of attraction represents the region in the phase space from which system trajectories converge to a specific attractor or steady state [3]. The grid-based method, involving discretizing the phase space into a grid and iteratively applying the system dynamics, is described as a simple but computationally intensive approach. The efficiency of the grid-based method depends on factors such as the dimensionality of the phase space, grid resolution, and available computational resources. Higher dimensions and finer resolutions can significantly increase computational costs. Therefore, other more efficient methods, including Monte Carlo, Lyapunov-based, optimization-based, probabilistic-based, phase-space reconstruction, and machine learning techniques, are mentioned as alternatives. The presentation includes the description of the methodology and numerical codes used for computing the basins of attraction for the studied dynamical systems of different complexities. The resulting portraits and conclusions drawn from the analysis are provided as outcomes of the investigation.

Keywords: Basin of attraction; computational algorithms, dynamical analysis.

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Some aspects on the nonlinear dynamics of magnetized Rossby waves in the Earth's ionosphere

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Abstract: In the frame of shallow water model the influence of free surface action on nonlinear propagation of planetary ULF magnetized Rossby waves in the weakly ionized ionospheric D-, E-, and F- layers is revealed. Relevant nonlinear dynamic equations satisfying several conservation laws obtained and investigated. The role of Hall and Pedersen conductivities investigated explicitly. It is shown that while potential vorticity is conserved in the ionospheric D- and E-layer it is broken by Pedersen conductivity in the ionospheric F-layer. Similar to KdV nonlinearity two new scalar nonlinearities due to Pedersen conductivity revealed in the F-layer.

Action of inhomogeneous zonal wind (shear flow) on magnetized Rossby wave dynamics in the Earth's ionosphere is also investigated. Appropriate nonlinear dynamic equations describing the propagation of planetary ULF magnetized Rossby waves in the ionospheric D-, E-, and F-layers obtained and investigated. The influence of existence of charged particles through Hall and Pedersen conductivities on such dynamic equations studied in detail. It is shown that the existence of shear flow and Pedersen conductivity can be considered as the presence of an external energy source. The possibility of a barotropic instability of the magnetized Rossby waves is shown. Based on the Rayleigh's theorem, the appropriate stability conditions are defined in case of the ionospheric D- and E-layers. It is indicated that magnetized Rossby waves under the action of shear zonal flow correspond to states with negative energy. Some exponentially localized vortical solutions are found for the ionospheric D- and E-layers.

Obtained results extend and complement known theoretical investigations and are especially relevant for nonlinear vortical propagation of magnetized Rossby waves in the weakly ionized ionospheric plasma. The carried out investigation performed in the collaboration with Turkish scientists from Firat University, Mus Alparslan University, Anatolian High School, Batman University, and Osmaniye Korkut Ata university scientists.

Keywords: Ionized ionospheric D-, E-, F-layers, nonlinear magnetized Rossby waves, Hall and Pedersen conductivities, vortices, shearless and sheared zonal flow.

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SYMPOSIUM

Organizers: Dumitru Baleanu, Carla M.A. Pinto, Amin Jajarmi.

Name:Nonlinear Models and Control of Biological Systems

PRESENTATIONS

Artificial Neural Network Analysis of Intensive Vegetable Farming Practices and Human Health

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Abstract: Intensive vegetable farming practices have been linked to various health concerns, including exposure to pesticides and heavy metals. In this study, we employed artificial neural networks (ANN) to model the complex relationships between intensive vegetable farming practices and human health. We considered several factors such as pesticide use, soil contamination, and farming practices. The results revealed a significant correlation between these factors and human health outcomes, particularly for neurological and developmental disorders. The ANN model provided insights into the nonlinear relationships between different factors and their relative contribution to health outcomes, which could aid in developing targeted interventions. The findings suggest the need for sustainable farming practices that minimize pesticide use and reduce soil contamination. Ultimately, the ANN-based analysis of intensive vegetable farming practices can provide valuable insights into the impact of these practices on human health, and guide evidence-based policy decisions to mitigate the associated health risks.

Keywords: Intensive vegetable farming, Artificial neural networks, Human health, Pesticides, Heavy metals, Soil contamination.

Viral infection with diffusion: Modeling, Mathematical Analysis and Numerical Simulation

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Abstract: The aim of this work is to study the dynamics of a class of viral infection models with diffusion and loss of viral particles due to the absorption into uninfected cells. We prove the global stability of equilibria by constructing suitable Lyapunov functionals for two cases: continuous and discrete. Also, some examples are given to illustrate the theoretical results.

Keywords: Viral infection, Reaction-diffusion equations, Basic reproduction number, Lyapunov functional, Global stability.

Mathematics Subject Classification: 35R11

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Decidability criterion for regional controllability of Cellular Automata models

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Abstract: Control theory deals with the behaviour of dynamical systems. A prototypical problem is that of controllability which has been used as crucial propriety for determining the system's behaviour. In this paper the main focus is on regional controllability which describes the possibility of forcing a system to reach a particular state in a portion of its domain by means of controls applied on the boundary or inside a region of interest. The problem of regional controllability has been studied for partial differential equations [1]. It has been also investigated via cellular automata (CA) that are discrete dynamical systems often considered as a counterpart of partial differential equations [2, 3, 4]. The paper focuses on the decidability criterion for regional controllability of CA and proposes a new criterion which draws from the rich graph theory. This criterion is analyzed and illustrated through several examples.

Keywords: Cellular Automata, Regional Controllability, Graph Theory, Tree.

Mathematics Subject Classification: 35R11.

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Analysis of parameters of an epidemiological survey on hepatitis A, B, C in the state of Sétif (East Algeria)

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Abstract: Viral hepatitis is a national and international public health problem and its frequency is increasing. The diagnosis of this disease is linked to several tests and techniques. The objective of this study is an epidemiological survey on viral hepatitis A, B, and C, on consultation of the registers and the records of diseases with the mandatory declaration of the direction of health and population of the state of Sétif (East-Algeria) for three years. Analysis of the data showed that viral hepatitis accounts for 11.1% of the cases affected among the reportable diseases. Hepatitis A is the most abundant form of hepatitis (84% or 1618 patients affected); hepatitis B is the second most common form of hepatitis (12% or 227 patients affected) and hepatitis C is the third most common form of hepatitis (4% or 75 patients affected). These diseases are particularly common in the municipalities of Setif: Setif, El Eulma, Ain Oulmene, and Ain El Kebira. The male sex is most affected compared to the female sex. The age range targeted by the hepatitis A virus is between 5 years and 14 years (usually children and adolescents in school), but the age range affected by the hepatitis B virus is between 20 years and 45 years (Adults), whereas the hepatitis C virus affected the age range from 45 to 64 years. The analysis of these data has enabled the health department of the Setif State to set up a strategy to fight against hepatitis, especially in the school field, based on prevention by raising awareness and informing the population.

Keywords: Epidemiological survey, Hepatitis A, Hepatitis B, Hepatitis C, Setif, Algeria.

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Analysis of data from a disease survey in the school sector of a region of Ain Arnat (Sétif East-Algeria)

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Abstract:
Object: The aim of the analysis of the data of this survey, is to describe and determine the diseases most encountered in school environments among the students of the different schools of the state of Sétif (region of Ain Arnat) and compare them with other states of Algeria and other countries.
Method: This is a cross-sectional study carried out on a sample of 33630 middle school students aged 5-18 years. Educated in 76 schools in the region of Ain Arnat (region (Sétif state - East Algeria).
Results: This investigation led to the discovery of 4143 students suffering from various diseases and a high prevalence rate of the maldid of vision loss was determined of 8.88% (2987 cases out of 33630 students) and 72.0% for the number of patients (2987 out of 4143 patients). 410 cases with enuresis with a rate of 9.89% for the total number of patients (410 cases out of 4143 patients). 260 asthma cases were recorded, representing 6.27% of patients. In terms of obesity, after using the WHO classification for BMI, 199 cases out of 33630 pupils were observed.195 cases of pediculosis representing 057% of the total number of schoolchildren.
Finally, 131 cases of anemia represent the lowest percentage, 0.38% of the total of college students.
Conclusion: The analysis of these data has shown that school medicine plays an important role in raising and improving the level of education. It is, therefore, necessary to improve health monitoring and raise the level of health management and awareness in school and family settings in the region of Ain Arnat (state of Sétif-Est Algerie).

Keywords: School health, Diseases, Survey, Analysis, Ain Arnat (Setif).

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SYMPOSIUM

Organizers: Maaita Jamal- Odysseas, Meletlidou Efthymia,

Name:Theory and Applications in nonlinear dynamical systems

PRESENTATIONS

False Strange Attractors as Sources of Pseudo-Randomness

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Abstract: In a recent work by Rezende, Leys & Bouali (2022), the authors proposed the technique of rearranging the time series of chaotic trajectories, in order to generate visually stunning new attractors. These attractors were termed 'false', as they do not correspond to a solution of a chaotic system, but are the result of editing operations on a system's real trajectory. The authors' motivation was the intersection of Chaos and Art, and the construction of intriguing new attractor shapes. In this study, we build upon that work, by further exploring how such techniques can be used to design different random bit generators from the rearranged chaotic trajectories. This is performed by first applying a rearrangement on the time series of a chaotic trajectory, and then using the resulting time series to generate a random bit generator. Such techniques can increase both the randomness of a generator, and its key space, so they can be highly useful in chaos based security applications.

Keywords: Chaos, Attractors, Bit generators, Randomness, Encryption.

Mathematics Subject Classification: 37D45, 37G35, 65P20

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Dynamical Investigation of an Active Discrete Memristor Model with an Exponential Memristance

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Abstract: In 1971, Chua discovered the memristor, which is considered the fourth fundamental electrical component alongside resistance, capacitance, and inductance. In recent years, numerous models of discrete memristors have been constructed since the formal proposal of the subject. However, there is rare discussion about the active discrete memristor models. This study combines a general map for constructing memristive maps with the modulo function and an exponential memristance, which produces a locally active discrete memristor model. Nonlinear tools, including bifurcation diagrams, Lyapunov spectrum diagrams, and phase portraits, were employed to investigate the system's dynamical behavior. The results revealed various intriguing phenomena related to chaos theory, including regular orbits, chaotic orbits, the mechanism of period doubling route to chaos, crisis phenomena, as well as coexisting attractors.

Keywords: Active memristor, Chaos, Coexisting Attractors, Crisis, Discrete map.

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Semi-separable potentials as solutions to the 3D Inverse Problem of Dynamics. I

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Abstract: We study three-dimensional potentials of the form $V(x,y,z) = \mathcal{P}(x,y)+\mathcal{Q}(z)$, or, $V(x,y,z) = \mathcal{P}(x,y)\mathcal{Q}(z)$, where $\mathcal{P}$ and $\mathcal{Q}$ are arbitrary functions of C^2-class of their arguments, and they produce a pre-assigned two-parametric family of spatial regular orbits given in the solved form $f(x,y,z)=c_1$, $g(x,y,z)=c_2$ (c_1, c_2=const). These potentials have to satisfy two linear PDEs which are the basic equations of the Inverse Problem of Newtonian Dynamics. Our aim is to find special solutions of the above form for these PDEs. Two-dimensional potentials are also studied. Families of straight lines is a special category of curves in 3D space and are examined separately. Finally, pertinent examples are given and cover all the cases.

Keywords: Classical Mechanics, inverse problem of Newtonian dynamics, families of orbits, potentials, linear and non-linear partial differential equations.

Mathematics Subject Classification: 70B05, 70F17, 70M20, 37N05, 35A08

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Composition of odd exponent polynomial functions with chaotic maps for enhancing chaos

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Abstract: A key feature regarding the research of chaotic systems, which are used for cryptography and secure communication schemes, is the introduction of novel chaotic systems, usually by adding complexity to existing ones to ensure security. This work proposes new chaotic systems, which are constructed out of odd exponent polynomial functions and well-known chaotic maps, to augment the dynamic characteristics of existing chaotic maps. The composition of a third order polynomial with the sine map, as well as the circle chaotic map, are introduced. When compared to their source maps, the resulting maps exhibit more complex behaviors. To demonstrate the aforementioned findings, well-known tools for studying the behavior of chaotic systems, such as bifurcation, Lyapunov exponent, and approximate entropy diagrams, are used.

Keywords: chaotic map, polynomial, odd exponents.

Mathematics Subject Classification: 35R11

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Stagnation and cycles in a Circuit of Capital model

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Abstract: In classical economic theory (as formulated by Quesnay, Smith, Ricardo and Marx), the economic activity is described as a circular process that involves the transformation of money to commodities and of commodities to money. The process is a qualitative and quantitative depiction of the turnover of capital from the sphere of production to the spheres of exchange and distribution, where it assumes different forms; namely, the productive capital, the commercial capital and the money capital respectively. This process is known as the Circuit of Capital and, for many economists in the heterodox tradition, was the prime tool to analyze the process of labor, the reproduction and accumulation of capital, and the possibility and actuality of crises in the capitalist mode of production. In a paper in 1982 and two books in 1986, Foley formulated a mathematical model for the circuit of capital using integral equations. In the present work, we reformulate this model into a closed and autonomous dynamical system. Not surprisingly, this model resembles the famous epidemiological models, used to describe a similar circular process for the spread of a disease; the money capital resembling the 'susceptible', the productive capital resembling the 'infected' and the commercial capital resembling the 'removed'. The equilibrium points of the system reveal the cases for a 'normal' phase of expansion, as well as for an 'excess capital', an 'excess commodities' and an 'excess money' crisis, all of which are associated with a specific type of stagnation in the economic literature. However, the stability of each indicates the existence of (at least) one limit cycle, separating the short-run stable phase of 'normal expansion' from the long-run unstable phase of a crisis.

Keywords: SIRS, limit cycles, homoclinic bifurcation, capital accumulation, economic crisis, financialization.

Epidemiological models using weighted graphs and differential equations

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Abstract:
In this paper, we conduct a comparative analysis by applying a simple SIR model and a simple SEIR model to both a plain random (Erdos-Renyi) graph and a weighted one. The statistical data obtained from the previous models are then fitted and compared to the solutions for the differential equations that describe the natural process. The simulations are then expanded for graphs and systems of greater size.
The manner in which viral charge spreads amongst populations has been extensively studied [1, 2] as a predominantly non-linear process or pseudo-linear [3]. Identifying the most appropriate network structure will enable us to develop more intricate epidemiological or social models based on non-linear systems and processes.
Here, we present a novel methodology aimed at the random allocation of weight values within a pregenerated random graph. By introducing weights and considering the adjacency matrix as symmetrical, our graph essentially possesses distinctive topological characteristics compared to its graph plain counterpart. This inherent dissimilarity holds significant importance in our effort to identify the most appropriate mesoscopic approach for simulating epidemiological models, particularly those that exhibit non-linear behavior. The comparison we make, is a qualitative comparison of the quantitative behaviour of many simulated epidemic outbreaks for each network and with the expected behaviour predicted from solving the differential equations.
Finally we discuss the possibility of exploring potential extensions such as the adoption of Barabasi-Albert or Watts-Strogatz models for further comparison and discuss whether or not we might need any new metric in order to more accurately compare the processes.

Keywords: epidemiology, graphs, dynamical systems.

Mathematics Subject Classification: 92D30.

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Robust Control of a Knee Exoskeleton Robot for Enhanced Stability During Lower Limb Rehabilitation

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Abstract: This study focuses on the robust control of lower limb exoskeletons specifically designed to assist elderly individuals in performing standing and walking tasks. Hence, a state feedback controller was developed to effectively control and stabilize the knee exoskeleton robot. Therefore, we describe the knee exoskeleton robotic system using its nonlinear dynamic model, accounting for solid and viscous frictions. Subsequently, employing the Lyapunov approach, we establish an LMI condition for the state-feedback gain of the proposed control law, ensuring robust control and stability of the lower limb exoskeleton at the knee joint level. The design of such LMI condition is demonstrated by virtue of some theoretical development and analysis and by incorporating some technical lemmas such as the Young inequality, the S-procedure, the Schur complement, and the Matrix Inversion Lemma. Finally, numerical and graphical results are presented to validate the designed LMI condition and demonstrate the effectiveness of the adopted control law in achieving robust position control of the knee exoskeleton robot for the rehabilitation purpose.

Keywords: State-feedback control, LMI stability condition, Lyapunov approach, Robust position control, knee exoskeleton, Lower limb rehabilitation.

Mathematics Subject Classification: 70E60, 93Cxx, 93Dxx

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Adaptive Gain Matrix Control for Chaos Mitigation and Accurate Human Walking Replication in the Compass-type Bipedal Robot

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Abstract: The compass-type bipedal robot is a fundamental model that can faithfully imitate human walking. However, its seemingly simple design conceals impulsive hybrid nonlinear dynamics, which can lead to complex phenomena such as chaos and various types of bifurcations. Gaining a comprehensive understanding of these behaviors necessitates a thorough analysis of compass-type bipedal walking. To mitigate the undesired effects associated with chaos and bifurcations, it becomes vital to employ continuous control utilizing conventional laws commonly used in robot manipulation. In our study, we focus on selecting optimal values for the gain matrices to achieve the most accurate imitation of human walking while simultaneously eliminating chaos and bifurcations. To accomplish this goal, we propose the implementation of an adaptive command that dynamically regulates the gain matrices in order to attain the best possible outcomes in terms of accurately replicating human walking. By meticulously analyzing and optimizing the gain matrices, we anticipate significant improvements in the performance of the compass-type bipedal robot.

Keywords: Passive dynamic walking, Compass-type bipedal robot, Chaos, Bifurcations, Chaos control, Adaptive gain control.

Mathematics Subject Classification: 34H10, 37Mxx, 70E60.

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Nambu bracket formulation and conservative discretization of a Hamiltonian magnetic reconnection model

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Abstract: Magnetic field line reconnection is a fundamental process in astrophysical, space and laboratory plasmas with important observational and theoretical implications. Of particular importance is the concept of collisionless reconnection, since it involves faster breaking of magnetic field lines due to electron inertial and kinetic effects, in comparison with reconnection due to magnetic field diffusion. In this regime a simple two-dimensional magnetohydrodynamic model with Hamiltonian structure has been proposed and extensively studied over the past two decades [1,2]. Since the model is Hamiltonian, it conserves a number of global invariants, including the Hamiltonian functional and two Casimir functionals, which should be preserved by an accurate and faithful collisionless magnetic reconnection simulation. Here, we review the 2D Hamiltonian magnetic reconnection model and formulate its Nambu trilinear bracket [3] which allows us to construct an energy and Casimir conservative discretization scheme using Salmon's prescription [4], along the lines of [5]. The numerical scheme is based on an appropriate spatial discretization of the Nambu bracket, leading to a discrete analog containing the Arakawa Jacobian [6]. For the discretization of the time derivatives we use the energy-conservative Crank-Nicolson scheme. The discretized equations of motion are then used to simulate a reconnecting Harris-type current sheet, exhibiting excellent preservation of the Hamiltonian and the Casimir invariants.

Keywords: Magnetic reconnection, Hamiltonian dynamics, Nambu bracket

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Application of a 4-D system without equilibrium points to Random Bit Generator and Image Encryption

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Abstract: In this work a chaotic 4-D system with a cubic nonlinear term and no equilibrium points is presented. The proposed 4D system is inspired by ''Elementary Quadratic chaotic flows with no equilibria" of S.Jafari et al. and its numerical investigation reveals interesting phenomena such as chaos, co-existing hidden attractors and antimonotonicity. The system is used to generate pseudorandom bit sequences which are applied to an image encryption application. The encryption process is resilient against statistical and differential attacks, as it is confirmed by various statistical measures.

Keywords: Hidden attractors, Co-existing attractors, Antimonotonicity, Random Bit Generator, Image Encryption.

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Uncertainty Quantification of Ocean Models using dynamical system tools

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Abstract: There are several ocean products, that provide ocean data for the same domains using different approximations. As more and more oceanic data become available the assessing quality of ocean models to address transport problems like oil spills, chemical or plastic transportation becomes of vital importance. In this work, we use the Lagrangian Uncertainty Quantification (LUQ) that was introduced in [G.García-Sánchez, A.M.Mancho, and S.Wiggins, Commun Nonlinear Sci Numer Simulat 104, 106016, 2022] to assess the performance of different ocean products in the same domain. LUQ is a new quantifier for forward time uncertainty for trajectories that are solutions of oceanic models. We address the analysis of the uncertainty associated with the transport of the global ocean reanalysis and analysis products offered by CMEMS, the Copernicus Marine Environmental Service. We perform our analysis in an area in the North Atlantic Ocean, where drifters observations were available and we study the dynamical structures describing the underlying transport problem, in the spirit of [C. Mendoza, A. M. Mancho, and S. Wiggins, Nonlin. Processes Geophys.21,677-689,2014].

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Chaos-based characterization of the spatial complexity of microscopy images

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Abstract: In this work, we use the basic ingredients of chaotic dynamics (stretching and folding of phase space points) for the characterization of the complexity of microscopy images of rough surfaces. The key idea is to use an image as the initial condition of a chaotic discrete dynamical system, such as the Arnold cat map, and track its transformations during the first iterations of the map. Since the basic effects of the Arnold map are the stretching and folding of image texture, the application of the map leads to an enhancement of the high frequency content of images along with an increase of discontinuities in pixel intensities. We exploit these effects to quantify the complexity of S-type (lying between homogeneity and randomness) of the image texture since the first (enhancement of high frequencies) can be used to quantify the distance of texture from randomness and noise and the second (the proliferation of discontinuities) the distance from order and homogeneity. The method is validated in synthetic images which are generated from computer generated surfaces with controlled correlation length and fractal dimension and it is applied in real images of nanostructured surfaces obtained from a Scanning Electron Microscope with very interesting results.

Exploring Mutual Synchronization: Network Stability, Effect of Time-Delay and Combination with Hierarchical Entrainment

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Abstract: In the pursuit to achieve coordinated and efficient operations in large, complex systems, various synchronization concepts have been proposed for oscillator networks. One such concept is mu- tual synchronization, allowing the synchronization of the frequencies and the locking phases of spatially distributed oscillators without relying on hierarchical entrainment from a reference clock. Analyzing the dynamics of mutual synchronization in mathematical models that incorporate nonlinear time delayed interaction terms and inertia can pose challenges. However, to obtain a deeper understanding of synchro- nization, we carried out a comprehensive study that incorporates nonlinearities, inertial-like effects and finite time delays. Taking these factors into account, we are able to predict and observe various dynamical phenomena, such as multistability of synchronized states, in networks of coupled oscillators with inherent time delays. In particular, the stability of synchronized states can be predicted in this framework. Our study includes an analysis of the linear stability of nonlinear synchronized states, allowing us to identify the specific system parameters under which synchronized states are considered stable. A notable result of our research is the identification of stable in-phase and anti-phase synchronized states, even in the presence of significant time delays. We derive algebraic criteria and conditions that enable fast and robust analytical linear stability analysis based on the system parameters. These criteria and conditions are applicable for identical oscillators to diverse network topologies, and time delays. This work also studies how hierarchical synchronization can be combined with coupling topology imple- menting mutual synchronization. The goal is to examine how self-organized dynamics are influenced by injecting a reference signal into a subgroup of the oscillators, or all of them . A key aspect of the analysis involves determining the frequency range within which the network of mutually coupled oscillators can lock with the reference frequency. By quantifying this relation, we obtain insights on whether and how hierarchical synchronization can be effectively combined with mutual synchronization.

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SYMPOSIUM

Organizers: Mark Edelman, Minvydas Kazys Ragulskis,

Name: Discrete Fractional Calculus and its Applications

PRESENTATIONS

Predictive machine learning models for fractional dynamics

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Abstract: We show how machine learning methods can unveil the fractional and delayed nature of discrete dynamical systems [6, 7]. In particular, we study the case of the fractional delayed logistic map. We show that given a trajectory, we can detect if it has some delay effect or not and also to characterize the fractional component of the underlying generation model [1, 2]. Our methods ar based on convolutional LSTM networks that have been previously used for studying the fractional nature of anomalous diffusion trajectories [3, 4, 5]. We also show how these methods still work when trajectories are incomplete or include noise.

Keywords: Fractional dynamics, logistic equation, Wu-Baleanu trajectories, machine learning.

Mathematics Subject Classification: 26A33, 65P20, 68U20.

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History of the Development of the Notion of Generalized Fractional Maps

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Abstract: In this presentation, we will describe the steps which led to the introduction of the notion of generalized fractional maps. This notion is narrower than the notion of maps with memory in general which was introduced in the middle of the last century [1], and it describes the discrete Volterra equations of convolution type [2] with kernels, which differences are absolutely summable, but the series of kernels are diverging. The most representative maps which belong to the class of generalized fractional maps are, introduced in 2008, fractional maps [3] and, introduced in 2014, fractional difference maps [4]. General properties of generalized fractional maps, like stability of fixed points and formulae defining asymptotically periodic points and bifurcations, can be derived and applied to all maps which belong to this class of maps [5, 6, 7, 3].

Keywords: Maps with memory, Volterra difference equations, generalized fractional maps.

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On the divergence rate of the fractional difference logistic map of nilpotent matrices

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Abstract: A scalar variable in a logistic map (proposed by May in 1976) can be replaced by a square matrix of variables of order two. The effect of the explosive divergence may be observed in the logistic map of matrices if the Lyapunov exponent of the appropriate scalar map is positive and the matrix of initial conditions is a nilpotent matrix.

Analogously, the fractional difference logistic map (introduced by Edelman in 2015) can be expanded into fractional difference logistic map of matrices of order two when a scalar variable is replaced by a square matrix of variables of order two. The memory horizon of the fractional difference logistic map reaches the initial conditions and can cause not only the effect of the explosive divergence but also the effect of intermittent bursting.

The complexity of the problem grows when the order of the matrix of initial conditions is extended to higher orders than two. The divergence rate of the classical logistic map of matrices is then governed by the divergence codes which do depend on the recurrences of the eigenvalues of the matrix of initial conditions. Those divergence rates are proportional to the Lyapunov exponent of the scalar logistic map. The major problem investigated in this talk is related to the divergence rates of the fractional difference logistic map of nilpotent matrices. It appears that the memory effect of the fractional difference map do not change the divergence rates if compared to the non-fractional counterpart. Such effects pave the way for the construction of novel image hiding algorithms with higher security measures.

Keywords: divergence, nilpotent matrix, fractional difference map.

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Leaking From The Phase Space Of The Riemann-Liouville Fractional Standard Map

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Abstract: In this work we characterize the escape of orbits from the phase space of the Riemann-Liouville (RL) fractional standard map (fSM). The RL-fSM, given in action-angle variables, is derived from the equation of motion of the kicked rotor when the second order derivative is substituted by a RL derivative of fractional order α. Thus, the RL-fSM is parameterized by K and $\alpha \in (1, 2]$ which control the strength of nonlinearity and the fractional order of the RL derivative, respectively. Indeed, for $\alpha = 2$ and given initial conditions, the RL-fSM reproduces Chirikov's standard map. By computing the survival probability $P_{\mathrm{S}}(n)$ and the frequency of escape $P_{\mathrm{E}}(n)$, for a hole of hight h placed in the action axis, we observe two scenarios: When the phase space is ergodic, both scattering functions are scale invariant with the typical escape time $n_{\mathrm{typ}} = \exp\langle \ln n\rangle \propto (h/K)^2$. In contrast, when the phase space is not ergodic, the scattering functions show a clear non-universal and parameter-dependent behavior.

Keywords: Fractional standard map, survival probability, frequency of escape.

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Complex Order Fractional Maps: Stability Analysis

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Abstract: Fractional order maps are the discrete systems with the arbitrary order difference operator. In this talk, we propose a generalization to such systems in which the order is a complex number $\alpha = u + iv$. We use the Z-transform and the properties of the generalized binomial coefficients to obtain the characteristic equation. This characteristic equation will be used to sketch the boundary of the stable region in the complex plane. We show that the system cannot be stable if $v > \sqrt{u - u^2}$. We sketch the stable region for various values of fractional order and provide examples supporting our claims.

Keywords: complex order fractional maps, stability, Z-transform.

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A modified approach to discrete fractional mappings

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Abstract: We propose a modified discrete fractions mappings. The method is inspired by an unusual presentation of fractional derivatives.

Keywords: Discrete fractional mappings.

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SYMPOSIUM

Organizers: Chaudry Masood Khalique, Maria Luz Gandarias,

Name: Lie group analysis and its applications to real-world problems

PRESENTATIONS

Solitary wave solutions of the singularly perturbed nonlinear partial differential equation

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Abstract: The solitary wave solutions of the singularly perturbed nonlinear partial differential equation are investigated by using the geometrical singular perturbation method and Melnikov's method. The persistence of solitary wave solutions of the unperturbed system and the principle for wave speed are discussed. Moreover, the new type of solitary wave with coexisting crest and trough for some perturbed wave equations are presented.

Keywords: Singularly perturbed differential equation, Melnikov's method, Solitary wave solutions.

Mathematics Subject Classification: 35B06, 37K06, 70H33.

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An optimal system of Lie subalgebras and group-invariant solutions with conserved currents of a (3+1)-D fifth-order nonlinear model I in science

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Abstract: Higher-dimensional nonlinear integrable partial differential equations are significant as they often describe diverse phenomena in nonlinear systems like laser radiations in plasma, optical pulses in the glass fibres, fluid mechanics, radio waves in the ion sphere, condensed matter and electromagnetics. In this talk, an analytical investigation of a (3+1)-dimensional integrable fifth-order nonlinear model with KdV forming its main part is considered. Lie group analysis [1–3] of the model is performed through which its infinitesimal generators are obtained. These generators are engaged in the construction of a one-dimensional optimal system of subalgebra from which various exact solutions of interest are obtained. Moreover, the conservation laws of the equation are presented.

Keywords: (3+1)-D fifth-order nonlinear model I, Lie group analysis, group-invariant solutions, conserved currents.

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Application of Lie symmetry for non-Newtonian fluid flows

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Abstract: In this talk we presented an application of Lie symmetry for the non-Newtonian fluid flows. We present numerical solutions and conservation laws for the underlying equation.

Keywords: Partial differential equation; Lie symmetry transformation; non-Newtonian fluids; numerical solutions.

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Exact solutions and Conserved vectors of the generalized equal width equations

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Abstract: In this presentation we firstly compute the Lie point symmetries of the generalized equal width equations. and thereafter perform symmetry reductions. Exact solutions are then obtained using Kudryashov's method. Moreover, conservation laws for this equation will be computed using the Ibragimov's method.

Keywords: generalized equal width equation, Ibragimov's method, Kudryashov's method, conservation laws.

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Lie symmetry analysis of a nonlinear partial differential equation

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Abstract: In this talk we perform Lie symmetry analysis of a nonlinear partial differential equation of mathematical physics. We present analytic solutions and conservation laws for the underlying equation.

Keywords: Partial differential equation; Lie point symmetries; conservation laws; analytical solutions.

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Conserved vectors and soliton solutions of the Landau-Ginzburg-Higgs equation

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Abstract: This talk focuses on the Landau-Ginzburg-Higgs equation, which is commonly used to explore the principles of superconductivity and cyclotron waves. The study employs the Lie group approach to perform analytical investigations on the equation. Exact solutions are then obtained by utilizing three different methods: Kudryashov's method, the generalized tanh-function method, and the simplest equation method. Finally, conservation laws are obtained using the multiplier method.

Keywords: Landau-Ginzburg-Higgs equation; Lie group approach; Kudryashov's method; the generalized tanh-function method; simplest equation method; multiplier method; conservation laws

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A study of generalized (2+1) dimensional equal-width partial differential equation of engineering

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Abstract: In this talk we study the generalized (2+1) dimensional equal-width equation which arises in various fields of science. Using Lie symmetry analysis along with power series expansion and Weierstrass methods, we construct closed-form solutions of this equation. Moreover, we derive the conserved vectors of the underlying equation by utilizing the multiplier method and Noether's theorem.

Keywords: Generalized (2+1) dimensional equal-width equation ; Lie point symmetries; conservation laws; multiplier method.

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SYMPOSIUM

Organizers: Mir Sajjad Hashemi, Aydin Secer, Muslum Ozisik, Mustafa Bayram, Mohammad Mirzazadeh,

Name: Advancements in Soliton Theory and Analytical Methods

PRESENTATIONS

Domain-dependent stability analysis and numerical simulations for a reaction-diffusion system with cross-diffusion on two dimensional geometries

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Abstract: In this work, domain-dependent stability analysis is investigated for the reaction diffusion systems induced by the linear cross-diffusion. The spatiotemporal dynamics are explored for the activator-depleted model of two chemical species in terms of the domain size and system parameters. Regions showing the Turing instability, Hopf and transcritical types of bifurcations are demonstrated using the parameter values of the system. To support our stability analytical findings, finite element solutions illustrating the pattern formation on two dimensional domains are presented.

Keywords: Cross-diffusion-driven instability, pattern formation, spatiotemporal dynamics

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Exploring soliton solutions with cross spatio-dispersive effects and Kudryashov's self-phase modulation in the extended (3+1)-dimensional nonlinear Schrödinger's equation

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Abstract: The paper presents soliton solutions to the nonlinear Schrödinger's equation, considering chromatic dispersion and cross spatio-dispersive effects, while incorporating a self-phase modulation proposed by Kudryashov with quadrupled power-law forms. Two approaches are employed to obtain these soliton solutions. These significant findings contribute to the field of quantum optics and have implications for the advancement of modern telecommunication engineering sciences. Furthermore, these results pave the way for exploring additional advanced topics, such as extending the model to include perturbation terms and addressing fractional temporal evolution. The outcomes of these ongoing research activities will be disseminated in the near future.

Keywords: Soliton solution, Kudryashov, cross spatio–dispersion.

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Optical solitons of (2+1)-dimensional Biswas-Milovic equation having kerr law nonlinearity

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Abstract: This work purposes to concede the effects of kerr law nonlinearity on the soliton behavior of the (2+1)-dimensional Biswas-Milovic equation with the Sardar Subequation method. Firstly, the nonlinear ordinary differential form (NODE) of the (2+1)-dimensional Biswas-Milovic equation has been obtained with the aid of the complex wave transformation. After that, Sardar Subequation method algorithms has been given and applied to the obtained NODE. In the next step, a polynomial expression has been achieved and converted to linear algebraic equation system. By solving the system and selecting the suitable solution set, the optical soliton solution of the investigated equation has been derived. Finally, graphical representations, gained results and necessary comments are presented.

Keywords: The Sardar sub-equation method; Optical solution; Complex transform; Chromatic dispersion.

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Retrieval optical solitons of perturbed Radhakrishnan-Kundu-Lakshmanan equation

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Abstract: In this paper, the soliton behavior of the (2+1)-dimensional perturbed Radhakrishnan-Kundu-Lakshmanan equation utilizing by the new Kudryashov method is investigated. First of all, the nonlinear ordinary differential equation form of the perturbed Radhakrishnan-Kundu-Lakshmanan equation has been obtained by inserting the complex wave transformation into nonlinear partial differential equation form of the perturbed Radhakrishnan-Kundu-Lakshmanan equation. The algorithm of the proposed method has been expressed and applied to the obtained nonlinear ordinary differential equation. Then, a polynomial expression has been achieved and converted to linear algebraic system. After solving and selecting the appropriate solution set, different soliton solutions of the investigated perturbed Radhakrishnan-Kundu-Lakshmanan equation has been derived. Finally, 3D and 2D graphics of some solutions are depicted for chosen suitable parameters.

Keywords: Optical soliton; The third order dispersion; The new Kudryashov method; Group velocity dispersion.

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Optical solitons of dispersive Schrödinger-Hirota equation having cubic-quintic-septic law nonlinearity with spatio-temporal dispersion

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Abstract: In this work, dispersive Schrödinger-Hirota equation having the cubic-quintic-septic law nonlinearity form, which is one of the important equations modeling dispersive pulse transmission in optical fibers, having the spatio-temporal dispersion term has been investigated with the new Kudryashov method. The objectives of the study are listed as obtaining the optical soliton solutions of the model, the effect of the cubic-quintic-septic form on the optical solitons represented by the model and examining the effects of other model parameters. Another main objective is to visualize the determined optical soliton solutions with appropriate 3D, 2D and contour graphics and to interpret them effectively.

Keywords: Impact; Soliton dynamic; Optical fibers; soliton propagation; Bright soliton.

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The Complex Cubic-Quintic Ginzburg-Landau Equation having Anti-Cubic Law Nonlinearity and Its Optical Solitons

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Abstract: This research investigates optical soliton solutions for the complex cubic-quintic Ginzburg-Landau equation having anti-cubic law nonlinearity which models the wave propagation in optical fibers. The study deals with the enhanced Kudryashov technique, which efficiently generates all solutions obtained from both the classical and the new Kudryashov methods, simultaneously. By applying this method to the considered complex Ginzburg-Landau equation, we successfully get dark, bright, and kink solitons. These soliton types play crucial roles in nonlinear systems and have been observed in diverse physical systems such as optical fibers, Bose-Einstein condensates, and superconductors. The findings of this investigation offer valuable insights into the behavior of soliton solutions for the complex cubic-quintic Ginzburg-Landau equation with anti-cubic law nonlinearity and have the potential to advance new technologies in nonlinear optics.

Keywords: The enhanced Kudryashov technique, Optical fiber, Chromatic dispersion, Superconductivity, Gauge theory.

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Dimensionless form of (1+1)-dimensional Radhakrishnan-Kundu-Lakshmanan equation with parabolic law of self-phase modulation in the presence of group velocity dispersion

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Abstract: This study aims to obtain optical soliton solutions of the (1+1)-dimensionless Radhakrishnan-Kundu-Lakshmanan equation with the parabolic law nonlinearity in the presence of the chromatic dispersion term. The Radhakrishnan-Kundu-Lakshmanan equation is a recently introduced model in the literature based on the Schrödinger equation and gives a different perspective to soliton transmission in optical fibers and is classified in the same group as models such as Chen-Lie-Lu, Kundu-Eckhaus, Sasa-Satsuma equation, Manakov, Schrödinger-Hirota. The study has been based on the new Kudryashov method and optical soliton solutions have been obtained, graphical representations of the obtained solutions have been given, along with the necessary interpretations.

Keywords: Nonlinear fiber optics; Complex wave transform; The new Kudryashov scheme; Dispersive soliton propagation.

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Reveal of optical pulse envelop of the perturbed Schrödinger-Hirota equation with anti-cubic law nonlinearity

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Abstract: The principal objective of this study is to procure optical soliton solutions of the perturbed Schrödinger-Hirota equation (SHE) with anti-cubic law nonlinearity by using the generalized Kudryashov method. In order to achieve our purpose, firstly, the SHE equation has been transformed into an ordinary differential equation, then in conformity with the definements of the given method the solution sets and the solution functions have been acquired. To model the new solutions we have achieved and make them more apprehensible, dark, singular and kink soliton solutions and the effects of the anti-cubic law nonlinearity terms on the soliton behaviour have been given by 3D, 2D and contour diagrams. In accordance with our literature survey, the proposed technique have not been performed to the SHE equation before, and we ensure that the new solutions we have attained will be beneficial to research specialists studying in modeling in this field.

Keywords: Perturbed Schrödinger-Hirota equation, generalized Kudryashov method, Anti-cubic law nonlinearity, Spatio-temporal dispersion.

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Optical Soliton Solutions of Stochastic Nonlinear Schrödinger Equation with Kerr Law Nonlinearity

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Abstract: In this study, the stochastic nonlinear Schrödinger equation with kerr law nonlinearity was examined by utilizing the Kudryashov auxiliary equation method (KAEM). The first stage of the study was to obtain the dark soliton solution of the equation, and then to observe the stochastic effect on the model obtained. For this purpose, stochastic term was added to the equation in the framework of Ito calculus, wave transformation was defined and applied for the transition from nonlinear partial differential form to nonlinear ordinary differential form. Then, stochastic optical soliton solutions were obtained by using the KAEM method. Among the solutions obtained, those that provide the main equation were taken into consideration and graphic presentations were made over them. In order to clearly observe the stochastic effect, 2D graphics and detailed analyzes were made for different values of the noise strength parameter.

Keywords: Stoctastic Schrödinger equation, optical soliton solutions.

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Extracting optical soliton perturbations for the perturbed Gerdjikov-Ivanov equation in the existence of the spatio-temporal dispersion

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Abstract: This scientific research paper is the result of an attempt to derive optical soliton solutions of the perturbed Gerdjikov-Ivanov equation, which is a governing model and has gained great popularity with its unique modeling of optical soliton transmission in the photonic crystal fibers and nonlinear fiber optics. For this study, targeted optical soliton solutions were obtained by using the new Kudryashov integral scheme, which was introduced to the literature recently and used by many researchers. 2D, 3D and contour visualizations of the solutions were presented and some model parameters were also examined.

Keywords: Photonic crystal fibers; Polarization preserving fibers; Soliton solution; Optic fiber.

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Optical soliton solutions of Schrödinger-Hirota equation with stochastic distribution with multiplicative white noise and nonlinear parabolic law via Ito calculus

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Abstract: In this study, our aim is to introduce the stochastic distribution Schrödinger-Hirota equation with multiplicative white noise and nonlinear parabolic law (SHEPL) through Ito calculation and to investigate its stochastic optical soliton solutions. To this end, we used the auxiliary and unified Riccati expansion of equations (UREEM) methods to generate analytical solutions. Firstly, we integrated multiplicative white noise with wave transform into SHEPL via Ito calculation and constructed the real and imaginary parts of nonlinear ordinary differential equation (NODE) form of SHEPL. We then introduced the solution algorithms of subversion of auxiliary and UREEM methods and successfully applied it to NODE. We composed analytical solutions of SHEPL using appropriate solution sets containing unknown parameters and required transformations. Then, we investigated the noise effect on the structure of soliton, we presented the graphical representations of these solutions and the research results. We obtained optical stochastic soliton solutions of SHEPL, reflected their graphical representations, and presented the effect of the noise factor on the obtained structure of solitons.

Keywords: Optical Fiber, Schrödinger-Hirota equation, Optical Soliton, Wiener proces, Noise effect, Analytical method.

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Bright soliton structure of Perturbed Schrödinger-Hirota equation with cubic-quintic-septic law of self-phase modulation

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Abstract: This study aims to peruse the optical soliton solutions of the perturbed Schrödinger-Hirota equation with cubic-quintic-septic law of self-phase modulation via the generalized Kudryashov scheme. Additionally, we analyze the impact of model parameters for the derived soliton solutions. 3D, Contour, and 2D graphs for the generated solutions are successfully indicated by selecting suitable values of parameters.

Keywords: Schrödinger-Hirota equation, Parameter effect, soliton.

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Soliton Solutions of the Drinfeld-Sokolov-Satsuma-Hirota Equation

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Abstract: In this paper, optical soliton solutions of the Drinfeld-Sokolov-Satsuma-Hirota equation (DSSH) are examined. Initially, a nonlinear ordinary differential equation (NODE) is obtained by applying a wave transformation to the DSSH equation. By balancing this NODE, the balance number is determined. The candidate solutions, along with their derivatives and wave transformation, are then substituted into the main DSSH equation. This substitution results in a polynomial form. Grouping together terms with the same power in the new equation and setting the coefficients of these terms to zero leads to an algebraic equation system. Solving this system enables the determination of unknown parameters in the candidate solutions and, consequently, the solutions of the DSSH equation. The obtained solutions are visualized through contour plots as well as two and three-dimensional plots. The proposed approaches successfully generate various types of solitons, such as kink solitons, singular solitons, and periodic singular solitons. The findings of this study will significantly contribute to future research in this field.

Keywords: Soliton, analytical methods, partial differential equation, nonlinearity.

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Soliton Solutions of the perturbed Radhakrishnan-Kundu-Lakshmanan model

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Abstract: This paper investigates the optical soliton solutions of the perturbed Radhakrishnan-Kundu-Lakshmanan (RKL) model. First, a wave transformation is applied to the RKL equation and a nonlinear ordinary differential equation (NODE) is obtained. The candidate solutions, along with their derivatives and wave transformation, are then substituted into the main equation. So, it results in a polynomial form. Grouping terms with the same power and setting their coefficients to zero, an algebraic equation system is obtained. Solving this system allows for the determination of unknown parameters in the candidate solutions and, subsequently, the solutions of the RKL equation. The used methodology successfully generates various types of solitons, including kink solitons, singular solitons, and periodic singular solitons. The obtained solutions are visualized using contour plots, as well as two and three-dimensional plots. The outcomes of this study may present significant contributions to future research in this particular field.

Keywords: Dispersive soliton, Radhakrishnan-Kundu-Lakshmanan, nonlinearity.

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On Soliton Solutions of Parabolic Law with Non-Local Nonlinearity for Improved Perturbed Nonlinear Schrödinger Equation

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Abstract: The nonlinear Schrödinger equation, which has Kerr, power, parabolic, dual power, cubic, anti-cubic, quadratic-cubic, cubic quintic-septic, triple power nonlinear forms from self phase modulation, is of great importance in the modeling of many physical phenomena, especially in the modeling of soliton transmission in the field of nonlinear optics. In addition to these nonlinearity forms, the cases whether the equation includes group velocity dispersion, spatio-temporal dispersion, perturbation terms are also important for the model created. In this study, under the shadow of all these issues, we aim to obtain the analytical soliton solutions of parabolic law with non-Local nonlinearity for improved perturbed nonlinear Schrödinger equation having group velocity and spatio-temporal dispersions by implementing the new Kudryashov approach. Following the acquisition of soliton solutions, graphic presentations and necessary comments are the natural parts of the study.

Keywords: Self-phase modulation; Self-steepening; Auxiliary equation; Optical soliton solution.

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On optical solitons of the (1+1)-dimensional Biswas-Milovic equation having Kerr law and parabolic-law with weak non-local nonlinearity in the presence of spatio-temporal dispersion

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Abstract: In this study, an effort has been made to obtain optical soliton solutions of the (1+1)-dimensional Biswas-Milovic equation having Kerr law and parabolic-law with weak non-local nonlinearity in the presence of spatio-temporal dispersion, which is one of the important models for nonlinear optics, which was introduced to the literature by Anjan Biswas and Daniela Milovic in 2010, giving a different approach to optical wave propagation in fibers. Although the model is an equation that has been studied a lot, the fact that the form to be examined has not been studied before, distinguishes the study and the results to be obtained from the others. As a general common umbrella of analytical soliton solutions, first converting the model to nonlinear ordinary differential form with a suitable wave transformation, then obtaining candidate optical soliton solutions by applying analytical method, determining the ones that satisfy the main equation from these solutions as the exact solution, and better understanding of the obtained solutions by making graphical presentations. providing the necessary comments and making the necessary comments constitute the main framework of the article.

Keywords: Self-phase modulation; Generalization parameter; Pulse propagation; Complex transform.

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Utilizing Nucci's Reduction Method for Obtaining Soliton Solutions of the Schrödinger Equation: An Exploration of its Applications

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Abstract: This paper explores the soliton solutions of Schrödinger-type equations through the utilization of a reduction technique. The research employs the reduction method to streamline the governing equations and diminish the intricacy of the mathematical model, enabling the derivation of closed-form solutions. The Nucci's reduction method enables the derivation of various solution types, including solitary wave, periodic wave, and singular soliton solutions.

Keywords: Nucci's reduction method; soliton solution; first integral.

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On optical soliton solution of the nonlinear Schrödinger's equation having Quadrupled Power-Law Nonlinearity

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Abstract: The optical soliton solutions of the nonlinear Schrödinger's equation (NLSE) having Quadrupled Power-Law (QPL) nonlinearity are intended to examine utilizing the Tanh-Coth approach. Moreover, the effects of NLSE having QPL nonlinearity parameters on the generated soliton dynamic are analyzed in detail. Graphical presentations and necessary comments have also been added for the obtained soliton solutions in this study. Finally, it has been observed that Tanh-Coth approach gives productive results to solve the model and has the capacity to be employed easily and does not take troublesome calculus and algebraic manipulations.

Keywords: Tanh-Coth scheme, Parameter effect, soliton.

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SYMPOSIUM
Organizers: Siyuan Xing, Pierpaolo Belardinelli,
Name: Nonlinear dynamics of engineering systems
PRESENTATIONS

Analytic Expression of Local Particle Density of an Ultracold Fermion Gas

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Abstract: Theoretical studies carried out on the properties of quantum gases of fermions confined by a harmonic trap potential have grown since the experimental observation by DeMarco and Jin of a fermion quantum atom gas degenerate [1]. Experimentally, temperatures of the order of a fraction of the Fermi temperature have been achieved. Research on quantum gases, either for boson or fermion gases, is a field of research in full development, and this is manifested by the impressive number of works published on the subject. In fact, the systems of ultra-cold atomic quantum gases provide an opportunity to study concepts essential to condensed matter theory, and this is thanks to the sophisticated experiments that have been developed over the past two decades and provide study environments with controllable conditions across light beams (lasers). Thus, interactions such as spin-orbit coupling and periodic potentials that can take place in a solid state environment will be simulated by those that occur in systems formed by cold atoms.

Keywords: Potential Harmonic Isotropic, Fermion System, Quantum Oscillations, Bloch Density Matrix, Local Density.

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Finite Element Analysis of Initially Curved, Extensible Euler-Bernoulli Beams (Arches) with Stretching-Due-To-Bending Effect

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Abstract: This study focuses on the analysis of initially curved, extensible Euler-Bernoulli beams (arches) using the Finite Element Method (FEM). A finite element formulation is developed to describe the curved element in the at rest configuration. The formulation proposes the implementation of the extensibility of the beam axis due to the absence of static condensation, which enhances accuracy but also adds complexity to the formulation of shape functions and equations. The obtained FE results are compared with available analytical results and the commercial software ANSYS. The distribution of natural frequencies in relation to the initial curvature is investigated. Furthermore, the research addresses the challenges associated with the nonlinear statics and dynamics of curved beam. The findings contribute to the understanding of the dynamic response of initially curved beams, including the contribution of curvature effects, such as the veering of natural frequencies, nonlinear mode shapes and dynamic behavior.

Keywords: Curved Beam (Arch), Finite Element Method, Natural Frequency, Veering, Curvature, Nonlinear Dynamic.

Mathematics Subject Classification: 74S05.

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Vortex-Induced Vibration of an Eccentric Circular Cylinder: Mechanism and Potential Application

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Abstract: Vortex-induced rotational vibration (VIRV) of an eccentrically pivoted circular cylinder in uniform flow is studied by fluid-structure interaction (FSI) simulation. Firstly, the mechanics model of VIRV of an eccentrically pivoted circular cylinder in laminar flow is proposed, and the corresponding mathematical formulations are derived. Then, an FSI solver combing the modified characteristic-based split finite element method, dual-time stepping method and spring analogy method is developed for VIRV of a bluff body in laminar flow, and its stability and accuracy are validated by two benchmark FSI problems involving transverse vortex-induced vibration (VIV) of a circular cylinder and VIRV of a circular cylinder with an attached splitter plate. Using FSI code validated, VIRVs of an eccentric circular cylinder in laminar flow are computed. The effects of mass ratio, eccentric length, and Reynolds number on the dynamic response, fluid load and vortex pattern of the eccentric cylinder are analyzed. Significant rotational response with maximum angle up to 30 degree is obtained and some novel VIRV features are observed. Finally, the potential applications of the proposed VIRV model in heat transfer enhancement and energy harvesting are discussed.

Keywords: Vortex-induced rotational vibration; eccentric circular cylinder; numerical simulation; fluid-structure interaction.

Separable Gaussian Neural Networks: Structure, Analysis, and Function Approximations

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Abstract: The Gaussian-radial-basis function neural network (GRBFNN) has been a popular choice for interpolation and classification. However, it is computationally intensive when the dimension of the input vector is high. To address this issue, we propose a new feedforward network - Separable Gaussian Neural Network (SGNN) by taking advantages of the separable property of Gaussian-radial-basis functions, which splits input data into multiple columns and sequentially feeds them into parallel layers formed by uni-variate Gaussian functions. This structure reduces the number of neurons from O(Nd) of GRBFNN to O(dN), which exponentially improves the computational speed of SGNN and makes it scale linearly as the input dimension increases. In addition, SGNN can preserve the dominant subspace of the Hessian matrix of GRBFNN in gradient descent training, leading to a similar level of accuracy to GRBFNN. It is experimentally demonstrated that SGNN can achieve 100 times speedup with a similar level of accuracy over GRBFNN on tri-variate function approximations. The SGNN also has better trainability and is more tuning-friendly than DNNs with RuLU and Sigmoid functions. For approximating functions with complex geometry, SGNN can lead to three orders of magnitude more accurate results than a RuLU-DNN with twice the number of layers and the number of neurons per layer. This network is suitable for applications such as Physics-informed neural networks (PINNs) and reinforcement learning.

A self-updated digit twin model for a discontinuous dynamical system with boundaries varying with the working conditions

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Abstract: The digit twin model is important to predict the motions of the corresponding physical system, and help to make plans and control such a system. For a discontinuous dynamical system with variant system properties due to the working conditions, such as the discontinuous switching boundaries, the digit twin model should be updated automatically in order to create correct predictions for the sub-systems upstream and downstream in the digit twin system. Additionally, it brings more difficulties when the working conditions cannot be measured real time due to some restrictions. In this presentation, a gear pair system with backlash is concerned, and the working temperature is considered to affect the clearance between the teeth of such a gear system. A new event-triggered superspiral sliding mode observer is designed to track the time-varying discontinuous boundaries and modify the forgetting factor recursive least square, when the variant and unmeasurable working temperature is considered. In the simulation, the proposed self-updated digit model can make good predictions even when the discontinuous properties of the real system change fast.

Keywords: Discontinuity, time-varying, event-triggered mechanism, state observer.

Multistable cantilever shell with embedded MFC patch: seeking energy harvesting efficiency from mechanical vibrations

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Abstract: The paper discusses an experimental campaign conducted on a cantilever composite shell with embedded Macro Fiber Composite (MFC) patch and strain gauge. The initial conical shape of the shell's free configuration is designed to be modified after flattening and clamping one of its short edge sides. The prestressed specimen possesses two distinct stable configurations, which are characterized by significant differences in terms of static deformations and associated natural frequencies. To study the dynamic behavior of the shell, a harmonic kinematic excitation is applied to its clamped side using an electrodynamic shaker. In addition to measuring the dynamic response of the shell using the strain gauge, the experimental test also includes the simultaneous measurement of the energy recovered on the MFC patch. By conducting excitation frequency and amplitude sweeps, various dynamic regimes are explored. The resonance scenarios occurring around the two natural frequencies associated with the stable configurations exhibit different types of softening behavior. The threshold level of excitation amplitude required to snap-through motion in the shell is identified. Additionally, experimental power generation maps are plotted on the excitation frequency-amplitude plane. These maps serve as valuable tools for gaining insights into the design considerations for vibration energy harvesting applications at low as well as large level of ambient excitation. The results contribute to the understanding of the considered bistable shell's dynamic characteristics and offer practical guidance for its potential applications in energy harvesting. Future developments will focus on exploring the energy harvesting possibilities presented by cantilever shells that possess four steady stable configurations. The quadristable shell holds potential for more efficient energy conversion and will be investigated to determine its effectiveness in presence of multiple snap-through mechanisms.

Keywords: Bistable canteliver shell, energy harvesting, snap through effect.

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SYMPOSIUM

Organizers: Yeliz Karaca, Dumitru Baleanu, Yu-Dong Zhang, Akif Akgül,

Name: Fractional Calculus in Complex and Nonlinear Systems

PRESENTATIONS

Impact of time delay on a prey-predator model with switching functional response

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Abstract:A delayed prey-predator model with switching functional response is proposed. The model includes two prey and one predator, and prey switching strategy is adopted by the predator. Firstly, local asymptotic stability and existence of Hopf bifurcation of the model are discussed by choosing the time delay due to gestation of the predator as bifurcation parameter. Secondly, direction and stability of the Hopf bifurcation exhibiting at the crucial value of the time delay are determined with the aid of central manifold method. Finally, computer numerical simulations are carried out to verify the availability of our obtained results.

Keywords: Hopf bifurcation, Delay, prey-predator model, Nonlinear incidence rate, Switching functional response.

Theoretical and Numerical Investigation of a New ABC Fractional Operator for the Multi-strain Tuberculosis Mathematical Computing Model

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Abstract: Characterized by intricate and latent attributes some of which are complexity, dimensionality and heterogeneity, nonlinear dynamic models are geared towards including the theoretical and application aspects of fractional calculus, fractional-order derivatives and fractional operators, which can lead to a profound understanding and optimal control of the related dynamics and structure. Thus, advanced fractional means have become prominent to address phenomena that show memory effects, time-dependent impacts and transient characteristics considering mathematical computing models. Analysis and control of fractional order nonlinear systems are also viewed to be important besides the observation of anonymous inputs employed and obtained analytically and numerically-based schemes. Accordingly, our paper investigates the multi-strain tuberculosis mathematical model under the modified Atangana-Baleanu-Caputo (mABC) fractional derivative. The new modified fractional operator presents the numerical approximations by having been applied to the related multi-strain tuberculosis mathematical model. New fractional operators, with their distinctive features, can be used extensively to model real-life problems in physical and natural world characterized by complexity, and therefore, the new operators are employed in the multi-strain tuberculosis mathematical model developed and presented in this study in depth. Moreover, the uniqueness of the solution and stability analysis provided by the considered model is presented through the use of the Picard successive approximate technique along with Banach fixed point theorem. For the numerical solution of the modified Atangana-Baleanu-Caputo (ABC) derivative, we have used the Laplace Adomian decomposition technique. The analysis of convergence is presented for the said method. With the help of the aforementioned technique, the numerical results and simulation are investigated for the proposed model. Based on the positivity of the solutions and numerical stability obtained, it has been established that the analysis of the mABC operator can point towards the field of fractional calculus, pure mathematics as well as their reflection in the applied sciences.

Keywords: Mathematical modeling; computational numerical modeling; multi- straintuberculosis mathematical model; optimal control; modified Atangana-Baleanu- Caputo fractional derivative; Laplace Adomian decomposition technique; stability analysis; Picard successive approximate technique; Banach fixed point theorem.

A Novel Chaotic and Convolutional Architecture-Supported Encryption Mechanism

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Abstract: Chaotic systems have emerged as a significant resource for secure encryption mechanisms in recent years. Moreover, convolutional layers, which are commonly used in the field of artificial intelligence, have also been preferred in the encryption domain. In this study, a new encryption mechanism based on a convolutional architecture and chaotic systems is proposed. First, a large 2D matrix is generated using random numbers from the Tent Map chaotic system, and 5x5 filter matrices are created using random numbers from the Zig Zag Map chaotic system. Then, the large matrix and filter matrices are subjected to convolutional processing using a ResNet-like architecture, and the matrices obtained from the last channel are merged. Finally, the merged matrices are subjected to an XOR operation with the original image to encrypt the image using a combination of chaotic systems and convolutional operations. To evaluate the performance of the proposed mechanism, the chaos analysis of the selected values from chaotic systems was conducted first. Then, the NIST-800-22 test was applied to the numbers obtained from the systems to analyze their randomness. Afterward, specific analyses were performed on the images encrypted using the mechanism to test the effectiveness of the encryption. Finally, the performance of the proposed mechanism was compared with other studies to demonstrate its effectiveness.

Keywords: Chaotic systems, convolutional architecture, encryption mechanism, Zig Zag Map chaotic system, XOR operation, ResNet.

Conformable Fractional Differential Operator Associated with Special Function

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Abstract: The k-convoluted operators related to the k-Whittaker function (confluent hypergeometric function of the first kind) are developed using k-symbol calculus, presenting a generalization of the gamma function. In the study, a new geometric formula for normalized functions in the symmetric domain known as the open unit disk using the conformable fractional differential operator is addressed. To adapt the theory of differential subordination, our technique entails investigating the most well-known geometric properties of this new operator, such as the subordination features and coefficient bounds. To this end, we point out a few prominent corollaries related to our primary findings as standout instances.

Keywords: univalent function; fractional calculus; fractional differential operator; conformable fractional differential operator; open unit disk; analytic function; subordination and superordination.

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ORAL PRESENTATIONS

Two orthogonal polynomials linear combination of Chebyshev polynomials off different kinds

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Abstract: In this paper we derive useful results regarding the analysis of differential properties and resultants. Moreover, we study a three-term recursive relation of associated Chebyshev polynomial-type families which are orthogonal with respect to some appropriate weight function.In his paper, "Random walks and orthogonal polynomials: some challenges", F. A. Grunbaum gave the polynomials $Q_n(x)$ orthogonal with respect to the weight $\frac{\sqrt{4pq}-x^2}{1-x^2}$ on $(-\sqrt{4pq}, \sqrt{4pq})$ explicitly as

$$Q_n(x) = \left(\frac{q}{p}\right)^{\frac{n}{2}} \left((2-2p)\, T_n\left(\frac{x}{2\sqrt{pq}}\right) + (2p-1)\, U_n\left(\frac{x}{2\sqrt{pq}}\right)\right),$$

where T_n and U_n are, respectively, the Chebyshev polynomials of the first and second kind. In similar way consider

$$R_n(x) = \left(\frac{q}{p}\right)^{\frac{n}{2}} \left((2-2p)\, V_n\left(\frac{x}{2\sqrt{pq}}\right) + (2p-1)\, W_n\left(\frac{x}{2\sqrt{pq}}\right)\right)$$

where V_n and W_n are, respectively, the Chebyshev polynomials of the third and fourth kind. In this paper we study some proprietes of Q_n and R_n.

Keywords: Chebychev polynomials, Three-term recursive relation, Quadratic transformation.

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How to compute minimum diagonal length for recurrence analysis of continuous systems

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Abstract: Recurrence Plots (RP) are binary matrices that quantify the recurrent and non-recurrent states of a trajectory. Each element of an RP matrix, denoted by $a_{i,j}$, consists of an one or a zero, indicating a recurrent or non-recurrent pair of elements (i, j) of the trajectory, respectively. RP represents a visual mosaic of the recurrent and non-recurrent states of a particular trajectory. The graphical properties of Recurrence Plots can be quantified using tools known as Recurrence Quantification Analysis (RQA), which rely on several structures embedded in an RP, such as diagonal, vertical, or horizontal line lengths. All of these quantifiers depend on free parameters, with the main ones being the threshold used to determine whether two points are recurrent and the minimum diagonal line length. One way to determine the recurrence threshold parameter (among other possible methods) is by using the concept of maximum recurrence entropy, which can turn it into a self-adjustable parameter. Here, we propose a new method for selecting an appropriate minimum length for recurrent diagonal lines (ℓ_{min}), which is critical for determining important recurrence quantifiers such as Determinism and other related quantifiers. We discuss how to choose an adequate minimum recurrent diagonal line length to accurately compute determinism and similar quantifiers that depend on diagonal line statistics. Our analysis reveals a well-defined limit for the credible applicability of recurrence analysis based on the number of data points. Moreover, we demonstrate a clear dependence of ℓ_{min} on the number of dynamical epochs (pseudo-periods) sampled. We also demonstrate how our method can maximize the sensitivity of determinism with respect to changes in the stationary character of the time series. Finally, we provide two experimental examples to illustrate our approach.

Keywords: recurrence analysis, recurrence quantification analysis, recurrence entropy.

Mathematics Subject Classification: 37M10.

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Regidity Problem of a Natural Metric

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Abstract: Let (M, g) be an n-dimensional smooth Riemannian manifold. In the present paper, we introduce a new class of natural metrics denoted by G and called the Mus-Cheeger-Gromoll metric on the tangent bundle TM. We calculate its Levi-Civita connection and Riemannian curvature tensor. Also we study the geometry of (TM, G).

Keywords: Horizontal lift, Vertical lift, Cheeger-Gromoll metric, Tangent bundle.

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The Experimental and theoretical evaluation of α-Keratin obtained from sheep horns for Co^{2+} adsorption: Adsorption isotherms, kinetics, and thermodynamic studies

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Abstract: Water pollution by heavy metals is considered a major environmental problem. Therefore, their removal by adsorption is of great practical importance. In this paper, the brut keratine powder (BKP) was used as an adsorbent for the adsorption of Co^{2+} in an aqueous medium. The adsorbent was characterized using SEM, FTIR, and XRD. The specific surface area of the BKP was also measured using BET and its point of zero charges was determined using a standard method. The effects of adsorption process parameters (adsorption time, pH of solution, adsorbent dose, and initial Co^{2+} concentration) on the response (percent Co^{2+} removal) were investigated using a batch adsorption system. The maximum adsorption capacity was observed at $pH = 4$ which is less than the pHzpc (4.2) of the adsorbent with an adsorbed amount of 7.92 mg/g and ($R = 99\%$). The Langmuir, Freundlich, and Temkin models were used to depict the adsorption of metal ions onto BKP. The smaller RMSE values obtained for the Langmuir Isotherm model indicate better curve fitting. A comparison between several models on the overall adsorption rate showed that the kinetic of adsorption was better described by the pseudo-second-order model that provided the best correlation ($R^2 = .99$). The thermodynamic parameters: enthalpy, entropy, and Gibbs free energy were calculated and discussed. The negative $\Delta G°$ and positive $\Delta H°$ values indicate that the overall adsorption is spontaneous and endothermic. This research revealed satisfactory biosorption capacity and can be considered an effective biosorbent for water treatment with a low concentration of Co^{2+}.

Keywords: Adsorption, Keratin horn sheep's powder, Isotherm, kinetics, Equilibrium, Thermodynamic.

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Improved Outcomes for Nonlinear Delay Integro-Differential Equations

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Abstract: In this researh, we discuss various qualitative motions of solutions to nonlinear delay integro-differential equations. By help of a suitable Lyapunov-Krasovskii functional, we obtain three new theorems that include sufficient conditons on the qualitative motions of solutions. Numerical applications of our results are shown by examples.

Keywords: Lyapunov- Krasovskii functions, Delay integro-differential equation, Qualitative properties.

Mathematics Subject Classification:34D05, 34K20, 45J05.

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Unsteady free convection flow of casson fluid with chemical reaction past infinite inclined plate

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Abstract: This paper studies the unsteady Casson fluid in the present of chemical reaction electrically conducting heat fluid near an infinite inclined plate. The effects of velocity, temperature and concentration were obtained by using Laplace transform technique. Besides, this method is also has been used to solve analytical governing equations. The impact of various embedded parameter on velocity, temperature and concentration such as Casson fluid, chemical reaction, radiation, isothermal and porous medium has been discussed graphically with numerical results. The results indicate that the increasing value of Casson and chemical reaction are increasing the speed of velocity. Also, it can be concluded that the enhancement in radiation decreases the temperature value because energy is taken away and when the value of chemical reaction increase, the concentration become decreases.

Keywords: Casson, Chemical reaction, Inclined plate, Radiation and Laplace transform.

Results on stability and square integrability of solutions to multidelay neutral differential equations of third order

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Abstract: In recent years, there has been growing interest in exploring neutral differential equations, with applications in many areas, including fluid dynamics, physics, chemistry and biology. Problems in these areas have often guided researchers and physicists to expend great efforts to investigate interesting phenomena, such as the effect of vibrating systems fixed to an elastic bar. These equations appear often in the modeling of networks containing lossless transmission lines. In the qualitative analysis of such systems, the stability and asymptotic behavior of solutions play an important role.
There is the permanent interest in obtaining new sufficient conditions for the stability, boundedness and square integrability of solutions of third order multi delay neutral differential equations.
In this work by constructing a Lyapunov functional, we obtain some sufficient conditions which guarantee the stability, boundedness and square integrability of solutions for some nonlinear multidelay neutral differential equations of third order.

Keywords: Boundedness, Multidelay differential equation, Lyapunov functional, Neutral differential equation of third order, Square integrability stability.

Mathematics Subject Classification: 34C11, 34D20.

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Optimal Control for Nonlinear Time Delay Systems

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Abstract: In recent years, researchers have shown considerable interest on nonlinear systems via differential inclusions. But few papers have been devoted to nonlinear systems with delay, despite the fact that delay is inherent in the transmission of information between the different parts of the system. These systems have a wide range of application including but not limited, to physics, engineering, biology, medicine, and economics. Optimal control for nonlinear control systems with delay, modeled by differential inclusions, has always been a crucial problem in practical applications. In this research we focus on investigating optimal control for a class of nonlinear control systems with delay. Our main objective is to study the problem of optimal control, which minimizes a certain cost function.

The Efficient Geometrical Non linear Analysis Method for Engineering Structures

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Abstract: In engineering structures, and especially in civil engineering, various structures can be solved analytically by the linear analysis methods. But, we must mention that the nonlinear analysis is necessary to determine the maximum force that causes the collapse of the structure. Additionally, structural instability is assumed to be caused by geometrically nonlinear effects, despite the fact that physically nonlinear material models can also play an important role in destabilization. In practice, there are no efficient methods valid for all cases of the structures due to different behaviors, geometrical forms and loadings applied to structures. In this paper, a contribution focus clarifying this problem by presenting the different numerical approaches used for the nonlinear solutions, followed by some applications. In addition, a few types of civil engineering structures are analyzed, such as cantilever beams, deep trusses, symmetrical sheds and buckling beams. This numerical study was carried out by the MATLAB code, and the results obtained are discussed, interpreted and compared to the analytical solutions found in the literature. Interesting findings are highlighted and useful recommendations are made to researchers and design engineers for practical purposes.

Keywords: Engineering structures, Geometrical nonlinear analysis, MATLAB code, Numerical approaches, Structure collapse.

Existence and dynamical behaviors of solutions to linear isotropic elasticity system with dynamic Wentzell boundary conditions

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Abstract: In this work, the uniform stabilization of isotropic elasticity system with dynamic Wentzell boundary conditions is considered, and the uniform energy decay rate for the problem is established by considering both internal localized damping and boundary feedback. The exponential stabilization is attained by constructing a new multiplier and using multiplier methods.

Keywords: Elasticity system, Wentzell conditions, Uniform stabilization, Internal damping.

Mathematics Subject Classification: 35Q60, 93D15, 93C20.

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Estimating RCA model parameters using machine learning technique

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Abstract: In this study, we propose a machine learning technique for the parameters estimation of the Random Coefficient Autoregressive model (RCA). This is an interesting approach, as RCA models have traditionally been estimated using quasi-likelihood or weighted least squares method. This class of models has experienced a resurgence of interest in recent decades. The first investigations into this class of models were carried out by Conlisk (1974-1976), Andel (1976), and Nicholls and Quinn (1982), who considered them as pure conditional mean models, using them solely for representing and forecasting "values". Currently, the RCA model is also considered a volatility model and is being used for representing and forecasting both the mean and the variability of values." To estimate the parameters of the RCA model using machine learning, we first define a loss function based on the likelihood function of the model. This loss function is then minimized using the Adam optimizer algorithm of TensorFlow, a popular machine learning framework. We compare the results of machine learning approach with those obtained using quasi-likelihood and weighted least squares methods. We find that the three methods provides accurate estimates of the model parameters. Furthermore, we investigate the convergence properties of the Adam optimizer algorithm and we find that the convergence rate increases as the learning rate increases up to a certain maximum learning rate. Overall, this study demonstrates the potential of machine learning techniques for the estimation of RCA models, and highlights the benefits of using these techniques over traditional methods.

Keywords: RCA model, Estimation, Simulation, Least squares, Quasi-likelihood, Adam optimizer.

Mathematics Subject Classification: 62M10; 62M86; 62F12; 62J12.

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Nonlinear Semivectorial Bilevel Optimization Problem: Formulation and Optimality Conditions

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Abstract: In this work, we consider a class of optimization problem with nonlinear scalar objective function at the first level and nonlinear vector problem at the second level. By using the optimistic approach and Karush-Kuhn-Tucker type conditions associated to the second level with an appropriate regularity condition, we reformulate the bilevel problem into an equivalent single level problem with complementarity constraints. We study the obtained problem and we establish optimality conditions for this problem and thereafter for the bilevel problem. An example is proposed to illustrate the obtained results.

Keywords: Bilevel programming, Multiobjective optimization, KKT conditions, Optimality conditions.

Mathematics Subject Classification: 90C30, 90C29, 90C26, 90C05.

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Numerical Solution of Nonlinear Differential System for Non-Newtonian Fluid Model by Using Prediction Application of Artificial Intelligence

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Abstract: It is consensus among researchers that the mathematical formulation of non-Newtonian fluid models results in non-linear differential equations. Therefore, the solution to such equations remains a challenging task for the investigators affiliated with fluid science. Owning to such difficulty, the present paper contains a numerical solution for non-Newtonian fluid flow towards an inclined cylindrical surface. The flow field is carried with various physical effects. Shooting method is used to solve flow equations. The surface quantity namely skin friction coefficient (SFC) is evaluated by using the prediction application of artificial intelligence. 160 sample values of SFC are collected towards mixed convection, magnetic field, Casson fluid, and velocities ratio parameters. 70% data is used for training of artificial neural networking (ANN) model while 15% data is used for each validation and testing. Levenberg-Marquardt is considered a training technique while both Tan-Sig and Purelin are used as transfer functions. The mean square error and determination coefficient admits the prediction accuracy of the ANN model. Considering such accuracy, we observed that the SFC shows a higher magnitude at the porous cylindrical surface as compared to the non-porous surface.

Keywords: Non-Linear PDEs, Non-Newtonian fluid, Shooting method, Artificial intelligence.

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Study of an Algorithm for Nonlinear Two Level Problems

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Abstract: Two level problems are mathematical models used in hierarchical decision making. They are characterized by the presence of two decision makers: the leader and the follower. Each controls a set of variables and attempts to optimise his own objective. However, the decisions of each one affect the decisions and the objective of the other. The complex structure of these problems makes their resolution difficult. In this paper, based on a reformulation technique, an algorithm for a class of two level problems is proposed. The algorithm uses nonconvex optimization techniques and have the advantage to solve simple subprograms at each iteration. Numerical performance and complexity of the algorithm are studied.

Keywords: Two level problems, Nonconvex techniques, Algorithm complexity.

Mathematics Subject Classification: 90C27.

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Hydrodynamics of gliding bacteria secreting non-Newtonian slime on a solid substrate: An implicit finite difference analysis

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Abstract: Soft nano-robots are transportable in hydrodynamic environment (governed by Stokes equations) just like propelling bacteria. In biomedicine these artificial crawlers which are useful for drug delivery, diagnostic, or therapeutic purposes are controlled via electric and magnetic sensors. In addition to the fluid rheology these external forces tend to reduce/enhance the speed of gliding cells. To investigate such effects on active bacteria we calculate the speed of an undulating sheet propelling on non-Newtonian fluid layer. After utilizing Galilean transformation, dimensionless variables, stream function, low Reynolds and long wavelength approximation on momentum equation one arrives at the fourth order ordinary differential equation with four boundary conditions involving two unknows i.e. flow rate and organism speed. This BVP is solved numerically by implicit finite difference method (IFDM). Unknowns satisfying the dynamic equilibrium conditions are simulated via modified Newton-Raphson method. Consequently, work done by the microorganism is also computed.

Keywords: Gliding bacteria, Navier–Stokes equations, Galilean transformation, Non-Newtonian fluid, Finite difference method.

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Transformation kernel density estimation for approximating ruin probabilities in risk models using the operator method : Application to financial data

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Abstract: We propose in this work a transformation kernel density estimation technique (semi-parametric approach) for the improvement of the quality of the stability bound on the probability of ruin in a classical risk model with large claims using the operator method (strong stability method) [1, 2, 3]. We use two approximation methods to obtain ruin stability bounds (the Markov chain method and the regenerative approach). To evaluate the performance and effectiveness of our proposed approach (semi-parametric technique), we carry out simulation studies as well as a comparative study with the nonparametric kernel method. A further comparison between both stability bounds is performed. We also present a study based on real financial data [4] to confirm the obtained results.

Keywords: Strong stability method, Ruin probability, Kernel method, Semi-parametric estimation, Financial data.

Mathematics Subject Classification: 91B30, 34K20, 62G07.

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Fractal Fractional Analysis of Non-Linear Electro Osmotic Flow with Cadmium Telluride Nanoparticles

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Abstract: Nanofluids have significant potential in various industrial applications, including heat transfer, lubrication, and energy storage. In energy storage, ternary nanofluids have been explored as a potential medium for thermal energy storage systems. Despite these potential benefits, the use of nanofluids in industry is still in the research and development stage, and more work needs to be done to fully realize their potential. Therefore, this article presents an analysis of the non-linear fractal-fractional nanofluid model with electro-osmotic effects and its solution through the use of numerical scheme. The fractal-fractional model considers the fractal nature of the nanofluid particles, which can affect the thermal properties of the fluid. Crank-Nicolson scheme is used to solve the governing equations of the model, which provides a more efficient and accurate solution compared to traditional numerical methods. The results of the analysis show that the fractal-fractional model can accurately predict the thermal behavior of nanofluids, and the Crank-Nicolson scheme is a useful tool for solving such models. It is also worth noting that the fractional and classical model can also been derived from the fractal-fractional model by taking the parameters tends to zero. From the analysis it is also observed that in response to 0.04 volume fraction of cadmium telluride nanoparticles, the rate of heat transfer (Nusselt number) and rate of mass transfer (Sherwood number) increased with 15.27% and 2.07% respectively. The research of this article is important for the understanding of the thermal properties of nanofluids and for the design of heat transfer applications utilizing nanofluids.

Keywords: Electro-osmotic flow, Zeta potential, Crank-Nicolson scheme, Cadmium telluride nanoparticles, Fractal-fractional model.

Conceptual DFT elucidation of the reaction mechanism in polysulfone and polyethylene glycol membranes

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Abstract: Polysulfone-based ultrafiltration membranes have been the subject of several research areas. In this work we carried out a theoretical study of the synthesis mechanism of these materials. In this study the mechanism of the chemical reaction between polysulfone (PSF), as a membrane matrix, and polyethylene glycol (PEG), as an additive, was elucidated by means of DFT conceptual derived indices. Our calculations were carried out using Gaussian 09 software. Hartree-Fock (HF) method and functional density theory (DFT) were used to obtain the optimized molecular structures of the PSF and the PEG. The obtained results, show that PEG plays the role of an electrophile and PSF plays the role of nucleophile during the reaction. It was also found that PEG reacts with oxygen from the extremities while polysulfone reacts with the C_{28} carbon regardless of the number of units per chain. Our results show that the DFT derived indices are directly correlated with the number of units per chain.

Keywords: Polysulfone PSF, Polyethylene glycol PEG, Membrane, Hartree-fock (HF), Functional density theory DFT.

Classification and prediction of water quality index using deep learning techniques

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Abstract: The classification of surface water quality status is a major environmental concern and one of the most important tasks of water sources. The Water Quality Index (WQI) describes a number of water quality variables at a certain location environment and time. Different input combinations were developed using the best dataset, and the work strategy was to demonstrate water quality variation where all or some inputs have been used. Deep learning models have been applied in the current research to investigate and try to emulate WQI's relationship with water quality variables in Tilesdit dam in Bouira (Algeria). Moreover, a comprehensive analysis has been performed for the performance assessment and sensitivity analysis of the variables. Our approach was appraised using several performance metrics. With high performance accuracy in the used models, the results achieved are promising.

Keywords: Water quality, Classification, Prediction, Water quality index (WQI), Machine learning, Deep learning.

Mathematics Subject Classification: 68Uxx.

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Computational Analysis on Thermal Boundary Layer Flow of Viscoelastic Micropolar Fluid Over a Bluff Body

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Abstract: The study focuses on the computational analysis of the boundary layer flow of a viscoelastic fluid consisting of rigid, randomly oriented (or spherical) particles suspended in a viscous medium, neglecting the deformation of the fluid particles. The fluid is assumed to flow over a steep body, with the sphere and horizontal circular cylinder assumed to be the geometry of the fluid to be flowed. The boundary layer equations of a viscoelastic fluid are one order higher than those of a Newtonian (viscous) fluid, indicating that the adherence boundary conditions are not sufficient to fully determine the solutions. Therefore, the augmentation of an extra boundary conditions is required for the calculation. The equations reflecting the proposed model are first undergoing the Boussinesq and boundary layer approximation before being transformed into a non-dimensional form which in partial differential equations system. The obtained equations, which are in a less complex form, are solved using Keller box method. It is worth mentioning that in the particular case the present model can be traced back to the established model, where the validation procedures can be carried out. Once the model and the presence calculation are validated, the current outputs of the current problem are obtained. The computed output will be served as a reference for the study of complex fluids, especially when the fluid has both viscous and elastic properties.

Keywords: Viscoelastic fluid, Computational, Boundary layer.

Analysis on Fluid's Characteristics of Thermal Boundary Layer Flow of Reiner–Philippoff Fluid Model Embedded with Temperature Jump Effect

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Abstract: The needs of reliable mathematical model in representing the physical problem is crucial since it will reduce cost and offer safer way in examine on certain process. Due to its practical uses, notably in engineering and manufacturing processes, the subject of fluid flow has recently attracted the attention of scientists and researchers. Therefore, this work will concentrate on identifying the characteristics of fluid flow past a shrinking sheet in the presence of temperature jump conditions using mathematical approach. The governing partial derivatives of multivariable differential equations including continuity, momentum, energy, and a relation of Reiner Philippoff term are first transformed to similarity equations in the form of ordinary differential equations by using appropriate similarity transformations. The numerical computation is done by using the bvp4c technique and the results will be presented as graphical and tabular form for fluid characteristics covering skin friction and heat transfer. The distribution of velocity and temperature also will be graphed for multiple values of parameters involved. The output from this investigation will be used as preliminary references for the study involving fluid flow.

Keywords: Reiner–Philippoff fluid, Shrinking sheet, Temperature jump, Numerical Analysis.

General and Optimal Decay Result for a Viscoelastic Timoshenko Beam Fixed into a Moving Base

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Abstract: A Timoshenko type beam subject to a viscoelastic and subject to a translational displacement is considered. The Timoshenko system is complemented by an ordinary differential equation describing the dynamic of the base to which the beam is attached to. We prove some new decay results which generalize and improve many earlier ones in the literature. We consider the case of equal-speeds and the case of non-equal-speeds of propagation.

Keywords: Timoshenko beam-Stabilization-viscoelastic, Dynamic boundary condition-Lyapunov's method, Tip mass.

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Estimation of Partially Linear Model with serially correlated errors based on Kernel Smoothing technique

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Abstract: This study focuses on the develop a new semiparametric estimator based on the kernel smoothing technique when the partially linear model (PLM) has autoregressive error terms. Let us consider the PLM as $y_i = \mathbf{x}_i\beta + g(t_i) + \varepsilon_i \quad 1 \leq i \leq n$ where y_i's are the responses, $\mathbf{x}_i\beta$ and $g(t_i)$ denote the parametric and nonparametric components, and finally, ε_i are the random error terms that are assumed to be independent with zero mean and constant variance. However, in real-world applications, this assumption is violated based on various reasons and serial correlation can be emerged which can be shown by autoregressive process of errors $\varepsilon_i = \rho\varepsilon_{i-1} + u_i$ where $u_i \sim N(0, \sigma^2)$. Serial correlation between error terms causes a major problem in obtaining reliable estimators in terms of the regression concept. Researchers face this problem in analyzing time-series models mostly. To solve this problem, a regularization in the semiparametric estimator is necessary otherwise estimated components of the partially linear models are misinterpreted. Although, in linear, nonlinear and nonparametric models, serially correlated errors are handled (see Cai, 2007; Thomson et al. 2015; Aydın and Yılmaz 2021 among others), this paper aims to fill the gap in estimation of PLM based on kernel smoothing by taking autocorrelation into account. As known, kernel smoothing with PLM is studied by Speckman (1988), Hardle et al. (2007) and so on, under ideal conditions for error terms. This study introduces the estimation process based on the double-weighted estimation process which is formed by both Nadaraya-Watson weights (Nadaraya, 1964; Watson 1964) and the weight matrix obtained based on the autoregressive structure of error terms.

Keywords: Partially linear models, Autocorrelated errors, Kernel smoothing, Time-series regression.

Mathematics Subject Classification: 62M10, 62J99, 62G05.

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Elastic and vibrational properties of KCuSe and KCuTe

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Abstract: First principles calculations are used to investigate the structural, elastic, and vibrational properties of KCuSe and KCuTe in their different phases. The obtained ground structures for both compounds agree with reported experimental ones. The phase transitions under pressure for these two compounds are predicted and the values of the transition pressure are evaluated using the enthalpy variation with pressure. The calculated equilibrium structural parameters with the modified generalized gradient approximation (PBEsol) agree closely with the available experimental values. The elastic constants are evaluated for all possible phases. The mechanical stability is investigated using the calculated elastic constants for all phases at zero and finite pressure. The mechanical parameters for polycrystalline materials are determined within the framework of the Voigt-Reuss-Hill approximation. From the Poisson's ratio and the B/G relationship both compounds are brittle in the P63???????, while they are ductile in the other phases. The variation with pressure of the bulk modulus (B), shear modulus (G), Young's modulus (E), and Poisson's ratio (ν) is also studied. The phonon spectra are also computed along high symmetry lines for both compounds in their different possible phases.

Keywords: Abinitio methods, Semiconductors, Structural properties, Elastic constants, Phonon spectra.

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Cancer Dynamic Systems: Mathematical Modelling for noninfectious diseases

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Abstract: In this lecture, we study the existence and uniqueness of a weak solution of the time-fractional cancer invasion system with nonlocal diffusion operator. Existence and uniqueness results are ensured by adapting the Faedo-Galerkin method and some a priori estimates. Further, finite element numerical scheme is implemented for the considered system. Finally, various numerical computations are performed along with the convergence analysis of the scheme.

Keywords: Cancer invasion dynamic system, Fractional differential equations, Reaction-diffusion system, Weak solution, Numerical solution.

Mathematics Subject Classification: 93A30, 35R11, 35K57.

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Passive fault-tolerant control method based on feedback linearization control technique of two tanks system

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Abstract: The aim of this paper is to develop a passive actuator fault-tolerant control law for a highly nonlinear hydraulic system with two reservoirs using the feedback linearization control (FLC). You start by modeling this system with state space and presenting the theory of this command. We presented the actuator fault (additive fault) by augmentation in the law control. The passive fault-tolerant control method based on feedback linearization control technique (PFTCFLC) are implemented to the two tanks system, their performance is compared with the PID control technique. The results of the study demonstrate the superior performance of the PFTCFLC technique in regulating the level of the hydraulic system, indicating its robustness and fault tolerance.

Keywords: Feedback linearization technique, Passive fault tolerant control, PID control, State space system, Two tanks system.

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Bifurcation analysis of a COVID-19 dynamical model with saturated treatment with compliance and impact of control measures

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Abstract: In the current study, a SARS-CoV-2 population dynamical model of $SEIR$-type is proposed to contemplate the amount of compliance and efficacy of mask usage throughout the duration of the pandemic in the presence of saturated treatment. The model is also incorporated with reinfection of the recovered individuals with comorbidities and relapse of the recovered and vaccinated individuals to the susceptible compartment after a period of time. Mask usage across the globe is found to be effective along with other public health guidelines in lowering the basic reproduction number $\mathcal{R}_0$. Due to the presence of saturated treatment and reinfection, the model shows some interesting behaviour. Depending on several sets of parameters, there exists a maximum of four endemic equilibrium points. Local and global stabilities of both the disease-free and the unique endemic equilibrium points are discussed via the Routh-Hurwitz criteria and construction of Lyapunov functions respectively. The model also exhibits the backward bifurcation phenomena under certain parametric conditions owing to multiple endemic equilibria when $\mathcal{R}_0 < 1$. This suggests that reducing the basic reproduction number to less than unity is insufficient to eradicate COVID-19 from the population. Hence, sensitivity analysis is performed for the parameters present in the model to identify the factors which have the most influence in the spread of the disease.

Keywords: Backward bifurcation, Global stability, Basic reproduction number, Nonlinear dynamical system.

Mathematics Subject Classification: 35R11.

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Existence Of The Solution Of A Nonlinear Boundray Problem and Optimal Control

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Abstract: We consider a nonlinear boundary value problem with unilateral constraints in a two-dimensional rectangle. We derive a variational formulation of the problem which is in the form of a history-dependent variational inequality. Then, we establish the existence of a unique weak solution to the problem. We also prove a convergence result which provides the continuous dependence of the solution with respect to the unilateral constraint. We proceed with the study of an associated control problem for which we prove the existence of an optimal pair. Finally, we consider a perturbed optimal control problem for which we prove a convergence result.

Keywords: Nonlinear problem, Weak solution, Boundary condition, Optimal control.

Mathematics Subject Classification: 74M15, 49J40, 49J45, 49J20.

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Single sample face recognition using multi-resolution analysis of color texture features

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Abstract: Single sample face recognition (SSFR) is a challenging biometric task that aims to identify a person based on a single image of their face. It is used in scenarios where multiple images cannot be captured, such as immigration management, fugitive tracking, and video surveillance. The accuracy of SSFR can be affected by factors such as lighting conditions, pose, and facial expression, making it more difficult to identify individuals reliably. The paper suggests a solution to improve the accuracy of SSFR systems by proposing a multi-resolution analysis method. This method uses the discrete wavelet transform (DWT) to extract color binarized statistical image features (BSIF) at different resolutions. This approach aims to capture more information and enhance the system's ability to recognize faces under varying conditions. The experimental analyses on the AR dataset show that this method outperforms several state-of-the-art SSFR methods.

Keywords: Biometrics, SSFR, DWT, BSIF.

Asymptotic bihavior of a Nonlinear Boundary Value Problem with Friction

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Abstract: In this paper, we consider the asymptotic analysis for the elasticity problem with a dissipative and source terms in a three dimensional thin domain $Q^{\xi} \subset \mathbb{R}^3$. Firstly, we obtain the variational formulation of the problem. Then we establish some estimates independent of the parameter ξ. Finally, we give a specific Reynolds equation associated and prove the uniqueness of the limit problem.

Keywords: Asymptotic approach, Dissipative term, Elasticity system, Reynolds equation, Source term, Tresca law.

Mathematics Subject Classification: 35R35, 76F10, 78M35.

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Backstepping fault-tolerant control for a Satlan system with actuator fault

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Abstract: This paper presents the fault tolerant control for a satellite (Satlan system) based on backstepping theory with actuator fault can be modeled by a step signal (additive fault). After dynamic modeling and system state modeling, we presented the technique of the backstepping control. We presented the actuator fault by augmentation in the control of this system. The proposed FTC is able to maintain acceptable performance in the control law and guarantees robustness against uncertainties and external disturbances. A comparative study is made between the proposed fault tolerance control and the PID control technique in the presence of actuator fault. The results obtained show that the proposed FTC has better robustness against actuator fault where the Satlan system operates with acceptable performance.

Keywords: Backstepping technique, Fault tolerant control, PID control, Dynamic modeling, Satlan system.

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Vibration modeling during turning of Ti-6Al-4V using two different methods response surface methodology (RSM) and artificial neuron network (ANN)

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Abstract: The vibrations have large amplitude and often lead to irreversible damage to the part during the finishing stage. These vibrations appear due to the resonance of the natural frequencies of the part and the harmonics of the spectrum of the cutting forces from the impacts of passing the tool. If the natural frequencies of the tool are known, one could select the frequency of rotation of the part, avoiding the resonance on the planning phase of the process, the objective of this work is to carry out the modeling of the vibrations during 'finish turning operation of titanium alloy Ti-6Al-4V using two different methods (response surface methodology (RSM) and artificial neuron network (ANN)).

Keywords: Ti-6AL-4V, Turning, Vibrations, ANN, RSM, Modeling.

Mathematics Subject Classification: 74H45, 68T01, 35R02.

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Optimal Control Strategies for Dengue Transmission in Selangor, Malaysia

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Abstract: Dengue is a mosquito-borne viral disease transmitted by Aedes aegypti mosquito. In Malaysia, dengue remains a public health threat, causing significant morbidity. The Ministry of Health Malaysia has identified a recurring pattern of high dengue cases every four to five years, with surges recorded in 2010, 2015, and 2020. Based on this trend, dengue cases are expected to exceed the 2020 record of 136,162 cases once again in 2024 or 2025. Hence, there is a need to identify effective dengue control strategies to prevent the spread of dengue cases. This study aims to determine the optimal control strategy by minimizing the number of infected mosquitoes and infected humans to reduce the number of dengue cases. In the model, susceptible, infected, and recovered (SIR) human framework with mosquito ecology is formulated. The data of dengue transmission in Selangor, Malaysia, is considered and simulated by using the model. Curve fitting of dengue data is then performed by using the Forward Difference method to estimate the important parameter value such as mosquito biting rate. Next, optimal control theory is applied to illustrate the effects of larvicide, insecticide, and vaccination in reducing dengue cases. Seven combination scenarios are simulated and analyzed by the means of numerical simulations in MATLAB. Based on the simulation results, a combination of larvicide, insecticide, and vaccination is identified as the most effective optimal control strategy in reducing dengue cases in Selangor. The analysis would provide insights on the optimal dengue control strategy in Selangor and to assist decision makers in implementing dengue control strategies.

Keywords: Dengue, Vaccination, Insecticide, Larvicide, Optimal Control Strategies, Simulations.

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Existence and uniqueness results for a class of delay differential equations with iterative terms

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Abstract: The main objective of this work is to create a set of sufficient criteria for proving the existence and uniqueness of periodic positive solutions of a class of first-order iterative differential equations arising in population dynamics. Our study is carried out using Schauder's fixed point theorem, Banach contraction principle and some properties of an obtained Green's function. The derived results complement some previous studies.

Keywords: First-order iterative differential equations, Population dynamics, Fixed point theorem.

Mathematics Subject Classification: 47H10, 34B24, 34C25.

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Iterative learning control of general conformable fractional differential equation

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Abstract: In this talk we will study the convergence of iterative learning control for fractional differential equations with general conformable derivative and for this cause we apply standard techniques to verify the convergence results. Numerical examples are given to illustrate the results.

Keywords: Fractional differential equation, General conformable derivative, Iterative Learning dapting laws, Convergence.

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Existence and Uniqueness result for semilinear fractional system involving a fractional gradient

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Abstract: we focus in this paper to study the existence and uniqueness of weak solution for semilinear fractional system involving Riesz fractional gradient in fractional Sobolev space. for establish the existence result we propose the application of Schauder fixed point theorem with suitable condition of semilinear term, In addition to condition we prove the uniqueness of weak solution and we suggest the Banach Contraction principle theorem.

Keywords: Weak solution, Semilinear fractional system, Riesz fractional gradient, Partial differential equations.

Mathematics Subject Classification: 35A16, 31C25,35J61.

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Verification of Mathematical Model of *n*-th Order Limit Language using Wet-Lab Experiment

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Abstract: The mathematical modelling of the deoxyribonucleic acid (DNA) splicing system was inspired by research on the recombinant behaviour of double-stranded DNA (dsDNA) molecules. This multidisciplinary research is built on understanding formal language theory as well as informational macromolecules. Formerly, *n*-th order limit language is described by the number of rules employed in the splicing system. A laboratory experiment was previously carried out to confirm the occurrence of a second-order limit language. However, no laboratory experiment has been conducted to verify the existence of the *n*-th order limit language. The existence of the *n*-th order limit language was validated in this study through a laboratory experiment. The model has been validated as a result of this investigation, indicating that the *n*-th order limit language's theory is biologically demonstrated through experiments conducted on third and fourth order limit language. Furthermore, provided that the dsDNA molecules generated in the experiment are as anticipated in the model, it further shows that the *n*-th order limit language's mathematical model was empirically confirmed.

Keywords: DNA, Splicing System, Formal language theory, Splicing language, Second order limit language, *n*th order limit language.

Mathematics Subject Classification: 68Q45, 68R01, 92-05.

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Quantum Sensing via Superconducting Qubit Control

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Abstract: The quantum sensing mechanism studied here is following our approach developed in [1]-[2], and it is based on coupling the measuring qubits with magnetic materials. The Holstein–Primakoff transformation [3] describing the ferromagnet excitations (magnons) as a superposition of the spin waves instead of dealing with each spin individually serves as a basic model for the Hamiltonian. The magnonic system is coupled to the superconducting qubits [4]. We consider the 2D case of the system like YIG (Yttrium Iron Garnet) or similar types [5]. The coupling parameter plays the role of control function maximizing the quantum Fisher information [6] under the application of a few alternative algorithms: speed gradient [7] and target attractor [8] feedback.
Our research has been supported by the Research Fund of Abdullah Gül University; Project Number: BAP FBA-2023-176 "Improving efficiency of qubit-based sensors via feedback control algorithms".

Keywords: Quantum sensors, Superconducting qubits, Quantum Fisher information, Sub-optimal feedback control.

Mathematics Subject Classification: 34A34, 93B52, 93C15.

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Impact of Biot Heat Flux and Suction/Injection on MHD Free Convection Carreau Fluid Flow along a Vertical Tube

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Abstract: This study aims to investigate the impact of the Biot heat flux and suction/injection on magnetohydrodynamics free convection flow along a cylinder, which has applications in various fields such as copper coating, chip coating, crude oil refinement, and paper construction. The Carreau fluid model is employed to represent the non-Newtonian fluid. Similarity variables are applied to simplify the governing equations, which are subsequently resolved using the homotopy analysis scheme. The analytical approximation solutions obtained are validated through comparison with the limiting cases reported in the literature. Parametric studies are conducted to examine the influence of Biot number, suction/injection parameter, and curvature number on the fluid flow and heat transfer. The results indicate that the Biot numbers expedite the temperature distribution, leading to an increase in the heat transfer rate. Meanwhile, the suction parameter decreases the temperature but increases the velocity profiles.

Keywords: Free convection, Stretching cylinder, Biot heat flux, Carreau fluid, Suction and injection.

Mathematics Subject Classification: 35Q35.

Polynomial coding theory to detect and correct errors in any codeword

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Abstract: In this work we have been interested in a Polynomial Coding Theory, we have worked out some very often used examples such as linear codes, polynomial and BCH codes.

Keywords: Polynomial Ring, Galois Fields, Linear Codes, Error-Correcting Codes.

Mathematics Subject Classification: 11T55, 12Fxx, 51E22, 94Bxx.

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Mittag-Leffler Stability in Time for fractional differential equations with Riemann-Liouville fractional derivatives

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Abstract: In this paper, we study several comparison results for nonlinear fractional derivatives with generalized proportional Riemann-Liouville fractional derivative. It is studied the case in the case when the order of fractional derivative in the interval $(0,1)$ and the parameter is on $(0,1[$. Note the initial condition for fractional differential equation with Riemann-Liouville type fractional derivative is totally different that the initial condition to ordinary differential equations of to fractional differential equations with Caputo type derivatives. Also, in connection with the applied fractional derivative and its singularity at the initial time, Mittag-Leffler stability in time of the solution is introduced and studied. The base of the study is Lyapunov method and the quadratic Lyapunov function is applied. About the basic concepts of the stability for Riemann-Liouville fractional differential equations we would like to recommend [1]An example is illustrating the studied stability properties.

Keywords: Generalized proportional Rieman-Liouvile fractional derivative, Mittag-Leffler stability in time, Quadratic Lyapunov function.

Mathematics Subject Classification: 34A34, 34A08, 34D20.

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A new viewpoint for numerical analysis of the modified regular long wave equation using operator splitting method

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Abstract: The aim of this study is to examine the numerical solutions of the modified regular long wave equation by the operator splitting method, which is based on dividing the complex problem into a series of simpler problems, which is widely utilized in the approximate solution of initial and boundary value problems for PDEs. When applying this technique, the Petrov-Galerkin method is applied, where the element shape functions are cubic and the weight functions are quadratic B-splines. In this study, the error norms L_2 and L_∞ with conservation constants I_1,I_2 and I_3 are calculated to show how accurate results are obtained and graphical representations are presented in relation to numerical results. In addition, the stability of the sub-problems are examined with the Von-Neumann stability analysis.

Keywords: The modified regularized long wave equation, B-splines, Petrov-Galerkin method, Operator splitting method.

Mathematics Subject Classification: 74J05, 33F05, 65D07.

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Three-dimensional numerical modeling of biochemical processes in land water bodies

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Abstract: In this work, we propose, develop, and implement a three-dimensional model for the generation, transport, and sink of biogeochemical impurities (dissolved gases and solid carbon) in an inland water body. The model complements the thermohydrodynamic model [1] based on the RANS-approach.

Since the blocks are combined, the model reproduces two-way relationships, such as the contribution of bioproductivity due to photosynthesis to the extinction coefficient of penetrating radiation. The so-called "surface renewal model" was used to describe gas exchange, taking into account turbulent processes that affect mixing near the air-water interface. The term included in it, which is responsible for the dissipation of turbulent kinetic energy, is calculated from the modified closure proposed with the participation of the authors, which takes into account the two-way transformation of the kinetic and potential energies of turbulent pulsations [2].

The model was used to calculate the fluxes and concentration distributions of biogeochemical substances for Lake Kuivajärvi (Finland) on a seasonal scale. It is shown that the model correctly describes the physical and biogeochemical processes occurring in the water body, and the obtained numerical results are consistent with the observed characteristics.

Keywords: Internal reservoir, Gas exchange, Biogeochemical processes, Turbulence, Stable stratification, Numerical modeling.

Mathematics Subject Classification: 86-10.

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On the dynamics of a class of differential systems with two limit cycles

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Abstract: An important problem of the qualitative theory of differential equations is to determine the limit cycles of a system of the form

$$\begin{cases} x' = \dfrac{dx}{dt} = P(x,y), \\ y' = \dfrac{dy}{dt} = Q(x,y), \end{cases} \tag{0.1}$$

where $P(x,y)$ and $Q(x,y)$ are real polynomials in the variables x and y. Here, the degree of system (0.1) is denoted by $n = \max\{\deg P, \deg Q\}$. In 1900 Hilbert [1] in the second part of his 16th problem proposed to find an estimation of the uniform upper bound for the number of limit cycles of all polynomial vector fields of a given degree, and also to study their distribution or configuration in the plane $\mathbb{R}^2$. This has been one of the main problems in the qualitative theory of planar differential equations in the 20th century.

In this work, we consider the special class family of the polynomial differential system of the form (0.1). We give an explicit expression of invariant algebraic curves, then we prove that these systems are integrable and we introduce an explicit expression of a first integral.

Moreover, we determine sufficient conditions for a polynomial differential system (0.1) to possess two limit cycles, explicitly given. Concrete examples exhibiting the applicability of our result are introduced.

Keywords: Dynamical system, Hilbert 16th problem, Limit cycle, Invariant algebraic curve, First integral.

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Numerical Modeling of Reinforced Shell Structure by An Efficient Solid Finite Element

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Abstract: Applied loads on structures have a significant impact on the deformations of the structures, especially, thin shells; due to their complex geometrical shapes and thin thickness. To avoid large deformations; shells can be reinforced by longitudinal or circumferential beams to increase their stiffness. However, the analysis of these types of structures requires numerical methods to be involved such as the finite element method. The shell structure can then be modeled with two different types of finite elements (shell element and beam element), unfortunately, this will encounter the problem of the incompatibility degrees of freedom at the junction between the shell and the beam. To overcome this difficulty, a three-dimensional finite element (solid element) can be used to tackle the numerical analysis of the entire structure (reinforced shell). This paper presents the numerical analysis of a cantilever cylindrical shell with the three-dimensional ABAQUS solid element as a frequent practical engineering structure. The results obtained are compared to the reference solution and with those found in the literature. The efficiency of the three-dimensional element used in analyzing reinforced shells with beams is confirmed and a very interesting conclusion is deduced for engineering applications.

Keywords: Numerical modeling, Solid finite element, ABAQUS software, Static analysis, Cantilever cylindrical shell.

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Collective dynamics of pinned corotating rotors : synchronization transition

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Abstract: Self-organization and pattern formation is very common in nature, from spot and strips in animal coats to spiral galaxy, the natural pattern is abundant. Our interest is limited to spiral and scroll patterns. Rotating spiral and scroll (three-dimensional counterpart of the spiral) patterns have drawn the attention of many researchers because of their connection to biology and physiology. Spiral formation occurs in the brain, retina, and heart. The formation of the spiral wave in the cardiac system is often dangerous for our health. So, we need to study the dynamics of the spirals. For this purpose, we use chemical system like Belousov-Zhabotinsky (BZ) reaction for our study, as this reaction can generate waves that can sustain for long at particular concentrations of its ingredients and the wave nature have very similar to the electrical activity of our heart. We pinned the spirals as pinning spiral waves are correlated with the cardiac spirals pinned to scar tissue. Here we study the dynamics of pinned spiral waves in the presence of ion exchange resin and in simulation we use Barkley model to mimic our experimental results.

Keywords: Pattern formation, Spiral, Belousov-Zhabotinsky reaction.

WKB Analysis for a multi-dimensional Burger's system

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Abstract: Let $\varepsilon \in]0,1]$ a parameter, we consider a multidimensional Burger's system

$$\partial_t U^\varepsilon(t,x) + (U^\varepsilon(t,x)\cdot\nabla_x)U^\varepsilon(t,x) = 0, \quad (t,x)\in\mathbb{R}_+\times\mathbb{R}^n, \quad U^\varepsilon(t,x)\in\mathbb{R}^n. \tag{0.2}$$

Let $\mathbb{T} = \mathbb{R}/\mathbb{Z}$ and $B(0,r)\subset\mathbb{R}^n$ the ball of center zero and radius $r>0$, and $(u,\varphi)\in C^1(B(0,r)\times\mathbb{T},\mathbb{R}^n)\times C^1(B(0,r),\mathbb{R})$ satisfies the condition

$$\forall (x,\theta)\in B(0,r)\times\mathbb{T}: \quad \partial_\theta u(x,\theta)\neq 0, \quad \nabla\varphi(x)\neq 0.$$

We complete (0.2) by initial data $U^\varepsilon(0,x)$ having a WKB development of the form

$$\forall (\varepsilon,x)\in]0,1]\times B(0,r): \quad U^\varepsilon(0,x) = u\left(x,\frac{\varphi(x)}{\varepsilon}\right) + O(\varepsilon), \tag{0.3}$$

We show that the Cauchy problem (0.2)-(0.3) has a C^1-solution with a life-time T^ε and, due to the formation of shocks, in general $\mathrm{Lim}_{\varepsilon\to 0}T^\varepsilon = 0$. The aim is to give necessary and sufficient conditions on the couple (u,φ) to ensure a solution with a life-time $T>0$ independent of the parameter ε. We determine a class of the previously mentioned couples (u,φ) and explain how they propagate over time.

Keywords: Supercritical WKB analysis, nonlinear geometric optics, Burger equations.

Mathematics Subject Classification: 35A21, 35A30, 76B99.

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Positive definiteness of quadratic forms generated by nearly convex sequences

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Abstract: This study examines the positivity of quadratic forms of convolution type generated by convex and nonconvex sequences of real numbers. The study has two main objectives. Firstly, we improve the well-known Zygmund inequality for convex sequences, and extend its validity to nearly convex sequences. Secondly, we establish a more general inequality for nearly convex sequences. Our results are then applied to demonstrate the positive definiteness of quadratic forms resulting from BDF2 approximations of time-fractional operators..

Keywords: positive quadratic form, nonconvex sequence, minimal convex sequence, convolution operator, time-fractional operator

Mathematics Subject Classification: 65M60, 65M12, 65M15

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An Input Feedback Control Design for the Benny-Lin Equation with Localized Damping

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Abstract: In this paper, we consider the distributed control problem of the nonlinear Benny-Lin equation with localized damping with periodic boundary conditions

$$\frac{\partial u}{\partial t} + \beta\frac{\partial u}{\partial x} + \mu\frac{\partial^3 u}{\partial x^3} - \eta\frac{\partial^5 u}{\partial x^5} + \gamma u^\alpha\frac{\partial u}{\partial x} + a(x)u + \nu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^4 u}{\partial x^4}\right) = \sum_{n=1}^{N} b_n(x)u_n(t)$$

$$\frac{\partial^n u}{\partial x^n}(0,t) = \frac{\partial^n u}{\partial x^n}(2\pi,t),\ n = 0,\cdots,4$$

and initial condition

$$u(x,0) = u_0 \in L^2(0,2\pi)$$

where $\eta,\gamma > 0$, $\mu,\nu,\beta \in \mathbb{R}$, $\mu \neq 0$, $a(x) \in L^\infty(0,2\pi)$ is positive, $b_n(x) \in L^2(0,2\pi)$ is an actuator and $u_n(t) \in \mathbb{R}$ is an input feedback control. We show that the above system is well-posed. That is, there exists a unique strong solution that satisfies the partial differential equation. Moreover, the stability of the zero equilibrium solution to the system above depends on the value of the parameter ν and the function $a(x)$. This is done using Lyapunov indirect method where stability conclusions about the nonlinear system are drawn using stability analysis of the linearized system at an equilibrium. Finally, bounded input-feedback control is designed to control the Benny-Lin equation with localized damping to the zero equilibrium. It is worth mentioning that first the controller is designed to stabilize the linearized system at the zero equilibrium solution, then it is implemented to the nonlinear Benny-Lin equation with localized damping to successfully stabilize the system to the zero solution. Some numerical simulations that illustrate the proposed approach are presented.

Keywords: input feedback control, linearization, Benny-Lin equation, Lyapunov indirect method, partial differential equations, stability of nonlinear systems.

Mathematics Subject Classification: 35B35,35Q35, 35Q53, 35Q93

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Generalized Synchronization Of Neuron Models With Inhibitory and Excitatory Couplings

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Abstract: In this paper, we propose an implicit manifold description to design synaptic interaction between neural models to achieve generalized synchronization in terms of specific coordinate transformations. In this context we explore two scenarios, that is, identical (with the same parameter values) and non-identical neurons, with different external currents given by their synaptic connections. In both scenarios, we consider Excitatory and inhibitory chemical synapses, that is, their couplings are time variant and either promote a stable equilibrium behavior; or oscillations, like spike-bursts in the entire network. To illustrate our results we present numerical simulations.

Keywords: Neuron models, Synchronization, Excitatory-inhibitory synapses, Stability Conditions.

Mathematics Subject Classification: 92B25.

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Unpinning of Chemical Waves at Resonance Pacing using Polarised Electric Fields

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Abstract: In this study, we investigate the unpinning of pinned chemical waves using the Oregonator Model of the Belousov-Zhabotinsky reaction. The mode of polarisation and strength of the electric field can regulate the drift velocity of a free spiral [1]. Therefore, to unpin a pinned spiral from the obstacle, we use an electric field that is (i) linearly polarised (LPEF), (ii) circularly polarised (CPEF), and (iii) elliptically polarised (EPEF). Except for CPEF, the electric field strength of LPEF and EPEF changes with time. The spiral and field rotational frequency is the same in all methods, known as resonance pacing. In a recent study using CPEF at resonance pacing [2], it was not possible to unpin for most initial conditions. In our numerical study, we conduct unpinning trials at resonance pacing for different spiral initial positions by varying electric field strength. We observe a window of spiral initial positions that yield unpinning. The window width increases with the electric field strength. The window width for LPEF and EPEF is wider than for CPEF, which increases the unpinning success rate. Our study shows that LPEF and EPEF are more effective than CPEF in unpinning a spiral wave at resonance pacing.

Keywords: Belousov-Zhabotinsky Reaction, Polarised Fields, Resonance Pacing, Unpinning.

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Chialvo neuron model of matrices

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Abstract: It is demonstrated that a replacement of a scalar variable by a 2x2 matrix of variables in a nonlinear iterative map may lead to nontrivial chaotic response. The extension of a scalar variable may reveal effects that cannot be observed in corresponding scalar maps. The effect of explosive divergence may appear in the iterative map of matrices if the Lyapunov exponent of the corresponding scalar map is positive and the matrix of initial conditions is a nilpotent matrix. The problem becomes more complex when the order of the matrix increases.
One of the first map-based neuron models was proposed by Chialvo in 1995. An extension of the paradigmatic Chialvo neuron model when a scalar variable is replaced by a square matrix of order n is presented in this talk. A theoretical framework describing the dynamics of Chialvo neuron model of matrices is introduced and different modes of this model are investigated with analytically and numerically.

Keywords: Chialvo neuron, divergence, nilpotent matrix, iterative map.

Mathematics Subject Classification: 92C10, 92C20, 92C15, 92C37

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Stochastic Fractional Optimization Over Integer Efficient Set by Chance-Constrained Method

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Abstract: ction over the efficient set of a Chance Constrained Multiple Objective Stochastic Integer Linear Programming Problem (CCMOSILP). To do so, the original problem (CCMOSILP) is transformed into an equivalent deterministic form. By using the inverse of the distribution function for right-hand-side coefficients in the probabilistic constraints. Then, the expected model optimizes the ratio of two linear parameters function. Moreover, by mean of a branch and cut approach, a sequence of more constrained integer deterministic linear fractional programs are obtained and solved till no improvement can be done for the objective function. To illustrate the effectiveness of the proposed algorithm,a numerical example is proposed solved.

Keywords: Stochastic Fractional programming, multiobjective programming, integer programming, Chance Constrained, branch an cut.

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Analysing the effect of Trastuzumab Treatment On Breast Cancer Stages And Cardiac Function :Mathematical Modeling And Numerical Simulation

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Abstract: Breast cancer is the second most common cause of death among women worldwide. Trastuzumab is the first humanised monoclonal antibody against HER2-positive metastatic breast cancer. However, the most serious side effect of trastuzumab is cardiotoxicity, which has become a limiting factor in the drug's safe use. In this study, we investigated the effect of trastuzumab treatment on breast cancer stages and cardiac function. Therefore, we constructed a mathematical model based on breast cancer patients. The model was created using a differential equation system, and equilibrium point and stability analysis were employed to study the associated temporal dynamics. The stability of the equilibrium point was analysed using the Routh-Hurwitz criteria, which identfied an asymptotically stable equilibrium point. To valudate these findings, numerical simulations were performed, which demonstrated that the equilibrium point is always stable regardless of the initial conditions. Finally, our results suggest that the five sub-populations of patients will reach a stable state upon reaching the equilibrium point.

Keywords: Breast Cancer; Cardiotoxicity; Cancer Stage; Trastuzumab; Mathematical model; Numerical simulation.

Mathematics Subject Classification: 92-10, 34A30.

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Synchronization of bidirectionally coupled nonidentical chaotic systems

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Abstract: We investigate the synchronization of coupled nonidentical chaotic systems. Additional to the complication generated by the nonidentical nature of the systems when going forward from a drive-response complication, to a bidirectional coupling between piecewise linear and smooth nonlinear systems with full relative degree. Our proposal consists on a nonlinear switching feedback law for synchronization of bidirectionally coupled systems with parameter mismatch and non-smooth components. Our proposed design achieves synchronization taking into consideration the variable structure nature of the systems, and guarantees the stability of an identical synchronization manifold for nonidentical systems using output feedback. We illustrate our results with numerical simulations of well-known piecewise linear benchmark chaotic systems.

Keywords: Synchronization, Bidirectional coupling, Piecewise linear systems, Relative degree.

Mathematics Subject Classification: 34D06.

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Impact of Carbon Nanotubes on Convective Nanofluid Flow over a Stretching Sheet with Heat Transfer

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Abstract: Carbon nanotubes (CNTs) are regarded as a potential nanomaterial for a wide range of applications due to their appealing properties; exceptional mechanical and thermal strength, and electrochemical activity. Their application in the current nanotechnology has promised better heat transfer performance. However, the study exploring the effect of carbon nanotubes in heat transfer through stretching sheet is limited especially in analytical area. Therefore, the present study investigated the carbon nanotubes impacts on the heat transfer and convective flow of nanofluid over a stretching sheet. The governed problem is solved analytically and the solutions for velocity and temperature are derived by means of Homotopy perturbation and Laplace transform method. The impacts of carbon nanotubes volume fraction on the velocity and temperature distribution profiles are visualized graphically. The increasing volume fraction of CNTs accelerates the nanofluid flow and grows the temperature profile. The study lays a strong basic for future research utilizing numerical approaches.

Keywords: analytical solution, heat transfer, carbon nanotubes, stretching sheet, Homotopy pertubation, Laplace transform method.

Mathematics Subject Classification: 35R11.

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Estimates for modified q-Bernstein-Kantorovich Operators based on weighted convergence

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Abstract: In this paper, we investigate the weighted approximation properties of a new modification of $q-$Bernstein-Kantorovich by using the weighted modulus of continuity and we provide the main convergence result for the weighted estimation of these new operators, which is given by

$$R_{n,q}^{*}(f,x)=\sum_{k=0}^{n} r_{n,k}(q,x)\int_0^1 f\left(\frac{[k]_q+q^k t^\lambda}{b_n}\right)d_q t,\qquad \lambda>0 \tag{1}$$

where $f:[0,\infty)\to \mathrm{R}$, $q\in(0,1)$,$a_n=[n]_q^{\beta-1}$, $b_n=[n]_q^{\beta}$, $0<\beta\leq\frac{2}{3}$, $n\in \mathrm{N}$, $x\geq 0$,
and $r_{n,k}(q,x)=\frac{1}{(1+a_n x)^n}\left[\begin{array}{c} n\\ k\end{array}\right]_q (a_n x)^k\prod_{s=0}^{n-k-1}\left(1+(1-q)[s]_q a_n x\right)$.
Let $B_2[0,\infty)=\left\{f:[0,\infty)\to R:|f(x)|\leq M_f(1+x^2)\right\}$ where $M_f$is a constant depend on the function f, $C_2[0,\infty)=B_2[0,\infty)\bigcap C[0,\infty)$ and $C_2^*[0,\infty)=\left\{f\in C_2[0,\infty):\lim\limits_{x\to\infty}\frac{f(x)}{1+x^2}<\infty\right\}$.
The norm of any function belonging to B_ρ is given by $\|f\|_\rho=\sup\limits_{x\geq 0}\frac{|f(x)|}{\rho(x)}$.
Let $\sigma(x)$ a weighted function which is $\sigma(x)\geq 1$ and the following inequality $\left|B_{n,q}^{*}(\sigma,x)\right|\leq L\sigma(x)$, $L>0$, is satisfied. Then we can say that the sequence $\left\{B_{n,q}^{*}\right\}_{n\in N}$ acts from $C_\sigma[0,\infty)$ to $B_\sigma[0,\infty)$.

Keywords: q-Bernstein operators; Kantorovich operators; weighted modulus of continuity.

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Quenching Time Of Solutions For Some Semilinear Parabolic Equations With Dirichlet Boundary Conditions And Variable Reaction

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Abstract: In this paper, we consider the following initial-boundary value problem for a semilinear parabolic equation with variable reaction subject to Dirichlet boundary conditions of the form

$$u_t(x,t) = \varepsilon\Delta u(x,t) + (1-u(x,t))^{-p(x)} \quad \text{in} \quad \Omega\times(0,T), \tag{0.4}$$

$$u(x,t) = 0 \quad \text{on} \quad \partial\Omega\times(0,T), \tag{0.5}$$

$$u(x,0) = u_0(x) \geq 0 \quad \text{in} \quad \Omega, \tag{0.6}$$

where Δ is the Laplacian, ε is a positive parameter, $p \in C^1(\overline{\Omega})$, $p(x)$ is positive in $\overline{\Omega}$. The initial datum $u_0 \in C^1(\overline{\Omega})$, $u_0(x)$ is nonnegative in $\overline{\Omega}$, $\sup_{x\in\Omega} u_0(x) < 1$.
Under some assumptions, we show that the solution of the above problem quenches in a finite time, and its quenching time goes to that of the solution of a certain differential equation. Finally, we give some numerical results to illustrate our analysis.

Keywords: Semilinear parabolic equation, Dirichlet boundary conditions, quenching, numerical quenching time.

Mathematics Subject Classification: 35B40, 45A07, 45G10, 65M06.

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Laser Irradiation and Riga Plate Effects on Blood Flow with Caputo-Fabrizio Fractional Derivative

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Abstract: This study aims to investigate the effect of laser irradiation on the unsteady free convection of a Casson fluid flow with the Caputo-Fabrizio fractional derivative, flowing over a Riga plate. The Casson fluid is a commonly used non-Newtonian fluid model for simulating blood flow. Various medical techniques utilize lasers to treat conditions such as refractive surgery, skin anomalies, varicose veins, and even cancer. Meanwhile, Riga plates are electromagnetic controllers used to manage fluid velocity. However, there is limited detailed analytical study on the effects of laser irradiation and the presence of the Riga plate with the Caputo-Fabrizio fractional derivative. Gaining a thorough understanding of these effects through analytical analysis would be beneficial in the medical field, as it could enhance treatment quality and ensure patient safety. This study also considers the Caputo-Fabrizio fractional derivative to investigate its effects on blood flow. The governing equations are solved using the Laplace transform method, and graphical analysis is performed using Zakian's Inverse Laplace Transform method. The results indicate that laser irradiation increases both blood flow velocity and temperature. However, a contradictory effect can be observed with the presence of the Riga plate. Lastly, the Caputo-Fabrizio fractional derivative produces valid analytical results that differ from conventional fluid flow models. These novel findings are advantageous for future experimental and numerical studies.

Keywords: Casson blood flow, laser irradiation, Riga plate, Caputo-Fabrizio fractional derivative, Laplace transform

Mathematics Subject Classification: 35Q35.

Nonlinear Modeling of Low Resistivity Pay Zones in Geophysics: Estimating Water Saturation using Machine Learning

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Abstract: The low resistivity pay zone phenomenon, initially observed in the Algerian Southern Field, involves hydrocarbon-bearing pay zones exhibiting unexpectedly low resistivity values instead of the expected high resistivity values. Extensive research has been conducted to overcome the underestimation of hydrocarbon volume derived from petrophysical logs, specifically resistivity logs. It has been established that heavy and electrically conductive minerals are the primary cause of these underestimated results. Previous literature suggests using a modified Simandoux equation with compensating terms to address this issue. However, these terms are added empirically without a solid practical background, making generalization to similar cases in the field challenging and unreliable. The main goal of this study is to design a modified model for estimating water saturation in low resistivity reservoirs by leveraging a trained artificial intelligence algorithm. We propose combining an artificial neural network derived model with a support vector machine technique, referred to as ANN. Compared to conventional water saturation models, our developed ANN model enables more reliable predictions that align closely with field measurements derived from well testing data and modular dynamic tester (MDT) samples of the training wells. By addressing the low resistivity pay zone phenomenon through nonlinear modeling approaches, our research contributes to the understanding of complex geophysical processes. The ANN model provides a valuable tool for estimating water saturation in low resistivity reservoirs, enhancing our ability to accurately assess hydrocarbon volumes and optimize oil production strategies in challenging geological conditions.

Keywords: Nonlinear Water saturation model; Low resistivity pay zone; Artificial neural network; Heavy minerals; Modular dynamic testing (MDT).

An interface capturing approach on falling liquid films

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Abstract: Falling liquid films down an inclined or vertical surface have rich wave dynamics, often occuring in many industrial applications, such as evaporators and chemical reactors. There are some numerical studies for falling liquid films, however most of them have focused on two-dimensional falling film or three-dimensional falling films in a periodic domain. The purpose of this study is to investigate flow dynamics of fully developed three-dimensional falling films using the Navier-Stokes equations coupled with interface capturing approach. An adaptive unstructured mesh modelling framework is employed here to study this problem, which can modify and adapt unstructured meshes to better represent the underlying physics of multiphase problems and reduce computational effort without sacrificing accuracy. Numerical examples of three-dimensional falling films in a long domain with different flow conditions are presented and discussed.

Keywords: fluid dynamics, falling films, interface, Navier-Stokes equations.

Mathematics Subject Classification: 76T06, 76A20.

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Oscillation Criteria for a Dynamic Equation on a Time Scale

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Abstract: In this work, the main properties of an exponential function for a dynamic equation on a time scale is considered. The sign of the exponential function, which is useful in determining the oscillatory or non-oscillatory properties of both the first order homogeneous dynamic equations and their adjoints, is studied. An oscillation criterion for a certain higher order dynamic equation on a time scale is given.

Keywords: Oscillation, Measure chains, Time Scales, Dynamic Equations.

Mathematics Subject Classification: 34C10, 34Nxx.

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Oscillation result for perturbed Nonlinear Differential Equations

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Abstract: In this work, the main oscillation properties of a problem for perturbed nonlinear differential equations of second order are studied and several new oscillation conditions are obtained. Our results extend, improve and unify a number of existing results and handle the cases which are not covered by known criteria.

Keywords: Oscillation, oscillatory solution, second order nonlinear differential equation, perturbed differential equation.

Mathematics Subject Classification: 34C10.

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Some new Sequence Spaces Obtained using Trigonometric Functions and Fibonacci numbers

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Abstract: In 2007, Barry Lewis revealed some interesting properties of trigonometric functions and integer sequences which are composed of the Fibonacci and Lucas numbers in his work [1]. The initial focus of this paper research is to construct some new sequence spaces by using two seemingly unrelated mathematical concepts. Some algebraic properties of the newly defined sequence spaces, especially under which conditions they have a inclusion relations have been examined.

Keywords: Sequence Spaces, Trigonometric Functions, Fibonacci numbers.

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Some Novel Sequence Spaces Obtained the Composition of Binomial matrix and Double sequential Band Matrix

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Abstract: In this work, we are going to construct three new sequence spaces, namely ${b_0}^{r_n,s_n}(G)$,${b_c}^{r_n,s_n}(G)$ and ${b_\infty}^{r_n,s_n}(G)$ mention some inclusion relations, in which G is generalized difference matrix, $(r_n)_{n=0}^{\infty}$ and $(s_n)_{n=0}^{\infty}$ are given convergent sequences of positive real numbers. Furthermore, some algebraic properties are going to be derived. Also, we determine $\alpha-$, $\beta-$ and $\gamma-$duals of those spaces. Finally, we characterize some matrix classes related to the space ${b_c}^{r_n,s_n}(G)$. When compared with the corresponding results available in the literature, it is seen that the results of the present study are more general and more inclusive.

Keywords: Sequence spaces, Matrix transformations, Matrix domain, $\alpha-$, $\beta-$ and $\gamma-$duals, Matrix classes.

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Generalized Binomial Difference Sequence Spaces of Fractional Order

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Abstract: What stands out in this study is the sequence spaces of new brand ${b_0}^{r_n,s_n}(\nabla^{(\alpha)})$,${b_c}^{r_n,s_n}(\nabla^{(\alpha)})$ and ${b_\infty}^{r_n,s_n}(\nabla^{(\alpha)})$ obtained by using two convergent sequences $(r_n)_{n=0}^{\infty}$ and $(s_n)_{n=0}^{\infty}$ which generalize the previous work of Meng and Mei [1], where $\nabla^{(\alpha)} = \left(\nabla^{(\alpha)}_{n,k}\right)$ is defined by $\nabla^{(\alpha)}_{n,k} = \begin{cases} (-1)^{n-k}\frac{\Gamma(\alpha+1)}{(n-k)\,!\Gamma(\alpha-n+k+1)} & , \quad 0 \le k \le n \\ 0 & , \quad k > n \end{cases}$. We are going to investigate some functional properties, inclusion relations, and the $\alpha-,\beta-,\gamma-$ and continuous duals of these spaces. The newly found results are more general and more comprehensive than the corresponding results in the literature.

Keywords: Sequence spaces, Matrix transformations, Fractional difference operator, $\alpha-$, $\beta-$ and $\gamma-$duals.

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Sequential Convergence in Generalized Topological Spaces

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Abstract: In this work, we study the concepts of sequential convergence in generalized topological spaces by using generalized nets and generalized filters. We compare some results obtained regarding the concepts of sequential convergence in generalized topological spaces with the results in the case of classical topological spaces.

Keywords: Sequential convergence, Generalized topological spaces.

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2^{-r} order starlike and convex functions on some of meromorphic functions

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Abstract: We consider the class of analytic and univalent S and $\sum$ to investigate some properties for this class. 2^{-r}, $(r = 1, 2, ..)$ order functions belonging to these class were created. We logarithmic derive some interesting conditions for the class of strongly starlike function and Strongly convex function of order 2^{-r} in the open unit disk D.

Keywords: Analytic functions, starlike functions, convex functions.

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Fractal analysis on albumin gene sequences

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Abstract: To examine the multifractality and cross-correlation in gene sequences, we used an integrative technique that combines two dimensional multifractal detrended cross-correlation analysis (MF-X-DFA) and Chaos game representation (CGR). In the present research, we estimated the singularity spectrum for various nucleotide genes. Our evaluation's findings show that all gene sequence pairs exhibit power law cross-correlation behaviour as well as multifractal properties. We carried out a clustering analysis on the scaling exponents to further categorise these data, and the resulting dendrogram gave us an understanding of the class affiliation. This method has potential applications in large data analytics, next-generation sequence analysis, and other relevant areas.

Keywords: Hurst exponent, chaos game representation, MF-X-DFA, Singularity spectrum, gene sequences

Mathematics Subject Classification: 37M10, 28A80.

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Discrete Fractional Operators and Their Applications

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Abstract: In this part, I recalled the modified discrete fractional operators with Mittag-Leffler kernel which was recently introduced. I presented the solutions of some linear discrete fractional order differential equations. Finally, some examples was given to confirm the importance from modelling point of view of the modified discrete fractional operators possessing Mittag-Leffler kernel.

Keywords: modified fractional operators with Mittag-Leffler kernel, modified discrete fractional operators.

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A numerical algortihm for the multicommodity capacitated fixed-charge network design problem

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Abstract: This study investigated the "arc-based minimum cost multicommodity network flow model" using the sequential quadratic programming (SQP) method, which starts with an initial solution and then takes iterative steps to improve the solution. The analyses showed that the approach obtained using the merit function converges to the optimal solution faster than the classical SQP method. Finally, a numerical example is presented in the text to demonstrate the application of this method. The example shows the effectiveness and accuracy of the approach.

Keywords: Multicommodity network flow model, Sequential quadratic programming, Merit function.

Mathematics Subject Classification: 90C30, 65K05

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Entropy Generation Analysis of a FENE-P non-Newtonian Polymeric Fluid with Soret and Dufour Effects

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Abstract: This is the first study on the analysis and entropy generation optimization of a polymeric FENE-P nanofluid stagnation point flow towards a shrinking sheet. This study emphasizes the importance of polymeric fluid properties and a variety of other factors that contribute considerably to the development of entropy generation. The heat-flux vector and stress tensor of the model is expressed using a continuous approach. First, we convert the nonlinear partial differential equations into ordinary differential equations utilizing suitable transformation and then solve the renovated system numerically. In addition to having a significant impact on entropy generation, the extensibility parameter, Brinkman number, concentration ratio paramter, and diffusive variable parameter are also investigated for their potential inverse effects on Bejan number. Bejan number is observed to increase for the retardation and temperature difference parameters, while entropy generation appears to decrease for these parameters. We show numerical comparisons to validate the used numerical approach and provide a thorough analysis of the drag force coefficient, Nusselt and Sherwood numbers to explore how different flow constraints influence physical measures of engineering interest.

Keywords: Entropy generation, polymers, stagnation point flow, FENE-P model, nanofluids, shrinking sheet, numerical solution.

Mathematics Subject Classification: 35R11.

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Classification of Seizure Stages in Electroencephalogram using Simplicial Analysis

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Abstract: This study applies simplicial approach on neuro signals captured through electroencephalogram (EEG) to detect and predict the occurrence of seizures. The simplicial method applies network analysis to determine the hidden functional complexities that are certain to seizure. The sampled output of EEG is converted into visibility graph, for which the maximal cliques are discovered before calculating the simplicial characterizers [1-5]. Three vector parameters and one scalar parameter are used to distinguish different stages of seizure i.e., interictal state, pre-ictal state and ictal state. The measures discussed have efficiently differentiated the three seizure stages and hence have performed seizure detection and prediction with 96% and 92% accuracy. Some conventional network parameters and entropies are also calculated and their classification performance is compared against the simplicial parameters. From the results, it is seen that the simplicial analysis has given better accuracy, sensitivity and specificity in distinguishing neurological signals related to different phases of an epileptic seizure.

Keywords: electroencephalogram, seizure, inter-ictal, pre-ictal, ictal, clique, simplex.

Mathematics Subject Classification: 05C99.

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Occurrence of Period-Doubling Cascades in Response Systems with Delay

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Abstract: In this study the extension of period-doubling route to chaos in coupled systems with delay is demonstrated. It is proved that the response system exhibits sensitive dependence on initial conditions and infinitely many unstable periodic trajectories in a compact region. Illustrative examples based on the Lorenz system and Duffing oscillator are provided.

Keywords: period-doubling route to chaos, coupled systems, sensitive dependence on initial conditions, Lorenz system, Duffing oscillator.

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Observer for sensorless control of a doubly fed induction motor drive in EV

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Abstract: This paper deals with the design of a luenberger observer for estimating the state of a doubly fed induction motor (DFIM) model, and for sensorless control of systems employing this type of motor as an actuator in electric vehicle (EV) with optimal performance. Therefore, this paper is concerned with the traction system based electric vehicle, which constitutes a DFIM for a traction motor and a separately excited DC machine (DCM) for an emulated system of EV. The results show the good performance of the sensorless control, and the structure of power applied to the DFIM.

Keywords: Doubly fed induction motor drive (DFIM), Sliding mode control (SMC), Luenberger observer (LO), Electric vehicle (EV).

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A qualitative Study on the Greitzer model with Axial compressor

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Abstract: A qualitative study on the Greitzer model equipped with an axial compressor is presented. This model consists of a nonlinear dynamic system by two differential equations. Based on the aerodynamic instability phenomena (surge and stall) occurring in the compression system, the operating point instability conditions are presented using some basic properties of the nonlinear dynamic system. In addition, a new model of the compressor characteristic curve is proposed which adapts to the compression system in steady state, its validation is done with a graphic identification for certain values with that of Greitzer. In order to determine the type of stability on the new model, the Routh-Hurwitz theorem was applied. An analysis with discussion is presented when the compression system moves towards the Hopf bifurcation point during the surge. For the Hopf bifurcation case, an approximate solution for the system's cycle from the equilibrium point is obtained. The direction is determined using Lyapunov's stability theory. A numerical simulation is carried out to illustrate the theoretical results.

Keywords: Hopf bifurction, compression system, Lyapunov's stability, local bifurcation, axial compressor, aerodynamic instability.

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Analysis of the Application of Artificial Neural Networks in Solving Forward Kinematics Problems for Manipulator Robots with Diverse Dataset Formats

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Abstract: We present an innovative solution to solve the Forward Kinematics (FK) problem of a robotic manipulator by employing an Artificial Neural Network (ANN). The FK problem pertains to determining the location of the robot's end effector based on given joint angles. Essentially, it establishes a mapping between joint space and Cartesian space, offering crucial information regarding the robot's position and orientation. Traditional approaches may encounter difficulties when dealing with FK problems involving manipulators possessing intricate joint configurations. To overcome this challenge, we propose the utilization of an ANN, which is a potential deep-learning technique. In our study, we utilize three distinct datasets: a random step-size, a fixed step-size, and a sinusoidal signal with varying frequencies. These datasets enable a comprehensive evaluation of the ANN's performance. The training process of the ANN involves integrating the input-output datasets and compiling the model/algortithm with the necessary hyperparameters. This methodology represents a significant advancement in solving FK problems, as it harnesses the capabilities of ANNs and their proficiency in handling complex relationships. Our research showcases the effectiveness of the proposed ANN architecture and its diverse datasets in accurately solving FK problems. This approach is particularly valuable in scenarios that involve intricate positions, as it enables the attainment of precise and reliable solutions.

Keywords: Manipulator robot, Forward kinematics, Artificial Neural Network, Random step-size, Fixed step-size, Sinusoidal signal.

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Hub location for a food supply chain network design problem

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Abstract: Food is the most essential of human needs and a healthy diet requires high-quality food, especially fresh foods such as fruits and vegetables. These last reach the consumer through a complex network, involving stages of production, aggregation, distribution and retail. Hubs or consolidation sites (collection centers (CC), wholesale markets (WM), etc.) are actors in this logistic. The design of efficient fruits and vegetables (known for their high rate of perishability) supply chain infrastructures is related to the location of these consolidation sites, according to those of agricultural fields, retail outlets and main roads. Note that these design decisions are long-term ones (strategic) because they involve a huge capital investment. The objective of our study is to contribute to the design of an efficient supply and distribution network for agricultural products, which are often inadequate. We propose a model for the location of WM and CC with respect to the given location of production centers and their capacity to offer the different products and retailers with their demands. The model is a mixed integer program (MILP), taking into account several objectives: travel and construction costs, wasting food cost, etc. It outputs the optimal number of CC and WM that should be established; the locations of the hubs to be established; the size of each hub and the allocations between supply, demand and the hubs. Through the MILP, the study of different problems for structuring distribution networks, encountered and motivated from real-life issues, allows suggesting strategic solutions for decision-makers. We have demonstrated how certain parameters affect the final decision and lead to a series of managerial recommendations for achieving the network design.

Keywords: Hub location problem, Network design, Mixed Integer Programming, Food safety.

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Endogenous Formation of Joint Research lab with heterogeneous firms: Approach by formation coalition games

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Abstract: This study analyzes the endogenous formation (Finus, 2009) of Joint research Lab between several heterogeneous firms. A two-stage model of R&D cooperation is developed to investigate the private versus the social incentives for R&D cooperation. We compare the stable coalition structures under two different rules of coalition formation: the open membership game (Yi and Shin, 2000) and the exclusive membership game (Hart and Kurz, 1983). Our main findings show that the open membership rule supports only the grand Joint Lab as an equilibrium. In contrast, the exclusive membership rule maintains the grand Lab as an equilibrium only for small spillover values. However, for intermediate spillover values, the exclusive rule supports multiple asymmetric partial Joint Lab as equilibria and leads to higher social welfare compared to the open membership rule.

Keywords: Formation coalition games; heterogeneous firms; R&D; Joint Research Lab; Exclusive membership Rule; Open membership rule; Internal and External Stability; Subgame-Perfect Nash Equilibrium; Social welfare.

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Analytical and numerical modelling of thermo-mechanical behaviour of additively manufactured Continuous Carbon Fibre Reinforced Polylactide (CCFRP)

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Abstract: Continuous carbon fibre reinforced polylactide (CCFRP) is a novel type of engineering material which is manufactured by a modified Fused Filament Deposition (FFD) method. In such manufacturing process the polylactide (PLA) filament and pre-impregnated continuous carbon fibre (CCF) are fed into an extruder, where the filament is melted, extruded through a nozzle and deposited in a precise pattern creating subsequent material layers. The application of easily processable PLA and pre-impregnated CCF of high strength results in generation of a composite material of improved interlayer adhesion and favourable mechanical properties. On the other hand, complicated system geometry combined with high thermal expansibility of the PLA matrix causes that the manufactured material is characterized by nonlinear and complex thermo-mechanical properties, which are thoroughly analyzed within this study. The contribution starts with a brief description experimental tests when the CCFRP composite is subjected to thermal loading of wide range of temperatures and its deformation is measured using Bragg grating sensors. Then, a micro-mechanical finite element model of the CCFRP composite subjected to thermal loading is developed. The proposed model utilizes temperature-dependent stiffness and thermal expansion coefficient of PLA as well as the obtained from the numerical homogenization material properties of pre-impregnated CCF. Further, a simplified analytical micro-mechanical model of a single ply is created, used to determine its homogenized properties and to develop an equivalent single layer (ESL) model of the CCFRP composite. The results obtained from both models are compared against each other, and against the results of the experimental tests. Finally, general conclusions about the thermo-mechanical properties of CCFRP composites and their response to a wide range of thermal loadings are presented.

Keywords: Potential Harmonic Isotropic, Fermion System, Quantum Oscillations, Bloch Density Matrix, Local Density.

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Mathematical modeling of infectious disease incorporating a vaccine and variable immunity period

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Abstract: Infectious diseases present a major global public health threat, and the development of effective vaccines has played a crucial role in preventing their spread. However, the duration of immunity provided by vaccines can vary, leading to important implications for the dynamics of disease transmission. In this study, we have constructed a mathematical model that incorporates a vaccine and a variable period of immunity for an infectious disease. Our model considers the interplay between susceptible, infected, and recovered individuals, taking into account the impact of vaccination and the potential loss of immunity. We have derived a formula for the basic reproduction number and utilized it to analyze the local stability of both the disease-free equilibrium (DFE) and the endemic equilibrium (EE). By comparing the time series solutions of the model with and without vaccination, we have demonstrated the critical role of vaccines in disease control. Additionally, we have estimated the time series solutions for scenarios involving constant and variable immunity durations, revealing distinct outcomes. Our findings highlight the importance of vaccination and underscore the value of the immunity period conferred by the vaccine. Ultimately, these results have significant implications for public health policy and efforts aimed at disease control.

On a bi-nonlocal $p(x)-$Kirchhoff equation with dependence on the Gradient via Mountain Pass Techniques.

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Abstract: In this paper, we propose new approaches to the class of quasilinear parabolic equation with nonlocal boundary conditions, in which is the generalization of the model proposed by Chen in 2011, where we prove the existence of a generalized solution using Faedo-Galerkin method.

Keywords: Quasilinear parabolic system, generalized solution, nonlocal boundary conditions.

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Novel discrete monotonicity results for delta sequential fractional operators

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Abstract: The connection between the sign of the delta fractional differences of sequential type and the monotone behavior of a function defined from the fractional difference operator has been investigated in the case where their orders, namely alpha and beta, in $(0, 1)$ with $0 < \alpha + \beta < 1$. We have demonstrated that this connection is dichotomous in the sense that on one subset of the $(\alpha, \beta)-$parameter space there is a strong connection and on the complement of this subset there is effectively no connection. Finally, we have shown that the obtained monotonicity results are sharp constructively.

Keywords: Delta Riemann-Liouville fractional difference, sequential operators, monotonicity analysis.

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Stochastic Epidemic Models in Discrete Time

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Abstract: In this paper, we compare the deterministic and stochastic epidemic models in discrete-time. Firstly, dynamics of the deterministic models are given and the corresponding stochastic models are formulated. Similarities and differences between the asymptotic behavior of the stochastic and deterministic models are discussed and the dynamics of the both models are analyzed. At the end of the study, analytical results are illustrated with the numerical simulations and our results are supported with the graphs and tables using MATLAB package program.

Keywords: stochastic calculus, differential equations system, epidemic models

Mathematics Subject Classification: 35R11

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Approximate solutions of a class of nonlinear initial value problems using Pell collocation method

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Abstract: In this paper, Pell polynomial approach is used for approximately solving a class of nonlinear differential equations with initial conditions. The given problem is firstly expressed as a matrix-vector system via collocation points. Then the unknown coefficients of the approximate solution are obtained. Also, some test problems are given to demonstrate accuracy and effectiveness of the proposed method. Additionally, the calculated numerical values are compared with exact solutions of the test problems and approximate ones obtained with other methods in literature.

Keywords: Collocation method, Pell polynomials, operational matrix, nonlinear differential equations

Mathematics Subject Classification: 34B15, 35C11, 65L60, 65L80.

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Numerical solutions of systems of nonlinear differential equations using a collocation method

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Abstract: In this study, Hermite collocation method is used for approximately solving systems of nonlinear differential equations with initial conditions. Some test problems are given to demonstrate accuracy and effectiveness of the proposed method. Additionally, the obtained numerical results are compared with exact solutions of the test problems.

Keywords: Hermite collocation method, Initial value problems, Differential equations.

Mathematics Subject Classification: 34B15, 35C11, 65L60, 65L80.

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Some inequalities involving Riemann-Liouville Fractional integrals for Hölder and Lipschitzian functions

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Abstract: New fractional integral inequalities for functions whose higher-order derivatives are Hölder continuous are established. With the help of these inequalities, some results for Lipschitzian functions are also examined.

Keywords: Riemann-Liouville Fractional Integral, Ostrowski Inequality, Hölder Continuous Functions.

Mathematics Subject Classification: 26D15, 26A33, 26A46, 26D10.

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Mathematical Modeling of Cancer with Mixed Therapies

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Abstract: Cancer is the biggest cause of mortality globally, with approximately 10 million fatalities expected by 2020, or about one in every six deaths. Breast, lung, colon, rectum, and prostate cancers are the most prevalent types of cancer. In this work, a fractional modeling is presented which describes the dynamics of cancer treatment with mixed therapies (immunotherapy and chemotherapy). Mathematical models of cancer treatment are important to understand the dynamical behavior of the disease. 1 Fractional model are studied considering immunotherapy and chemotherapy to control cancer growth at the level of cell populations. In this paper, fractional models are studied while integer order was already available in literature. The models consist of the system of fractional differential equations (FDEs). Fractional term is defined by Caputo fractional derivative. The models are solved numerically by using Adams Bashforth-Moulton method. The fractional model of secondary stage gives a better approximation for $\beta = 0.7$ as compared to $\beta = 1$. For all fractional models the reasonable range of fractional order is between $\beta = 0.6$ and $\beta = 0.9$. The equilibrium points and stability analysis are presented. Moreover, positive and bounded solution of the equations is proved. Furthermore, a graphical representation of cancerous cells, immunotherapy and chemotherapy is presented to understand the behavior of cancer treatment. At the end, a curve fitting procedure is presented, which verified our results with 99 percent goodness of fit and allow us to verify the experimental results.

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Prediction of Optimal Fertility Treatment using Machine Learning Algorithms

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Abstract: Infertility is a significant public health issue that requires careful consideration. This thesis aims to provide a critical examination of the methodological challenges involved in defining and studying infertility while exploring its epidemiology, including the prevalence and potential early life and reproductive risk factors. Infertility in women is characterized by the inability to conceive after at least one year of regular, unprotected sexual intercourse following marriage. Primary infertility refers to the inability to conceive at all, while secondary infertility refers to the inability to conceive following a previous successful pregnancy. In response to ethical concerns regarding the use of human embryos, the UK established the Human Fertilization and Embryology Author- ity (HFEA) to regulate reproductive technologies and embryo research. Approximately one in ten women between the ages of fifteen and forty-four face difficulties in conceiving. Infertility has a profound impact on couples, particularly women, who may experience adverse circumstances such as emotional stress, social stigma, depression, anxiety, and low self-esteem. Some individuals who fear infertility may choose to avoid contraception due to societal expectations and the desire to demonstrate fertility. Currently, predicting the chances of pregnancy relies heavily on the expertise and experience of individual medical specialists. Therefore, there is a need for a decision-making tool that can provide guidance to medical specialists and patients regarding the appropriate use of IUI and IVF treatments, considering various factors.

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General decay for a translational viscoelastic Euler-Bernoulli beam

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Abstract: In this work, we consider a translational viscoelastic Euler-Bernoulli beam. Under the assumptions of wider classes of kernel functions, we establish an optimal explicit energy decay result from which we can recover the exponential and polynomial decay.

Keywords: Convexity, translational Euler-Bernoulli beam, Memory term, Relaxation function, Viscoelastic damping.

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Capacity Analysis for Urban Area Scenario for Long Term Evolution–Advanced with Wireless Network Service

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Abstract: In order to meet the increasing demand and stringent design requirements for coverage expansion and capacity enhancement. Relay Node (RN) has been considered as a promising solution, in urban area scenario. However; the user density is quite high and often non-uniformly distributed. The main objective of the RN is to enhance the capacity.
This innovation increases the cell-edge coverage radius and through put as well as enhances the usage efficiency of network resources. In fact, the basic idea of relay is to forward signals through one or more relay nodes (RNs) before retransmitting to the destination node .
In this paper, we propose how RN can be made compact to allow more flexible deployment. We can apply for Wireless Network Service.

Keywords: Wireless network, LTE-A, Capacity Analysis, Urban Area.

Network traffic assignment using lagrange neural networks

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Abstract: In this research, we employ a neural network approach to achieve user equilibrium for network traffic assignment problems with capacity constraints. Initially, the optimization problem related to network traffic assignment is reformulated into a Lagrange problem. Leveraging the gradient method, we derive a set of differential equations. These equations are then solved using the Runge-Kutta method. The performance and efficiency of the proposed neural network methodology are illustrated through a numerical example.

Keywords: Nonlinear Optimization,Traffic assignment, Neural Networks.

Mathematics Subject Classification: 90C30, 37N40

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POSTERS

Performances of Robust Sliding Mode with Type-2 Fuzzy Logic Controller for Dual Star Induction Motor

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Abstract: To ensure the proper control of the system of doubly star induction motor (DSIM), a novel proposed scheme control using the technique sliding mode via Type-2 Fuzzy logic (T2FSMC) for to control the speed of a DSIM, to make guarantee the performance robustness and stability of the machine model. An appropriate combination of the sliding mode controller (SMC) improved by the type-2 fuzzy logic is adopted for approximate the second step discontinuous control of SMC to get better with high accuracy the robustness of the DSIM control systems and can eliminates the chattering effect. The dynamic system of the machine is modeled, simulated and validated in Simulink by MATLAB, behavior, the modeling details and the simulations results obtained are presented described in detail after.

Keywords: Galerkin approximation, Maple Computer Algebra System, Differential

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Diagnosis of Static DC-AC Converters Application to the parallel active filter

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Abstract: The most important task in a diagnostic system is the choice of fault indicator variables which must be reliable for the different conditions of the system in order to avoid confusion between one fault and the other. In this work an analysis will be carried out in order to identify these indicator variables for the diagnosis of transistor faults held open in a non-autonomous PAF based on a 2-level voltage inverter. In this sense, a new method of detecting this type of defect will be developed. This method allows the detection and localization of faulty power electronic components using an algorithm based simultaneously on a "time criterion" and on a "current and voltage criterion". In this context, we are more specifically interested in the problems of detection and localization of transistor faults kept open in a two-way voltage inverter used as a parallel active filter which is intended for filtering harmonic currents. To do this, a series of simulation tests, for the various faults considered, must be carried out in order to extract the various information contained in the electrical signals of the inverter (phase currents and voltages).

Keywords: Diagnostic, Fault, PAF, Voltage Inverter.

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Semi-numerical Magnetic Field Calculation for Synchronous Machines by Using Hybrid Model

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Abstract: Based on the finite-element method (FEM) and exact subdomain (SD) technique, this paper proposes a 2-D hybrid model (HAM) for semi-numerical magnetic field calculation in synchronous machines. The magnetic field solution is computed by solving Laplace's and Poisson's equations through exact subdomain SD technique in all regions at unitary relative permeability, however, a numerical model based on FEM is used in ferromagnetic regions. These two models are specifically coupled in both directions. To provide accurate solutions, the current density distribution in slot regions is modeled by using Maxwell's equations. Finite-element analysis (FEA) is used to validate hybrid model and demonstrates excellent results of the developed technique.

Sensitivity Analysis of a Single Server Retrial Queue with Priority Mechanism

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Abstract: In this paper, we are interested in analyzing a single server retrial queue with non-preemptive priority mechanism at which, in the case of blocking, the high priority customers can be queued whereas the lower priority customers have to leave the service area and return after some random period of time to retry their service. The main objective is to use stochastic ordering techniques to establish various monotonicity results with respect to arrival rates, service time distributions, and retrial parameters [1, 2, 3]. In the present investigation, we derive several stochastic comparison properties in the sense of strong stochastic ordering and convex ordering. Then, we carry out a sensitivity numerical analysis.

Keywords: Retrial queues, Markov chain, Stochastic comparison, Stationary distribution

Mathematics Subject Classification: 60K25, 90B22.

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DWT and STFT applied to Detect and locate leaks in WDNs

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Abstract: Water is a precious, sometimes scarce resource that is crucial for all kinds of life. In the last two decades, the water demand has far exceeded the supply in many countries. It is also worth mentioning that distribution networks are constantly increasing. According to an international study 20-50% of the produced quantities are lost due to leaks. These leaks can cause significant economic losses and multiple water contaminations that are carried as a major health risk for the citizen. Therefore, network managers are always looking for fast and inexpensive harmless leak detection systems. The rapid detection of a leak in underground pipes is widely taken into account in the performance evaluation of water supply systems. In addition, detection methods should not interfere with the normal operation of water transport. To minimize the effect of false alarms (FA) that have a costly effect on infrastructure. These false alarms are produced by the use of the most widely used acoustic detectors in the world, which are usually based on the signal correlation technique to know the exact location of the leak in relation to one of the sensors. In this work, we present a new leak detector applied to a prototype pipe using highly sensitive pressure transmitters. For this purpose, we have applied the wavelet technique (DWT) for denoising our non-stationary signals from these transmitters. The STFT (Short time Fourier transform) will be used for the analysis of these non-stationary and non-linear signals coming from the leaks to know the exact position of the leak. Validation tests have proven the efficiency of our detector.

Keywords: Leak, DWT: STFT, Detection, WDNS.

Mathematics Subject Classification: 35R11.

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Comparative study between two artificial intelligence techniques (NN and SVM) applied in fault diagnosis of Wind Turbine

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Abstract: This study addresses the application of artificial intelligence techniques (AI) for the classification of faults in wind turbine. Wind Energy Conversion Systems have become a focal point in the research of renewable energy sources. Reliability of wind turbine is critical to extract this maximum amount of energy from the wind. Many condition monitoring techniques that are based on steady-state analysis are being applied to wind generators. Bearing faults in this generator causes mechanical vibrations and the variations in the air gap density. The air gap flux density is modulated and currents are generated at different frequencies related to the mechanical vibrations. Classical spectral analysis by means of the Fourier transform (FT) initially used. The magnitudes of the frequencies components formed by the bearing defect are small compared to the rest of the current spectrum. In this paper, we show that the utilization of different approaches of artificial intelligence such as neuronal network (NN) and support vector machines (SVM) can be discriminate different failure modes and gives a good basis for an automatic and non-invasive condition monitoring for wind turbine.

Keywords: Artificial Intelligence, NN, SVM, Classification, Bearing fault, Wind turbine.

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Design of leaks detection and localization in WDNs based on LabVIEW and pressure signals

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Abstract: Water distribution networks around the world suffer from leaks. These are due to the movements of various agents such as ground movements, and vibrations caused by road traffic without forgetting the nature of the ground. For this, permanent control is needed. In this work, we have developed a LabVIEW interface for the acquisition and processing of signals received from pressure transmitters. A Wifi system for transmitting and receiving signals from the pressure transmitters is used. To analyze signals to remotely detect anomalies that may occur on the network. The work is divided into two parts: a practical or hard part and a soft part. The hard one is used to obtain the signals containing the leakage information. The soft part is based on the application of signal processing techniques for the detection and location of the exact position of the leakage and therefore minimize the amount of water that is lost.

Keywords: Leak, LabVIEW, WiFi, Detection, WDNS.

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First report on the damage caused by a new bark beetles pest on fig trees in the Bejaia region (north central Algeria)

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Abstract: In response to alerts from farmers in Bejaia region (central-north Algeria) about the decline of their fig trees, researchers from Bejaia University, in collaboration with the National Institute of Agronomic Research, conducted a survey between 2019 and 2021 in the main localities known for fig crops. The authors identified Hypocryphalus scabricollis (Eichhoff, 1878) (Coleoptera, Scolytinae) [1] as the causal agent of fig tree decline in the region. This species is reported as the first record in Algeria. A morphological description and main biological traits of this species are given [2, 3]. The authors present the different localities where this pest has been reported in the Bejaia region, besides giving an overview of its behaviour, they also discuss the potential impact of this insect in the invaded orchards as well as symptoms and damage to the host plant. This work aims to provide a preliminary database to the scientific community about this xylophagous pest of fig trees and to alert regional and national policy makers to take it seriously and address emerging bark beetle problems before it is too late.

Keywords: Fig pests, Ficus carica, Bark beetles, Hypocryphalus scabricollis, Bejaia.

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Palmprint Authentication using Triangular and Orthogonal Local Binary Patterns

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Abstract: Biometric authentication, such as fingerprints or facial recognition, is becoming increasingly popular for securing access to networks and devices. However, it is essential to understand that biometrics is not foolproof, and there are still potential security risks associated with using them. In this work, we are interested in palmprints as a new biometric technology and an alternative to classical biometric modalities. We suggested a new feature extraction approach based on the Local Binary Patterns (LBP) descriptor, titled: Triangular and Orthogonal Local Binary Patterns (TAO-LBP). TAO-LBP descriptor has several advantages compared to the classical LBP, like coding orientation and the image's local texture information, making it more robust to rotation and orientation changes. An extended experimental analysis was conducted using two challenging palmprint datasets, IITD and CASIA, which showed that the suggested descriptor has an impressive performance compared to the classical LBP and state-of-the-art approaches.

Keywords: Biometrics, Authentication, Palmprint, Local binary patterns.

TEM Study of Precipitation Hardening and Dispersoid Particles in an Al-Mg-Si Alloy

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Abstract: Al-Mg-Si alloys have a wide applications range, mostly used in construction, automotive and aerospace industries as a result of their good physical and chemical properties such as corrosion, formability, weldability [1] and because they are age hardenable to develop acceptable strength [2]. In this present research work, we have investigated the precipitation of an Al-Mg-Si alloy by using especially transmission electron microscopic (TEM). This technique can be used to obtain information on the precipitation phases and dispersoid particles. TEM observation of an as-cast Al-Mg-Si alloy, microstructural development during ramp heating treatment and during isothermal ageing treatment at $350°C$ was studied. TEM result shows there are only coarse particles mainly localized along grain boundaries in an as-cast alloy. Two main types of precipitating phases were observed in alloys during ramp heating precipitation $of\beta$'rods-liked phases occurred before precipitation of the transition-bearing dispersoid precipitates. Increasing the heat treatment time and/or ageing temperature provided an increase in the coarsening of the dispersoid particles.

Keywords: Al-Mg-Si alloy, TEM, precipitation, Dispersoid.

Mathematics Subject Classification: 58K60.

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Large deviation principle and application to queueing systems

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Abstract: The large deviations theory is interested in the asymptotic calculation of the probabilities of rare events in an exponential scale. We say that a sequence of random variables (Xn) with values in E, satisfies a Principle of Large Deviation (PLD) with a good function of rate $I : E \longrightarrow [0, +\infty[$ and of speed v_n if the probability that X_n is close to $x \in E$ is of the order $\exp\{-v_n I(x)\}$. In the case where v_n is always equal to n (we speak of rare events) because in this case the probability that X_n is close to x decreases rapidly.
The large deviations theory finds many applications in insurance, finance, physics, statistic and telecommunications.
In the last two decades, there has been an interest in studying the rate of convergence of maximum likelihood estimators. Gao (2001) proved the results of the theory of moderate deviations in the case of independent and identically distributed observations and Xiao and Liu (2006) in the case of independent observations not identically distributed. Miao and Wang (2014), and Singh (2020) proved moderate deviations for maximum likelihood estimators. The objective of this work is the study of the problem of large deviations and their application for the analysis of the asymptotic behavior of waiting time in Markovian queueing systems.

Keywords: Large deviation, Function rate, Queueing theory, Asymptotic behavior, Waiting time.

Mathematics Subject Classification: 60K35, 68M20.

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Asymptotic behaviour of solutions for wave Equation with multiple α(x)-laplacian and variable-exponent nonlinearities

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Abstract: In this paper, we consider an initial value problem related to a class of wave equation with multiple α(x)-laplacian with homogeneous Dirichlet boundary condition in a bounded domain Ω. Under suitable conditions on variable-exponent, we prove a blow up of solutions with negative initial energy.

Keywords: Wave equation, Negative initial energy, Blow-up.

Mathematics Subject Classification: 35L05, 35B44, 35B38.

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Numerical modeling of mixed convection in a horizontal pipe containing an electronic component in the presence of a nanofluid

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Abstract: In this study, the heat transfer by laminar and stationary mixed convection of a nanofluid during the cooling of an electronic component enveloped by a porous layer and attached to the lower wall of a rectangular horizontal channel is investigated. The mathematical description of the problem is presented by using the conservation equations that are solved numerically to obtain isothermals contours, streamlines contours, and the Nusselt number profile within the channel.
The effects of different parameters, such as the volume fraction of nanoparticles, their geometry, as well as the influence of the thickness of the porous layer on the heat transfer by mixed convection have been examined. The results showed that the increase in the volume fraction of the nanoparticles and the increase in the thickness of the porous matrix contributed to the increase in the average Nusselt number and to the improvement of the heat transfer rate, while the use of spherical nanoparticles gave a better heat transfer rate than cylindrical nanoparticles.

Keywords: Nanofluid, mixed convection, Porous medium, Electronic component, Horizontal channel.

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S-box generation bases on dynamical systems with a selection criterion

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Abstract: Even though many encryption systems have been defined. Most of them focus on the design and analysis of the encryption function, leaving aside the stages prior to encryption, however it has been proven that the previous stages are relevant to obtain a higher level of security. One of the most used tools in the stages prior to encryption is the generation of substitution boxes, where it is sought that the generated boxes have characteristics that prevent the disclosure of information. In this sense, a time series selection criterion is presented according to the type of behavior of time series from dynamic systems. The results have shown that the generated S-boxes are more robust and perform better in different tests.

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Keywords: S-box, Dynamical systems, Scaling analysis.

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Numerical resolution for differential equation

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Abstract: In this work, we resolve differential equation with three numerical methods. At first we use Euler's method which is the simplest of the numerical methods. This one based directly on simple geometric ideas. Then in this paper we are going to derive the family of numerical methods that is known as Taylor methods. The idea behind Taylor methods is to approximate the solution by a Taylor polynomial of suitable degree. In Euler's method which is the simplest Taylor method, we uded the approximation

$$x(t+h) = x(t) + hx'(t).$$

The third one is Mann's stochastic algorithm. This method is different from the others, it is an iterative schema with random errors. Finally, We show the convergence of each one to the exact solution using a numerical example.

Keywords: Fixed point iteration, Mann's stochastic algorithm, Taylor methods, Euler's method, Differential equation.

Mathematics Subject Classification: 47j26, 34A06,65L20, 65L05.

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Sensitivity analysis of Basket option model

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Abstract: In this work, we propose the sensitivity analysis of basket options, using for the first time the Taylor Series expansion method to study the sensitivity of the different parameters of the call European basket options model. We calculate the price of two underlying assets and then compare the results obtained by Monte Carlo simulation.
Keywords: Basket option model, Sensitivity analysis, Taylor series expansions.
Mathematics Subject Classification: 91B70, 49Q12, 41A58.

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Optimization design parameters for desired magnetic flux density in the air-gap of PMSM motors using inverse method

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Abstract: The use of the inverse method in the design of electrical machines is to seek the predefined optimal specifications of the shape of the machine using a given output taking into account the constrained variables. Parameter identification is usually treated as an optimization problem, where the objective function to be examined gives the offset between the measured values and the simulated results in a Euclidean norm (least squares method) or any other suitable norm. In this presentation, we discuss an approach for using the inverse problem in the design of electrical machines and an overview of optimal machine design via inverse problems is given. An overview of the machine design as well as PMSM simulation results are presented.
Keywords: Optimization design; magnetic flux density; inverse method.

Comparative Study of non-Gaussian Radar Clutter Modelling Using Compound Models

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Abstract: Radar echo modelling is a major step in the development of robust detection schemes. Compound Gaussian models are largely used to model non-Gaussian radar clutter and provided good results, compound models are characterized by two components speckle and texture, where the speckle component follows Rayleigh law. In this paper, we consider a comparative study using the real data of high-resolution sea clutter collected using IPIX radar by McMaster University, Canada. Several compound models according to the texture distribution are investigated in this study.

Keywords: non-Gaussian distributions, sea clutter, compound model, radar, statistical modelling.

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Impact of setting metal on structural properties of (Diphenyl-Amin-4 sulfonate poly {tetraaquabis(4,4'bipyridine)Zinc(II)}hydrate}phase)

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Abstract: The aim of this work is to prepare a new material by aqueous reaction and to study the effect of zinc setting in (4, 4'-bpy) ligand in different stoichiometries on the structural properties. The new phase was prepared and its crystal structure solved. The compound structure was establish by an X-ray diffraction and the structural data were collect on a CAPPA CCD diffractometer. The title compound structure consists on discrete neutral unit. The geometry examination of the structure shows that it crystallizes in the $P2_1/n$ monoclinic space group, where the new material is based on a Centro-symmetric cation [Zn (4, 4'-bpy)$_2$(H_2O)$_4$] $^+$ joining an anion ($C_{12}H_{10}NO_3S$)$^-$ and a water molecule of solvation via the bond's hydrogen. The association of these entities within the same building has made it possible to access a hybrid compound. The latter confirms the contribution of the diphenyl-amin-4 sulfonate ligand to co-crystallize with the [tetra aqua bis (4, 4'-bipyridine) Zinc (II)] complex. All these components have a tendency to form sheets held together by strong intermolecular interactions. In addition, although the calculations have shown the existence of specific stabilizing interactions between the different groups, this does not prevent having strong intermolecular interactions, which play a major role in the 2D organization.

Keywords: (4, 4'-bpy) ligand, X-ray diffraction, KAPPA CCD diffractometer.

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An Investigation of Solutions of Fuzzy Differential Equations

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Abstract: In this study we have investigated the qualitative behavior of solutions of fuzzy differential equations, a topic that is very important both from a theoretical point of view and for their applications [1, 2, 3, 4, 5]. First, we presented some basic definitions and terminology. Then, using the hypotheses of continuity and monotonicity of set-valued mappings, we obtained our results.

Keywords: Analysis, fuzzy differential equations, fuzzy derivative, differential inclusions.

Mathematics Subject Classification: 34A07, 34K36.

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Numerical Analysis Study of a Tri-Hybrid Nanofluid Flow in a Vertical Pipe

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Abstract: In this work, we present a numerical analysis study of a tri-hybrid nanofluid in a vertical pipe. Three-dimensional non-linear elliptic partial differential governing equations are discretized using finite volume method (FVM). The resulting discretized equations are solved iteratively, using the Tri-Diagonal Matrix Algorithm (TDMA). The effects of Richardson number, nanoparticles size and nanoparticles volume fractions on the velocity, temperature as well as circumferentially average Nusselt number are analyzed and discussed.

Keywords: Heat Transfer; Tri-Hybrid Nanofluid; Pipe (3D); Nanoparticle Size; Elliptic Equations; FVM.

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