JANO'14 PROCEDING OF
Mini-Symposium & Session

The 14th Edition of "Journées d'Analyse Numérique

Optimisation"

20- 22 February, 2023

ENSMR- **Rabat, Maroc**

SCOOP

The main goal of this scientific meeting is to bring together researchers from different fields of Applied Mathematics, and more particularly researchers working in the field of numerical analysis, optimization, scientific computation, and the growing research domains of Data Science and Artificial Intelligence. The conference offers the possibility to develop new ideas and collaborations and to be aware of the latest search trends in numerical and optimization techniques and their applications in various fields. Participants will present and discuss their latest results in these areas. Thus, the 14th edition of JANO is an opportunity to discuss a number of research topics on recent developments in Applied Mathematics. This edition of the meeting follows thirteen previous editions which took place in different Moroccan universities and will be distinguished by the organization of a half-day dedicated to pedagogical engineering.

As a tradition, the conference offers the participants a friendly environment suitable for establishing scientific collaborations and fruitful exchanges.

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Computing Algebra and Related topics

International Conference of Numerical Analysis and Optimization Days (JANO'14)
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minimal lambda dimension in an abelian category

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Abstract:

λ-dimension was introduced by Enochs, Jenda and Oyonarte in their article [2] as an extension of the classical λ-dimension. In this talk, we present some results on minimal λ-dimension, which is constructed using covers rather than precovers.

Keywords: PRECOVERS, COVERS AND ABELIAN CATEGORY.

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On S-coherent rings

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Abstract :

Let R be a commutative ring and S be a multiplicative subset of R. In 2018, D. Bennis and M. El Hajoui introduced S-finitely presented modules and S-coherent rings which are S-version of finitely presented modules and coherent rings and obtained an S-version of Chase's result. They proposed an interesting question as an S-version of Chase Theorem that characterizes coherent rings in terms of flat modules : How to give an S-version of flatness that characterizes S-coherent rings similarly to the classical case ?

In this talk we present a recent work answering the above question. Our investigation yields also some new results on S-coherent rings.

Keywords : S-finitely presented, S-coherent modules, S-coherence rings, S-flat modules.

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A new approch on phantom morphisms.

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Abstract :
We will give in this talk new results on phantom morphisms, showing how various types of phantom morphisms can be unified under a single framework. Our focus is on demonstrating that the majority of existing results hold true in this general context

Keywords : (n,d)-X_R-phantom morphism, (n,d)-${}_RX$-cophantom morphism, n-X-coherent rings.

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Fault-tolerent metric dimension of i-extended zero-divisor graphs of commutative rings

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Abstract :

Let R be a commutative ring with unity. For a positive integer i, the extended zero-divisor graph of R, denoted by $\overline{\Gamma}(R)$, is the simple graph $\overline{\Gamma}_i(R) = (V(\overline{\Gamma}_i), E(\overline{\Gamma}_i))$, where $V(\overline{\Gamma}_i)$ is the set of non-zero zero-divisors of R and two distinct vertices x and y are joined by an edge if if there exist two positive integers $n \leq i$ and $m \leq i$ such that $x^n y^m = 0$ with $x^n \neq 0$ and $y^m \neq 0$. A set of vertices S resolves a graph G if every vertex is uniquely determined by its vector of distances to the vertices in S. The metric dimension of G is the minimum cardinality of a resolving set of G. If we remove any vertex in a resolving set, then the resulting set is also a resolving set, called the fault-tolerant resolving set, and its minimum cardinality is called the fault-tolerant metric dimension. In this talk, we present a study of the fault-tolerant metric dimension for the i-extended zero-divisor graphs associated with commutative rings.

Keywords : Extended zero-divisor graph, commutative ring, metric dimension, fault-tolerant metric dimension.

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On i-extended zero-divisor graphs of commutative rings

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Abstract :

The zero-divisor graphs of commutative rings provide a bridge between ring theory and graph theory. However, many results are established only for reduced rings because a zero-divisor graph defined in the classical manner lacks information on the relationship between powers of zero-divisors. The aim of this talk is to remedy this situation by introducing a parametrized family of graphs, $\{\overline{\Gamma}_i(R)\}_{i\in^*}$, which reveals more of the relationship between powers of zero-divisors. We characterize girth and diameter of $\overline{\Gamma}_i(R)$ and give various examples.

Keywords : Commutative rings, zero-divisor graph, i-extended zero-divisor graph, filtration.

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n-gr-COHERENT RINGS AND GORENSTEIN GRADED MODULES

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Abstract :

In this talk, we introduce the notions of of Gorenstein n-FP-gr-injective and Gorenstein n-gr-flat modules over a graded ring R by using the notion of special finitely presented graded modules. On n-gr-coherent rings, we investigate the relationships between Gorenstein n-FP-gr-injective and Gorenstein n-gr-flat modules. Among other results, we prove that any graded right (or left) R-module admits a Gorenstein n-FP-gr-injective (or Gorenstein n-gr-flat) cover and preenvelope, respectively.

Keywords : n-gr-coherent ring, Gorenstein n-FP-gr-injective module, Gorenstein n-gr-flat module.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

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Solving a variant of Lvov-Kaplansky conjecture using $\mathcal{G}_n$-derivations

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Abstract :

In this talk, we present our contribution that solves a variant of Lvov-Kaplansky conjecture on path algebras using a new kind of derivations called $\mathcal{G}_n$-derivations.

Keywords : Lvov-Kaplansky conjecture, $\mathcal{G}_n$-derivations, Path algebras.

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weak u-S-flat modules and dimensions

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Abstract :
In this paper, we generalize the notions of u-S-flat modules and dimensions. Hence, we introduce and study the notions of weak u-S-flat modules (u- always abbreviates uniformly). An R-module M is said to be weak u-S-flat (w-u- always abbreviates weak uniformly) if $\mathrm{Tor}_1^R(R/I, M)$ is u-S-torsion for any ideal I of R. This new class of modules will be used to characterize u-S-von Neumann regular rings. Hence, we introduce the weak u-S-flat dimensions of modules and rings. The relations between the introduced dimensions and other (classical) homological dimensions are discussed.

Keywords : flat module, u-S-flat module, weak u-S-flat module, u-S-torsion, u-S-exact sequence, u-S-von Neumann regular ring.

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Data Assimilation, Inverse Problems, Recent advances in PDEs and their dynamics

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February 20-22, 2023, Mines School of Rabat, Morocco

Numerical study for a Thermistor problem using Discrete Duality Finite Volume scheme

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Abstract:

We propose a DDFV for a coupled nonlinear parabolic-elliptic equations. The system is known as a generalization of the Thermistor problem which models a temperature dependent electrical resistor.

We first establish some a prior estimates satisfied by the sequences of approximate solutions. Then, it yields the compactness of these sequences. Passing to the limit in the numerical scheme, we finally obtain that the limit of the sequence of approximate solutions is a weak solution to the problem under study.

Keywords: DDFV, Finite Volume, nonlinear, p-Laplacian.

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Reference model tracking for Markovian Jump systems with partially unknown transition rates

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Abstract :
This work addresses the tracking reference model problem for a specific class of Markovian Jump linear systems MJLS with partially unknown transition rates. We present two control strategies based on LMI approaches to force the system trajectories to track asymptotically the state of the deterministic reference model.

Keywords :Markovian jump linear systems ; stabilization ;transition rates ; control law ; dynamic system.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

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On global existence for parabolic reaction-diffusion systems modeling reversible chemical reactions : a numerical study

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Abstract: The modeling and mathematical analysis of concrete phenomena are of great interest to better understand our environment and its evolution. Several analogies between chemistry and biological systems have led researchers to introduce mathematical models of "reaction-diffusion", whose objective is to follow the evolution of the quantities interacting during the process. Since the early 1980's, considerable efforts have been devoted to the study of these systems ; see, e.g., [4, 5, 6, 7, 9] and the references therein.

In this talk, we are interested in reaction-diffusion systems modeling reversible chemical reactions with polynomial growth. First, we provide a general overview of the different theoretical results obtained. Then, we present our investigation from a numerical point of view on open cases. For more details, see [1, 2, 3, 8].

Keywords: reaction-diffusion system, reversible chemical reaction, polynomial growth, classical solution, weak solution, global existence, blow-up in finite time.

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Stochastic Rayleigh diffusion process related on the Rayleigh density function : inference aspects and simulation

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Abstract :

In this work we proposed a new diffusion process related on the Rayleigh density function curve. First, we managed to obtain the main characteristics of the new proposed model as the explicit expression of the stochastic process by applying the Ito lemma, then we proposed the probabilistic characteristics such as the density function, the mean and the conditional mean function. Unlike other processes in the same context, this one allowed us to find the explicit form of the estimators of these parameters by solving the maximum likelihood equation system. finally a simulation study was proposed to see the behaviour of our process and the efficiency of the estimators.

Keywords :Rayleigh distribution, Diffusion process estimation, Mean function.

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A class of parabolic fractional reaction-diffusion systems with polynomial growth: Theory and numerics

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Abstract : In this talk based on [1], we consider a class of parabolic reaction-diffusion systems where the reaction terms are of polynomial growth and the diffusion terms are governed by fractional Laplace operators. For more details on the last point, we refer the interested reader to [7] and the references cited therein.

First, we present some global existence results for that class of systems. Our results extend those obtained in [5, 2, 4, 3] where the diffusion is governed by the classical laplace operator. Second, we propose a numerical scheme to approximate the solutions and we verify its validity. It should be noted that the proposed method was already applied with success in [8, 9]. Finally, we deliver several numerical simulations in order to confirm the achieved theoretical results.

Keywords: Reaction-diffusion System, Fractional Laplacian, Polynomial growth, Global existence, Numerical Approximation.

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A comparative study on the application of the method of fundamental solutions to the inverse problem of heat conduction

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Abstract :

We study an application of the fundamental solution method to the inverse heat conduction problem, where the boundary data are reconstructed on the fixed boundary with the source points placed outside the spatial domain of interest. Theoretical properties and numerical results of the method show accurate and stable results can be obtained with low computational cost.

Keywords : Inverse problem, Fundamental solution method, Heat conduction.

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A Novel Method to Restore Noisy Piecewise Linear Signals

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Abstract :

The problem of restoring piecewise linear signals while preserving their slope changes is a challenging problem that arises in a variety of disciplines, including environmental science [1], genomics[2], to name but a few. In this paper, we propose a novel method for detecting multiple change points (knot points) in noisy data sequences under piecewise linearity condition. The number of change points and their locations are unknown. The proposed is based on Hodrick-Prescott filtering [3], a widely used method for trend estimation. It minimizes the weighted sum objective function that is convex and coercive. Our approach consists of using *line process-trend restoration* by introducing a new variable called line process [4], which describes the presence or absence of change points. The line process aids to restore the continuous piecewise linear signal. The line process allows us to define a non-convex non-smooth energy function that we minimize using sweep strategy. Numerical results show that our proposed method is as accurate as the state-of-the-art methods, and it outperforms most of them [3, 5, 6].

Keywords : Energy minimization, piecewise linear signal, change point detection, trend restoration, Hodrick-Prescott filtering.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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NEČAS IDENTITY FOR THE BIHARMONIC OPERATOR IN LIPSCHITZ DOMAIN

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Abstract :

We derive an identity, that go back to Nečas, for fourth order elliptic operators in smooth domains (see [3]), for the biharmonic operator in lipschitz domain. This identity is useful in the control theory (see, [2, 1, 5], and [4]).

Keywords : Lipschitz domain, biharmonic operator, Nečas identity, Hilbert space method.

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solving steady state Richards equation with a truly local meshless method.

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Abstract :

In this talk, the Richards equation, which is used to predict water flow in porous media, is examined in both two and three dimensions. This equation is known to be highly non-linear, making it challenging to solve analytically. A local meshless method based on radial basis functions (RBFs) is used for space discretization. Two simulations are presented for both 2D and 3D, with the first simulation providing the solution of the linear operator after the equation has been linearized. The second simulation gives the solution of the non-linear form of the Richards equation directly, using the Picard iteration to obtain a linear formulation. The method is easy to implement and is compared to analytical solutions to demonstrate its good accuracy.

Keywords : Meshless method, Multiquadric (MQ), RBF, Richards equation.

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Parameter recovery of an epidemic model with continuous data assimilation

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Abstract. We study the numerical performance of a continuous data assimilation algorithm, based on ideas from feedback control theory of dynamical systems, in the context of compartimental mathematical model of SEIR pandemics. The motivation of this work is the estimation of some parameters as contact parameter in the SEIR model. This system may have limited predictive value due to idealized assumptions underlying the model, measurement error in experimental data and parameters. We implement this model as paradigm in view of application to more realistic epidemic models. The comparison betwen our nudging data assimilation method end the sequential stochastic data assimilation is provided.

Keywords: Parameter estimation, Data assimilation, Azouani-Olson-Titi (AOT) algorithm, Inverse problems.

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Controllability of bilinear systems, survey and some new results.

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Abstract :

A brief survey on different methods to examine the controllability of bilinear systems is given. Some results, obtained with the help of semigroup theory and sepctral analysis are presented in more detail. This survey encompasses recent results on the controllability of heat and wave equations via bilinear controls in the linear and semilinear cases.

Keywords : Controllability, Bilinear systems, Heat equation, Wave equation.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

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Feedback stabilization for prey predator general model with diffusion via multiplicative controls

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Abstract :

In this paper, we consider a predator–prey model given by a reaction–diffusion system. This model encompasses the classic Holling I, Holling II, Holling III, and Holling IV functional responses. We investigate the stabilization problem of the considered system using multiplicative controls. By linearizing the system and using the maximum principle, we construct a multiplicative control that exponentially stabilizes the system towards its steady-state solutions. The proposed feedback control allows us to reach a large class of steady-state solutions. The global well-posedness is obtained via Banach fixed point. Applications and numerical simulations to Holling responses I, II, III, and IV are presented.

Keywords : Prey predator with diffusion, Holling responses, Feedback stabilization, Multiplicative controls, Numerical simulations.

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Numerical simulation of MHD non-Newtonian effects on elastic lubricated contacts

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Abstract :

A numerical simulation of finite Magneto-HydroDynamic (MHD) elastic journal bearings lubricating with non-Newtonian couple stress fluid is presented. The modified Reynolds equation type is derived based on the MHD and Stokes theories. This governing equation is discretized by finite differences method and solved iteratively by the Gauss-Seidel method. Various bearing characteristics are analyzed using different couple stress parameter, elastic coefficient and Hartman number values.

Keywords : Numerical simulation, Finite differences method, Finite journal bearings, Bearing deformation, Magneto-HydroDynamic, Non-Newtonian couple stress fluid.

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Numerical Analysis and Scientific computing.

International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Investigation of Transient Nonlinear Heat Transfer Using FEM in Metal Plate with Variable Thickness

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Abstract :

Heat exchange via conduction and radiation is a dynamic topic of long-standing interest with applications ranging from aeronautical engineering and design to power production to industrial and civil security. To have a better understanding of the performance of various factors during the nonlinear heat transfer study. Several instances of solutions are numerically investigated using the finite element method. To investigate this performance, we will use the FEM approach to solve the nonlinear conduction issue with a non-source term via a rectangular metal plate domain linked with radiation by adjusting the temperature values for the other three edges and the thickness parameter. When the status of the temperature distribution is examined, the findings for Copper and Aluminium are compared.

Keywords : Conduction-radiation, thermal plate, heat transfer.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

DDFV scheme for nonlinear parabolic problems on general meshes

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Abstract :

This paper, focuses on nonlinear anisotropic parabolic model of the form $\partial_t C(u) - div\Big(\Lambda \nabla u\Big) = f$, where C, f and Λ are respectively : a nonlinear function, a source term and a tensor diffusion. This model is used in many problems, such as Richard's equation, two-phase flow in anisotropic porous media. For space discretization, various types of the DDFV scheme are elaborated leading to positive definite stiffness matrices. A general mesh is used and anisotropic tensor is considered. For the temporal discretization, an implicit time scheme is used as well as the Newton-Raphson method to solve the resulting nonlinear system. An iterative incremental approach is elaborated handling the anisotropy and nonlinear effects. Various numerical experiments show the performance of the developed DDFV scheme for different meshes. A super-convergence in the discrete L^2-norm is demonstrated.

Keywords : Richard's equation, DDFV, Newton-Raphson. Anisotropic porous media.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Reliable and accurate method for modelling and simulations of parameterized partial differential equations

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Abstract :

Modelling and numerical simulations of parameterized partial differential equations (PDEs) play an important role in several areas, Manzoni et al [1], such as engineering, chemistry, biology . . .. In many cases, accurate and rapid numerical simulations with a low cost are required. The objective of this paper is to develop a method enabling to accurate and rapid numerical simulations for various problems, Rozza et al [2]. To this end, we consider a technique which combines high and low fidelity methods to reduce the computational cost. The reduced basis (RB) method allows to obtain a quickly and accurate solution of the parameterized PDEs. The RB method enables high fidelity real-time simulations of complex systems, that thanks to design of fidelity certificates on outputs by a suitable *a posterior* error. We discuss also the convergence properties of this method and the performance is showed numerically for some applications, Patera et al [3].

Keywords : Parameterized partial differential equations, Reduced basis methods, A posteriori error, POD, Greedy algorithm.

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February 20-22, 2023, Mines School of Rabat, Morocco

Reactive solute transport with degenerate parabolic equation in porous media

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Abstract :

This work deals with the numerical solution of a nonlinear degenerated model arising from the mathematical modeling of reactive transport in porous media, including equilibrium sorption. The model is a simplified, yet representative, version of multicomponents reactive transport models. The scheme is based on the monotone Nonlinear Two Point Flux Approximation (NTPFA). The discrete nonlinear system is solved by the Picard method that preserves the positivity of solution on each iteration. Our aim is, on the one hand to introduce a regularization step for dealing with degenerated model of sorption (Freundlich type). On the other hand we employ the Anderson Acceleration method (AA) to accelerate the convergence of the Picard iteration, while still satisfying the monotonicity of scheme. This results are illustrated by some numerical experiments showing the performance of the AA method in term of the computation time.

Keywords : Reactive transport, monotone method, porous media, degenerated model, Anderson Acceleration.

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February 20-22, 2023, Mines School of Rabat, Morocco

A Meshless Method for Solving the Nonlinear Hyperbolic Equation with Variable Coefficients

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Abstract :
In this paper, a numerical scheme based on the moving least squares (MLS) approximation and finite difference method (FDM) is proposed for solving a class of the nonlinear hyperbolic equation with variable coefficients. In the new developed scheme, we use collocation points and approximate solution of the problem under study by using MLS approximation. The MLS method is a meshless approach and does not need any background mesh structure. A time stepping approach is employed for the first and second-order time derivatives. The proposed method provides a semi-discrete solutions for the problems under study. In space domain, the MLS approximation and in time domain, the finite difference technique are employed. This method after discretization leads to a linear system of algebraic equations. Some numerical results are given and compared with analytical solutions to demonstrate the validity and efficiency of the proposed technique.

Keywords : Moving least squares (MLS) method, Nonlinear hyperbolic equation, Finite difference method (FDM).

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February 20-22, 2023, Mines School of Rabat, Morocco

The Approximate Solution by Meshless Method of Volterra Integro-Differential Equation

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Abstract :

In this work, we introduce an enhanced moving least square method for the solution of Volterra integro-differential equation : an interpolating polynomial. It is a numerical scheme that utilizes a modified shape function of the conventional Moving Least Square (MLS) method to solve fourth order Integro-differential equations. Smooth orthogonal polynomials have been constructed and used as the basis functions. An unrestricted trigonometric weight function, along with the basis function, drives the shape function and facilitates the convergence of the scheme. The choice of the support size and some controlling parameters ensures the existence of the moment matrix inverse and the MLS solution. Valid explanation and illustration were made for the existence of the inverse linear operator. To overcome problems of near-singularity, the singular value decomposition rule is used to compute the inverse of the moment matrix. The integral part is approximated by Gauss quadrature rule . Some tested problems were solved to show the applicability of the method. The results obtained compare favourable with the exact solutions. Finally, a highly significant interpolating polynomial is obtained and used to reproduce the solutions over the entire problem domain.

Keywords : Volterra integro-differential equation, Moving least square (MLS), Interpolating polynomial, Trigonometric weight function.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

On the monotonicity of finite volume scheme for parabolic equations with anisotropy

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Abstract :

In this talk, we present an original approach allowing to preserve the weak monotonicity of a finite volume discretization in the case of highly anisotropic parabolic equations. In other words, the computed numerical solution honors the physical ranges of the initial condition. The main idea lies in devising a nonlinear damping parameter eliminating the problematic fluxes when they occur. Then, we examine the ability of the scheme to ensure the energy estimates. This is essential for the existence proof of the discrete solutions. Finally, some numerical results are performed. The objective is to highlight the respect of the weak monotonicity, the optimal accuracy of our scheme, and its robustness with respect to the mesh and high ratios of anisotropy.

Keywords : monotonicity, finite volume method, parabolic equation, anisotropy.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Analytical solution of Newtonian Poiseuille flow in a channel of rectangular cross-section with dynamic wall slip

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Abstract:

The objective of this work is to derive analytical solutions for the cessation of Poiseuille flow of a Newtonian fluid in a channel of rectangular cross-section , under the assumption that slip occurs along the walls. We first consider a static slip law according to which wall slip occurs a critical value of the wall shear stress known as, the slip yield stress τ_c:

$$u_w = \begin{cases} 0, & \tau_w \leq \tau_c; \\ \frac{1}{\beta}(\tau_w - \tau_c), & \tau_w > \tau_c; \end{cases}$$

where β is the slip coefficient, which varies in general with temperature and the properties of the wall/fluid interface [1]. In the case of steady-state flow, there are two critical values of the pressure gradient. Below the first critical value no-slip occurs while above the second-one, slip occurs at all walls. Therefore, there are two intermediate regimes for which there are no analytical solutions. In the first regime slip occurs only in the middle sections of the wider walls and in the second-one partial slip also occurs along the narrower walls. The regimes where analytical solution of the cessation flow are possible are discussed. We then consider the case of a dynamic slip law with zero slip yield stress:

$$u_w + \Lambda \frac{\partial u_w}{\partial t} = \frac{\tau_w}{\beta},$$

where Λ is the slip relaxation time. By using the technique of separation of variables, the relaxation time-dependent term forces the eigenvalue parameter to appear in the boundary conditions and, thus, the resulting spatial problems correspond to Sturm-Liouville problems different from their static-Navier slip counterparts [2]. The orthogonality conditions of the associated eigenfunctions for both flows are developed and analytical solutions are then obtained.

Keywords:

Rectangular Poiseuille flow. Navier slip. Slip yield stress. Dynamic slip. Analytical solution.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Isogeometric analysis applied to 2D Brinkman problem

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Abstract :
Isogeometric analysis (IGA) is a numerical technique that combines the advantages of finite element analysis (FEA) and computer-aided design (CAD) by using the same basis functions for both the design and analysis stages. The Brinkman equations describe the flow of a fluid through a porous medium and can be solved using IGA which has the potential advantages of exact geometry representation, efficient mesh generation, h- and k-refinements, and smooth basis functions. The talk you mentioned provides numerical examples in 2D to demonstrate the accuracy, efficiency, and convergence of IGA based on non-uniform rational B-splines.

Keywords : NURBS, Brinkman problem, error estimate, isogeometric methods.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Acceleration of a higher order compact difference scheme for solving plate vibrations problem

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Abstract :

This work is addressed to the numerical resolution of a fourth order parabolic partial differential equation governing the transverse vibrations of a beam with cross section dimension considered not negligible.

We apply a higher order compact difference approximation to derive a scheme that is fourth order accurate in space and second order accurate in time, and we show that the proposed scheme is stable. Several numerical tests are achieved which illustrate this theoretical result.

To accelerate the resolution of the linear system arising from the discretization of the equation, a domain decomposition method are described and employed as a preconditioner for Krylov methods. A large number of numerical test cases shows the efficiency and the good accuracy of the proposed approach.

Keywords : Plate Equation, Domain Decomposition Method, Higher Order Compact Difference Scheme, Stability analysis, Krylov Methods, Schwartz Method, Preconditioning.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

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A parallel preconditioning Schur complement for large scale industrial problems

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Abstract:

The purpose of this work is to introduce a new strategy to improve the convergence and efficiency of the class of domain decomposition known as Schur complement techniques related to interface variables for the simulation of mechanical, electrical and thermal problems in presence of cross points. More precisely, we are interested not only in domain decomposition with two equal parts having the same physical properties but rather in more general splitting components. It is known that in the first case, the optimal convergence with good pre-conditioner is obtained in two iterations and the problem is still challenging in the second case. The primary goal then is to fill part of the gap in such problem domain decomposition techniques and to contribute to solve extremely difficult industrial problems of large scale by using parallel sparse direct solver of the multi-core environment of the whole system and handling each part of the system independently of the change of the mesh or the shifting of the mathematical method of resolution and subsequently, we treat the interface as boundary conditions. The numerical experiments of our algorithm are performed on few models arising from discretizations of partial differential equations using finite elements and meshless methods.

Keywords: Domain decomposition method, Schur complement, Meshless method, Finite Element Method, parallel computing.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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The Singular Function Boundary Integral Method for 3-D Laplacian problems with Conical Vertex Singularities

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Abstract:

The solution of the Laplace equation in the neighborhood of a vertex in a three-dimensional domain may be described by an asymptotic series in terms of spherical coordinates. The objective of this work is to extend the Singular Function Boundary Integral method developed by Georgiou et al. (1996) for a two-dimensional Laplacian equation to a 3-dimensional Laplacian equation with conical vertex singularities. As in the case of two-dimensional problems, the solution is approximated by the leading terms of the local asymptotic solution expansion which are also used to weigh the governing equation in the Galerkin sense. The resulting discretised equations are reduced to boundary integrals by means of the divergence theorem. The Dirichlet boundary conditions are then weakly enforced by means of Lagrange multipliers. The values of the latter are calculated together with the coefficients, which appear in the local asymptotic solution.

Keywords: Laplace equation, vertex singularities, Singular Function Boundary Integral Method.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Burgers' equation resolution using Node Averaged Nodal Integral Method

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Abstract :

Burgers' equation is a partial differential equation introduced by Bateman in 1915 and analyzed by Burgers in 1948. The equation is used as a model in many fields such as shock waves, gaz dynamics, acoustics, continuous stochastic processes, traffic flows, heat conduction, jet flows and turbulence. [1], [2].

Solving this equation attracts many mathematicians, many ideas and methods are developed to solve this equation such as finite difference method (FDM) [8], finite element method (FEM), and finite volume method (FVM).

These standard schemes require very fine grids for complex flows. As the grid is refined, the number of iterations required for convergence increases linearly, and computational time increases quadratically [3].

Therefore, there is a continuing need for better resolution of these equations, some schemes have been proposed, as nodal integral method (NIM) [5] [4], modified nodal integral method (MNIM) [5] [6] and modified MNIM (M2NIM) [4], that rely on coarse mesh methods. These schemes need a significantly lower number of grid points compared to the point-based schemes for the same level of accuracy, and hence, the matrix size gets reduced, facilitating a faster computational convergence [4].

In this article, we are interested in the development of a new variant of the NIM, for the resolution of 1D Burgers' equation, where, in NIM and MNIM, the scheme is derived using Transverse Integration Process (TIP), the TIP involves local averaging of the PDE over the cell in all independent variables except one, which results in a corresponding ODEs, this process is repeated for all independent variables yielding transverse integrated ODEs, and analytical solutions of ODEs within nodes. This analytical pre-processing dramatically improves the quality of the solution, which is the most important characteristic of nodal methods [7].

However, in this new scheme, the TIP is performed at node center instead of node edge, which lead to 3 unknowns per cell, the mean centered values of the solution and the source terms, and as in traditional NIM, the nonlinear convection term become a part of the pseudo-source term, on the other hand, in MNIM, rather than making the nonlinear term a part of the pseudo-source term, we retain it on the

left-hand side and realize that the mean of the product is approximated by the product of the two means [5].

Adapting this approach simplifies the scheme, make it easier to solve, and makes it possible to effectively suppress the oscillations obtained during the resolution by NIM and MNIM [5].

Several tests are proposed to illustrate the efficiency of this newly developed scheme.

It can be seen that the developed scheme gives a precise results, even for a large Reynolds number, and was motivated by its stability, and its precision.

Keywords : Burgers' equation, Nodal Integral Method, Modified Nodal Integral Method, Node Averaged Nodal Integral Method, Modified Modified Nodal Integral Method.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

A hybrid FE-MESHLESS method for modeling and studying FGM structures

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Abstract:

In this work, we are interested in the study of functionally graded composite materials, as these materials can play a major role in different industries (e.g. automotive, aerospace, civil engineering, etc.). We present a hybrid numerical development, by combining weak and strong formulations, to simulate functionally graded composite materials. The hybrid approximation is based on the meshless strong form method and the Finite Element Method (FEM). The proposed approach allows us to exploit the advantages of both formulations. Numerical tests are performed to demonstrate the reliability and performance of the proposed approach by setting up a comparative study with the results obtained by the analytical solution and the FEM.

Keywords: functionally graded material, hybrid algorithm, meshless methods, finite element method

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Computer-aided Design and Shape Optimization

International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

On a new numerical approach for solving shape optimization eigenvalue bi-laplacian problems under convexity constraint

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Abstract :
In this work, we deal with a new numerical approach for solving some shape optimization eigenvalue problems governed by the bi-harmonic operator under volume and convexity constraints. This is based on the shape derivative formula recently developed in [2, 1], which is expressed in term of the support function. This allows to avoid the tedious computation required for the classical method involving the vector fields [4, 3]. So, we first show the existence of the shape derivative of the eigenvalues for these fourth-order problems with respect to a family of convex domains and establish the expression of its shape derivative by means of support functions. Then we propose a new numerical shape optimization process based on this shape derivative formula and the gradient method combined to the finite element discretization. The obtained numerical results show the efficiency and the ability of the proposed approach in producing good quality solutions and in providing better accuracy for the ten first optimal eigenvalues and their associated optimal shapes.

Keywords : Shape optimization, bi-laplacian, eigenvalue problem, convex domains, shape derivative, numerical method, support functions, gradient method.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Optimization of the makespan for a permutation flow shop problem under the constraint of a sequence-independent setup time

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Abstract :

This work aims to study a permutation flow shop problem (PFSP), in order to get closer to the reality we will integrate the constraint of the setup time independent of the sequence (SIST). This is a very important constraint in the manufacturing industry, it means that the machine setup time will be determined by the nature of the machines independently of the jobs. Aware of the importance of the criterion of the maximum completion time of all jobs, also known as the Makespan in the industrial environment, this article has as main objective to minimize this criterion. To do this, we use three categories of resolution methods, represented by, the mixed integer linear programming (MILP) as an exact method, an algorithm based on Johnson's rule and the Nawaz-Enscore-Ham (NEH) algorithm modified as heuristics, in the third category, we have adopted two meta-heuristics namely the iterated local search (ILS) and the iterated greedy (IG). In addition to solving the flow shop problem with permutation, this paper tries to present a comparative study between the different resolution methods adopted. From the numerical results, the NEH heuristic outperforms the modified Johnson approach for small problems. For larger problem sizes, the developed IG algorithm outperforms the ILS algorithm.

Keywords : Permutation flow shop problem · Sequence independent setup time · Makespan· MILP·Heuristics· Metaheuristics.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Mechanical energy absorption capacity of porous FGM materials during a progressive collision

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Abstract :

The study of mechanical energy absorption capacity of materials is very interesting in different industries. For example, biological systems must have the capability to withstand impacts generated during collisions due to combat and defense. In recent years, composite sandwich structures have been widely used in large applications due to their exceptional properties. These components can be used as energy absorbing devices, which leads many researchers to study the mechanical energy absorption capacity of these materials. This also leads us to study a particular type of this kind of materials, called Porous Functional Graded Materials (PFGM), which is used in many areas of applications. The main objective of the present investigation is to analyze the specific energy absorption in PFGM structures. In this context, we studied four forms of porosity distribution in PFGM plates to know which shape offers a high resistance to mechanical shocks. The study is done by the Hamilton's principle to obtain the equations of motion. Afterward, we use a variational formulation based on third-order shear deformation theory. And after, the obtained equations are resolved numerically by the finite element method by adopting four node quadrilateral element with 7 degrees of freedom per node. The analysis shows that the porosity have a significant effect on the mechanical energy absorption capacity of PFGM plates

Keywords : Specific energy absorption, functionally graded material, nonlinear dynamic, porosity distribution.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Geometrical design, numerical modeling and control of a magnetic levitation train

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Abstract :

Magnetic levitation is open to several methodologies of study that concern specifically the automation community, since it presents a non-linear and unstable system. In this paper, we focus on levitation in the railway domain while performing the design, the numerical modeling and the control of a magnetic levitation train prototype. First, we design the prototype of the magnetic levitation train on COMSOL MULTIPHYSICS and we study its behavior by the finite element method. Then, we establish the numerical model of the system to stabilize it with a proportional-derivative digital controller (PD). Finally, we refine the regulation by state feedback control. The simulation performed on MATLAB SIMULINK allows the validation of the numerical model based on the vertical position of the train, the response time and also the value of the current. This paper proposes a complete study of mechanical design and numerical control for the magnetic levitation system of the high speed train.

Keywords : Finite element method, Magnetic levitation, Very high speed train, Numerical control, Numerical model, State feedback.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

A meshfree approach based on TSDT theory for CNT reinforced concrete skew plate

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Abstract:

Getting the new frontiers feature nanocarbon technology for improving construction materials, and the importance of concrete substance used for construction, we investigate the stability analysis of Carbon Nanotube (CNT) Reinforced Concrete Skew Plate (CNT-RCSP) using a meshfree approach based on the Third-order Shear Deformation Theory (TSDT). We assume that the distribution of CNTs is uniform or functionally graded across the thickness of RCSP. The proposed approach is adopted using both rule of mixture theory and meshfree method. The rule of mixture theory is used to estimate the effective material properties for CNT-RCSP. To produce high quality and low cost carbon fiber-based concrete skew plate, the design optimization of CNT distributions in concrete skew plate is studied. In this regard, the influence of reinforcement on the static response of CNT-RCSP is investigated. The effects of various parameters, such as the CNT volume fraction and distribution patterns of CNTs, are also investigated.

Keywords: meshfree method, third-order shear deformation theory, carbon nanotube reinforcement, concrete skew plate.

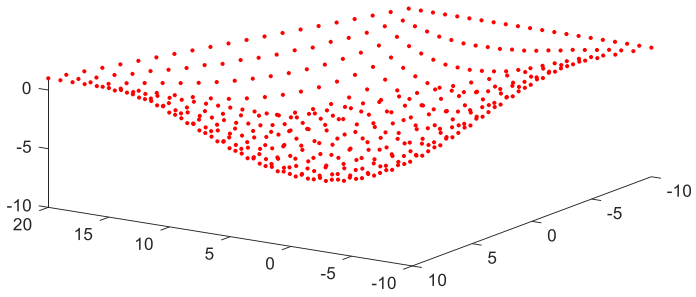

Figure: Deflection for a plate with a skew angle of 30°

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Robust shape optimization. Application to the optimization of an aircraft wing profile.

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Abstract :

Aerodynamic shape optimization is a very active area of research that faces the challenges of highly demanding computational fluid dynamics (CFD) problems, optimization with partial differential equations (PDEs) as constraints, as well as the appropriate treatment of uncertainties. This includes the development of robust design methodologies that are computationally efficient while maintaining the desired level of accuracy in the optimization process. In this paper, aerodynamic shape optimization problems involving uncertain operating conditions are addressed. After a review of possible approaches to account for uncertainties, an artificial neural network (ANN) model is used to approximate the aerodynamic coefficients when the operating conditions vary. Robust optimization problem-solving approaches based on deterministic measurements are used, inspired by the work of Deb [17]. The first procedure is a direct extension of a technique used for single-objective optimization and the second procedure is a more practical approach allowing a user to define the desired degree of robustness in a problem. These approaches have been tested and validated in the case of the optimization of an aircraft wing profile in the transonic regime considering two uncertain variables : the Mach number and the angle of incidence.

Keywords : Shape optimization, Aerodynamic analysis, Free-form deformation, Surrogate model, Uncertainty modeling, Artificial neural networks.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Model Reduction Using Artificial Neural Networks for Parametric Shape Optimization

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Abstract :

Numerical aerodynamic shape optimization is of paramount interest in many industries, including aerospace, automotive, and renewable energy. Shape optimization improves, for example, the lift-to-drag ratio of an airplane wing and reduces the sonic boom of a supersonic jet. Numerical optimization is an iterative process that seeks to improve one or many properties of a system. To this end, an optimization algorithm evaluates a given objective function and drives either its minimization or maximization. Aerodynamic objective function evaluation usually invokes a CFD solver to compute the flux state and performance metrics such as lift and drag coefficients. This computation can have a high CPU-time cost, particularly with high-fidelity solvers.

Moreover, free-gradient optimization algorithms require many objective function evaluations in each optimization iteration. Which significantly increases the optimization time cost. Surrogate Modeling proposes to alleviate the total computation time cost by building a reduced model. Various approaches like Kriging, Response Surface Methodology, interpolation using Radial Basis Functions (RBF), and deep learning techniques enable the approximation of solver response before coupling the resulting model with an optimizer.

This work suggests the application of Artificial Neural Network (ANN) to build a meta-model for airplane wing aerofoil optimization in trans-sonic flight conditions. The wing shape is parameterized using Free Form Deformation (FFD). First, we train the ANN model to predict lift and drag coefficient given FFD control points displacement. Then, it is coupled to a Particle Swarm Optimization (PSO) optimizer to reduce the drag coefficient for a constant lift coefficient leading to a significant reduction of the overall CPU-Time cost.

Keywords : Model Reduction, Parametric Shape Optimization, ANN.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

New optimization of Q for a general class of the fractional Zener model

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Abstract :

The use of seismic waves to study media such as earth, thus to extract information on the fluid and solid phases and on the porous skeleton of the medium through which they pass. Seismic wave modeling is an essential research topic to study wave attenuation. The quality factor $(i.e.\ Q)$ is a physical quantity that allows to measure the absorption of mathematical model and is a common assumption for the inversion of the seismic Q. We have developed new optimization of Q for a general class of the fractional Zener model, based on nonlinear constrained optimization methods with fractional order optimization. We prove by numerical results that the proposed method is more efficient to obtain almost constant Q.

Keywords : Fractional derivative, viscoelastic waves, Zener's model, constrained optimization, quality factor. .

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Topological Data Analysis

International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Linear codes associated to zero-divisor graphs.

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Abstract :

Super-λ graphs were used to construct linear codes using their incidence matrix. Thus, in order to see whether the zero-divisor graphs might be useful in coding theory, it is natural to investigate when zero-divisor graphs of some non elementary ring constructions are super-λ graphs. In this talk, using the finite direct product of finite fields, the ring of the residues, and the trivial extension of rings by a module, we show that there are various classes of rings whose zero-divisor graphs are super-λ. We apply these results to determine parameters of some linear codes associated to zero-divisor graphs.

Keywords : Zero-divisor graphs ; Super–λ graphs ; finite direct product of commutative rings ; extension trivial of commutative rings.

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Abstract$_{F}atiimatou$

FATIMATOU EL BAIHI

January 2023

1 Abstract

In their article titled: "Topological measurement in deep neural networks" Watanabe and Yamana proposed a novel approach to investigate some deep learning algorithms using persistent homology. Clique Complexes are constructed based on a trained models, allowing for the construction of so-called persistence diagrams. This method demonstrates through numerous tests that PH might disclose modest perturbations in the model such as the number of output neurons and variety of input data for deep learning models. Although the proposed algorithm for building these complexes is exponentially complex, making it inapplicable in larger neural networks. In order to address this issue, we suggested certain adjustments to improve the time complexity.

International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

A simplified algorithm for identifying abnormal changes in dynamic networks

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Joint work with Driss Bennis and Bertrand Michel.

Abstract :

Topological data analysis has recently been applied to the study of dynamic networks. In this context, an algorithm was introduced and helps, among other things, to detect early warning signals of abnormal changes in the dynamic network under study. However, the complexity of this algorithm increases significantly once the database studied grows. In this talk, we propose a simplification of the algorithm without affecting its performance. Various applications and simulations of the new algorithm on some weighted networks will also be discussed. The obtained results show clearly the efficiency of the introduced approach. Moreover, in some cases, the proposed algorithm makes it possible to highlight local information and sometimes early warning signals of local abnormal changes.

Keywords : Persistent homology, closeness centrality, Central subnetwork.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Precover completing domains and approximations

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Abstract :

We introduce an $\mathcal{X}$-precover completing domain $\mathcal{X}^{-1}(\mathcal{L})$, with $\mathcal{L}$ being a class of modules and not necessarily a single module, and then investigate when every module in $\mathcal{L}$ has an $\mathcal{X}^{-1}(\mathcal{L})$-preenvelope. Epic and monic $\mathcal{X}^{-1}(\mathcal{L})$-preenvelopes are also investigated. This study plays a key role in setting a general framework for a number of classical results. Then, for a class of finitely generated modules $\mathcal{M}$, we introduce the notion of $\mathcal{M}$-Mittag-Leffler modules as a natural extension of Mittag-Leffler modules. This enabled us to find easier proofs of some known results and also establish new ones.

Keywords : Precover completing domains, precovers, preenvelopes.

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February 20-22, 2023, Mines School of Rabat, Morocco

The Categorical Aspect of Subprojectivity Domains

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Abstract :

In the last few years, López-Permouth and several collaborators have introduced a new approach to studying the classical projectivity, injectivity, and flatness of modules. This way, they introduced subprojectivity domains of modules as a tool to measure, somehow, the projectivity level of such a module (so not just to determine whether or not the module is projective). In this talk, we develop a new treatment of the subprojectivity in any abelian category with enough projectives which shed more light on some of its various important aspects. Namely, it is shown that, in some categories, the subprojectivity characterizes notions other than projectivity. It is also shown that this new approach allows, in addition to establishing nice generalizations of known results, to construct various new examples. Furthermore, a study of when a subprojectivity domain of a class coincides with its first right Ext-orthogonal class is given.

Keywords : Subprojectivity, projective, abelian category.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

BIG DATA APPROACH TO KNOT THEORY

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Abstract :

In recent years, Machine Learning and Topological Data Analysis techniques have just started to attract attention in Knot theory. This talk focus on some new applications of Big Data and deep learning methods that serve to provide useful tools for analyzing and exploring the statistical nature of knot invariants and relations between them that are difficult to see using the traditional tools.

Keywords : Knots ; topological data analysis ; knot invariants.

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Nonlinear PDE and its applications

International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Mathematical and Numerical Analysis of a new Fractional Model of Acquired Immune Deficiency Syndrome.

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Abstract :

The aim of this article is to produce a new epidemic model of HIV/AIDS transmission, we take into consideration the individuals who don't know of their infection. In this paper, we propose a Caputo-Fabrizio order fractional model for HIV/AIDS, the analysis of local stability about the equilibrium and numerical simulation are given.

Keywords : Caputo-Fabrizio derivative, Dynamical systems, Stability analysis,Reproduction number R_0.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

ON A CLASS OF KIRCHHOFF TYPE PROBLEM INVOLVING THE GENERAL NONLOCAL INTEGRO-DIFFERENTIAL OPERATOR

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Joint work with : El Houssine Azroul, Maria Alessandra RAGUSA, and Mohammed SHIMI

Abstract :

In this paper, we consider a class of $p(x)$-Kirchhoff type problem with Dirichlet boundary conditions, considering miscellaneous variational methods we establish the existence of multiple solutions taking into account the different situations concerning the non-linearity and growth conditions.

Keywords : General nonlocal integro-differential equation, variational methods, $p(x)$-Kirchhoff type problem.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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On the existence of a solution to a strongly nonlinear coupled system in anisotropic Orlicz-Sobolev spaces

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Abstract. We study the existence of a capacity solution for a nonlinear elliptic coupled system in anisotropic Orlicz-Sobolev spaces. The unknowns are the temperature inside a semiconductor material, u, and the electric potential, φ. This system may be considered as a generalization of the steady-state thermistor problem.

Keywords:Nonlinear elliptic equations; capacity solution; anisotropic Orlicz-Sobolev spaces;

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A strongly nonlinear anisotropic elliptic system : Analysis and numerical simulation

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Abstract :

We analyse the existence and the numerical simulation of a capacity solution to a coupled nonlinear elliptic system with a quadratic growth in the gradient and a non-uniformly elliptic problem in the context of anisotropic Sobolev spaces. The system may be regarded as a generalization of the so-called thermistor problem.

Keywords : Capacity solution, anisotropic Sobolev spaces, nonlinear elliptic equation, thermistor problem.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Dynamics modes of a fractional order model for fluid membranes

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Abstract :
Using a small deformation approach, a fractional ordinary differential system is proposed to investigate the motion and deformation of a vesicle in shear flow. Closed analytical expressions of the orientation angle and the ellipticity of the vesicle contour (shape deformation) are provided. Three different motions are identified, the classical Tank Treading state (TT) ; in which the vesicle deforms into a prolate ellipsoid inclined at a stationary angle smaller then $\pi/4$ with the flow, and two new types of motions, namely the over-damped tank-treading (OD-TT) ; in which the vesicle's orientation angle ψ and its shape deformation R tend more slowly toward equilibrium and the under-damped tank treading (UD-TT) mode ; in which ψ oscillates all the time along the flow direction with decreasing amplitude, while R start making a breathing motion and then tends to an attractive amplitude.

Keywords : Fractional calculus, Red blood cells, Vesicles.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

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Existence of renormalized solutions for elliptic problem with Neumann boundary condition

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Abstract :

In this work, we study the following quasilinear Neumann boundary-value problem

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

where Ω is a bounded open domain in $I\!R^N$, $(N \geq 2)$. We prove the existence of a weak solution for $L^\infty(\Omega)$ and $g \in L^\infty(\partial\Omega)$, the existence of renormalized solutions for L^1-data f and g. The functional setting involves anisotropic Sobolev spaces with constants exponents.

Keywords : Weak solutions, renormalized solutions, nonlinear elliptic problem, anisotropic Sobolev spaces, Neumann boundary condition.

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Modelling and analysis of the Caputo fractional differential system describing vesicle dynamics mapped into the rigid sphere

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Abstract :

In this paper, we used the fractional Caputo derivative to introduce the memory effect and study the dynamics of a rigid particle in the shear plane that can map the deformation of a vesicle that mimics certain characteristics of red cells. The existence and uniqueness of the solution for the fractional model is proved. We also carry out a detailed analysis on the stability of equilibrium. We used a numerical approach based on the Adams-Bashforth-Moulton predictor-corrector scheme to determine the numerical solution and to support the theoretical results.

Keywords : Red cells, Memory effect, Caputo derivative, Vesicle dynamics, Fractional Adams method.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Solving a coupled elliptic-hyperbolic system: Existence and Unicity

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Abstract:
Conservation law problems are omnipresent in fluid flows. The simplest ones are hyperbolic equations or systems while the most complicated ones are of mixed type (hyperbolic-elliptic). We are interested in a partial differential system of mixed type: we study essentially the existence and the unicity of the entropic solution .

Keywords: Hyperbolic, choc, viscosity, solution entropic.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

On the Existence and Positivity of a Cell Population Balance Model

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Abstract :

A nonlinear age-structured cell population model coupled with an ordinary integro-differential equation accounting for substrate consumption is presented and analysed. We use the nonlinear semigroups theory to reformulate the model as an abstract quasilinear equation in a Banach space. Under some suitable assumptions, we show the existence, uniqueness and nonnegativity of the model.

Keywords : cell population balance equations, partial integro-differential equations.

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Solving Fractional Differential Equations

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Abstract :

Since fractional differential equation (FDEs) have been used for mathematical modeling in numerous potential fields such that mathematical engineering and physics, the framework of fractional calculus has been contoured by considerable popularity and importance during the recent years.
In this paper, we deal with a study of FDEs where the derivatives are taken in the Riemann-Liouville fractional sense. Green's function approach is used to convert time fractional differential equations into integral equations. First, we discuss existence and uniqueness of solutions of this kind of differential equations of fractional order. Second, we present a new numerical tool to approximate the time fractional differential equations. Finally, numerical experiment is performed to demonstrate the effectiveness of the proposed numerical scheme.

Keywords : Fractional differential equation, Integral equation, Fixed point theorem, Approximate solution.

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February 20-22, 2023, Mines School of Rabat, Morocco

Existence of solutions for strongly nonlinear anisotropic parabolic unilateral equations with variable exponents and involving an obstacle depending on time

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Abstract :

The aim of this work is to investigate the following class of strongly nonlinear anisotropic unilateral parabolic problems, with non-standard structural conditions involving a variable growth exponent $\overrightarrow{p}(\cdot)$, and an obstacle depending on time :

$$\begin{cases} \dfrac{\partial u}{\partial t} - \operatorname{div} a(x,t,u,\nabla u) + \displaystyle\sum_{i=1}^{N} h_i(x,t,u,\nabla u) + \Theta(x,t)|u|^{p_0(x)-2}u = \mu + f & \text{in } Q_T, \\ u \geq 0, \quad \mu(u-\psi) = 0, \quad u \geq \psi & \text{in } Q_T, \\ u(x,t) = 0 & \text{on } \partial Q_T, \\ u(x,0) = u_0(x) & \text{in } \Omega. \end{cases} \tag{1}$$

with $u_0 \in L^2(\Omega)$, $f \in L^{\overrightarrow{p}'(\cdot)}(0,T,W^{-1,\overrightarrow{p}'(\cdot)}(\Omega))$, the positive function $\Theta(x,t) \in L^\infty(Q_T)$. Indeed, we establish the existence of a couple of solutions by relying on the penalization method, and by taking into account the complications due to the variation of the exponents. Later, our proof is fulfilled thanks to compactness theorems and a complementary condition.

Keywords : Keyword one, keyword two, keyword three.

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Modular Fixed Point Theorem in the Variable Exponent Spaces $\ell_{p(.)}$

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Abstract :

In this work, we prove a fixed point theorem in the variable exponent spaces $\ell_{p(.)}$, when $p^- = 1$ without further conditions. This result is new and add more information on the modular structure of these spaces. To be more precise, our result concerns ρ-nonexpansive mappings defined on convex subsets of $\ell_{p(.)}$ that satisfy a specific condition which we call "condition of uniform decrease".

Keywords : Fixed point theory, Modular spaces, Variable exponent spaces.

ICRAMCS 2023

THE FIFTH EDITION OF THE INTERNATIONAL CONFERENCE ON RESEARCH IN APPLIED MATHEMATICS AND COMPUTER SCIENCE
March 16-17-18, 2023 | Casablanca, Morocco

Nonnegative solution of a class of double phase problems with logarithmic nonlinearity

Communication Info

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Keywords:
(1) Double-phase problem
(2) Existence of solutions
(3) Sobolev space on Riemannian manifold

Abstract

This manuscript proves the existence of a nonnegative, nontrivial solution to a class of double-phase problems involving potential functions and logarithmic nonlinearity in the setting of Sobolev space on complete manifolds. Some applications are also being investigated. The arguments are based on the Nehari manifold and some variational techniques

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Existence of weak solutions for quasilinear elliptic systems in sobolev spaces with weak monotonicity and rafined conditions

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Abstract :

In this work, we prove the existence of weak solutions to a quasilinear elliptic systems in Divergence Form with Weak Monotonicity whose right hand side depends on u and Du. We use the techniques of Young measure and the Galerkin method to attain the needed result.

Keywords : Quasilinear elliptic system, Young measure , Weak solution, Galerkin approximation.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Mathematical analysis of electro-thermo-fluid model for cardiac radio-frequency ablation

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Abstract :
This paper is concerned with a nonlinear reaction-diffusion-fluid system modeling radio-frequency ablation in cardiac tissue. This model describes the evolution of cardiac tissue's temperature, velocity, and potential. The right-hand sides are taken abstract to cover a large class of dependencies between the temperature, velocity, and potential. The heat conductivity, the kinematic viscosity, and the electrical conductivity are treated as nonlinear functions of temperature. A mathematical analysis of the existence of a global solution based on the Faedo-Galerkin and Schauder's fixed point methods is established, in two and three-dimensional space.

Keywords : Bio-heat equation, Navier-Stokes equation, Radiofrequency ablation, Cardiac tissue, Finite element method.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

On the study of some noncoercive elliptic equations in weighted Sobolev spaces

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Abstract :

In this work, we consider some nonlinear and non-coercive elliptic Dirichlet problem

$$\begin{cases} -\mathrm{div}\Big(\dfrac{|\nabla u|^{p-2}\nabla u}{(1+|u|)^{\lambda}}\omega_1\Big) + d(|u|)|\nabla u|^p\omega_0 = f(x,u) & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

in the weighted Sobolev spaces $W^{1,p}(\Omega, w_0, w_1)$. We study the existence and regularity of renormalized solutions for this elliptic equation. Also we will conclude some regularity results.

Keywords : Weighted Sobolev spaces, elliptic equation, renormalized solutions.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Fractional model and numerical algorithms for analyzing the impact of HIV/AIDS migration.

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Abstract :

Every year, millions of people die in the world because of infectious diseases, such as human immunodeficiency virus infection and acquired immunodeficiency syndrome (HIV/AIDS).In this article, we discuss how migration affects the growth of HIV and AIDS cases. In order to account for migration's role in the spread of HIV and AIDS cases, we created a simple fractional model for HIV and AIDS. Data on the incidence of HIV and AIDS in Malaysia were used to calibrate the model. The fractional models are demonstrated to have a disease-free and endemic equilibrium point, and the existence and uniqueness of solutions for the fractional model with migration and without migration are proven.The local and global stability of the disease-free equilibrium of the model are calculated. For the numerical simulation of the models under consideration, the fractional Adams-Bashforth approach is created.

Keywords : SIA epidemic model, Caputo fractional derivative, Stability analysis, Reproduction number, Adams-Bashforth-Moulton method.

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Renormalized Solutions For Some Non-Coercive Singular Quasilinear Elliplic Problems

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Abstract :

This paper is devoted to the study of following non-coercive quasilinear elliplic problem :

$$\begin{cases} -\sum_{i=1}^{N} D^i(|D^i u|^{p_i-2}D^i u) = \sum_{i=1}^{N} \frac{|D^i u|^q}{|u|} + f & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega \end{cases}$$

in anisotropic Sobolev spaces framework, where Ω is a bounded open set of $\mathbb{R}^N$ ($N \geq 2$), where $f \in L^1(\Omega)$. We show the existence of renormalized solutions for this elliptic equation. Also we will conclude some regularity results.

Keywords : Anisotropic Sobolev spaces, elliptic equation, renormalized solutions.

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Fractional eigenvalue system with variable exponents

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Abstract :

In this talk, we consider a class of eigenvalue elliptic systems involving the fractional $(p(x,.),q(x,.))$ $-$Laplacian operators. Our main tools are based on Mountain Pass Theorem and Fountain Theorem.

Keywords : Elliptic systems, Generalized fractional Sobolev spaces, Variational methods, Fractional $p(x,.)$-Laplacian, Mountain Pass Theorem, Fountain Theorem.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Existence of radial solutions for a semilinear problem on exterior domains with boundary conditions

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Abstract :

In this paper we are interested to the existence and multiplicity of radial solutions of elliptic equations $\Delta u(x) + K(|x|)f(u) = 0$ with any given number of zeros on exterior of the unite ball centered at the origin in $\mathbb{R}^N$ such that $u(x) \to 0$ as $|x| \to \infty$, where the nonlinearity $f(u)$ is odd and superlinear for u large enough. In addition, we assume that $K(r)0$ is C^1, $0 < K(r) \leq c_0\, r^{-\alpha}$ and $2(N-1) + r\frac{K'}{K} < 0$ on $[R, \infty)$ where $\alpha > 2(N-1)$ and $N > 2$.

Keywords : Radial solution, nonlinear mixed boundary problem, exterior domain.

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Weak periodic solution for strongly nonlinear parabolic problems without sign condition and nonlinear boundary conditions

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Abstract :
This work deals with an existence result of a weak periodic solutions for non- linear parabolic equations of the type

$$\begin{cases} \frac{\partial u}{\partial t} + \Delta u + H(x,t,u,\nabla u) = f & \text{in } Q = \Omega\times]0,T[, \\ u(x,0) = u(x,T) & \text{in } \Omega, \\ -\frac{\partial u}{\partial \nu} = \beta(x,t)u + h(x,t,u) & \text{on } \Sigma = \partial\Omega\times]0,T[, \end{cases}$$

where $\Omega \subset \mathbb{R}^N (N \geq 2)$ bounded open domain with smooth boundary denoted by $\partial\Omega$. We assume that

- f is a periodic function such that $f \in L^2(Q)$.
- β is a periodic positive continuous and bounded function.
- $h : \Sigma \times \mathbb{R} \mapsto \mathbb{R}$ is a Carathéodory function periodic in time, $s \mapsto h(x,t,s)$ is nondecreasing for a.e $(x,t) \in \Sigma$, $h(x,t,s)s \geq 0$ and $|h(t,x,s)| \leq \xi(x,t) + |s|$ where $\xi \in L^2(\Sigma)$.
- $H : Q \times \mathbb{R} \times \mathbb{R}^N \to \mathbb{R}$ is a Carathéodory function such that $H(x,t,s,\xi) \in L^1(Q)$ $\forall s \in \mathbb{R}, \forall \xi \in \mathbb{R}^N$ and a.e $(x,t) \in Q$.
- $|H(x,t,s,\xi)| \leq g(s)|\xi|^2$ a.e $(x,t) \in Q, \forall s \in \mathbb{R}, \forall \xi \in \mathbb{R}^N$, where $g : \mathbb{R} \to \mathbb{R}^+$ is a continuous function and $g \in L^1(\mathbb{R})$.

Keywords : Weak Periodic solution , parabolic equation , nonlinear boundary conditions.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Existence result for strongly nonlinear elliptic unilateral problems with mesure data in the setting of Musielak-Orlicz spaces

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Abstract :
In this work, we give an existence an existence result for the following unilateral elliptic problems of the type

$$\begin{cases} u \geq \omega & \text{a.e.in} \quad \Omega, \\ A(u) - \text{div}\Phi(u) + g(x,u,\nabla u) = f - \text{div}F \quad in \quad \Omega \\ u \equiv 0 \qquad on \quad \partial\Omega, \end{cases} \tag{1}$$

with $A(u) = -\text{div}a(x,u,\nabla u)$ be a Leray-Lions operator defined on $D(A) \subset W_0^1 L_\varphi(\Omega) \to W^{-1}L_{\bar{\varphi}}(\Omega)$ where φ and $\bar{\varphi}$ are two complementary Musielak functions and $\omega : \Omega \to \overline{\mathbb{R}}$ be an obstacle measurable function and g is a non-linearity satisfying the following growth condition

$$|g(x,s,\xi)| \leq \delta(x) + b(|s|)\varphi(x,|\xi|))$$

where $b : \mathbb{R} \to \mathbb{R}^+$is a continuous positive function belonging to $L^1(\mathbb{R})$ and $\delta(.)$ is a given non-negative function in $L^1(\Omega)$.

$$\Phi : \mathbb{R} \longrightarrow \mathbb{R}^N \text{ is a continuous function,}$$

and the datum $\mu = f - \text{div } F$ is assumed to belong to $L^1(\Omega) + W^{-1}E_{\overline{\varphi}}(\Omega)$.
Keywords : Musielak-Orlicz-Sobolev spaces, Elliptic equation, Entropy solutions, truncations.

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A strongly non-linear elliptic problem with L^1-data in Musielak-Orlicz spaces

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Abstract :
In this work, we give an existence result of renormalized solutions for strongly nonlinear boundary value problem of the type :

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

where Ω is a bounded domain of $\mathbb{R}^N, N \geq 2$, $A(u) = -\operatorname{div}(a(x,u,\nabla u))$ is a Leray-Lions operator defined from the space $W_0^1 L_\varphi(\Omega)$ into its dual $W^{-1}L_{\bar{\varphi}}(\Omega)$, with φ and $\bar{\varphi}$ are two complementary Musielak-Orlicz functions and where a is a function satisfying the following conditions :

$$a : \Omega \times \mathbb{R} \times \mathbb{R}^N \longrightarrow \mathbb{R}^N \text{ is a Carathéodory function.} \tag{2}$$

There exist two Musielak-Orlicz functions φ and P such that $P \prec\prec \varphi$, a positive function $d(x) \in E_{\bar{\varphi}}(\Omega)$, $\alpha > 0$ and $k_i > 0$ for $i = 1, \cdots, 4$, such that for a.e. $x \in \Omega$ and all $s \in \mathbb{R}^N$ and all $\xi,\ \xi' \in \mathbb{R}^N,\ \xi \neq \xi'$:

$$|a(x,s,\xi)| \leq k_1 \left(d(x) + \bar{\varphi}_x^{-1}\left(P\left(x, k_2|s|\right)\right) + \bar{\varphi}_x^{-1}\left(\varphi\left(x, k_3|\xi|\right)\right)\right), \tag{3}$$

$$\left(a(x,s,\xi) - a\left(x,s,\xi'\right)\right)\left(\xi - \xi'\right) > 0, \tag{4}$$

$$a(x,s,\xi).\xi \geq \alpha\varphi(x,|\xi|) + \varphi(x,|s|). \tag{5}$$

Furthermore, let $g : \Omega \times \mathbb{R} \times \mathbb{R}^N \longrightarrow \mathbb{R}^N$ is a non-linearity satisfying the following growth condition

$$|g(x,s,\xi)| \leq \delta(x) + b(|s|)\varphi(x,|\xi|))$$

where $b : \mathbb{R} \to \mathbb{R}^+$is a continuous positive function belonging to $L^1(\mathbb{R})$ and $\delta(.)$ is a given non-negative function in $L^1(\Omega)$.

The lower order term Φ is a Carathéodory function satisfying, for a.e. $x \in \Omega$ and for all $s \in \mathbb{R}$, the following condition :

$$|\Phi(x,s)| \leq \bar{\varphi}_x^{-1}\varphi(x,\alpha_0|s|), \tag{6}$$

$$f \in L^1(\Omega). \tag{7}$$

Keywords : Musielak-Orlicz-Sobolev spaces, Elliptic equation, Renormalized solutions, truncations.

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Mathematics of Artificial Intelligence, Machine Learning and Data Analysis

International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Bellman activation function : an activation function that satisfies a 1-dimensional projection of the bellman equation

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Abstract :

The deep Q-network (DQN) algorithm uses a deep neural network to approximate the optimal Q-function that satisfies the optimal Bellman equation. The ReLu activation is the most used activation function in DQN. However, the Relu activation function does not take into account that a Q-function satisfies the Bellman equation. In this study, we investigate whether an activation function that satisfies a 1-dimensional projection of the bellman equation can improve the effectiveness of the DQN algorithm.

Keywords : Reinforcement learning, activation functions, Bellman equation, ReLu function, Deep Q-network algorithm

Références

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February 20-22, 2023, Mines School of Rabat, Morocco

Machine Learning for forecasting some stock market index

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Abstract :

In this paper we evaluate our algorithm for estimating the parameters of GARCH models (see M. Benmoumen, 2022) by transposing it to real data and then we present our Maching learning for forecasting the returns of some stock market index.

Keywords : Maching Learning, GARCH models, Kalman Filter, Stock market index.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Simple convergent procedure to Estimate Exploratory Factor Analysis Model

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Abstract :

Exploratory Factor Analysis is a prevailing statistical reduction technique for explaining the covariance structure of high-dimensional data using a small number of factors. The main step in the whole modeling process is parameter estimation. The method used for this purpose is the BFGS procedure. In practice, BFGS does not present any problem of convergence. However, to date, no proof of its convergence is available. The present paper introduces an alternative estimation strategy based on the least-squares criterion and establishes its convergence properties. An illustrative example of this proposed strategy is presented. Furthermore, theoretical and numerical comparisons between the classical estimation method and the proposed procedure are discussed and illustrated.

Keywords : Exploratory Factor Analysis, Implied Covariance Matrix, Least Square Criterion, BFGS procedure.

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February 20-22, 2023, Mines School of Rabat, Morocco

Deep learning for solving PDEs that simulate nuclear waste disposal

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Abstract :
Deep disposal of nuclear waste raises a number of challenges for numerical simulations : widely differing lengths and time-scales, highly variable physical coefficients and stringent accuracy requirements. It is no wonder therefore if the topic is catching the attention of computational scientists and numerical analysts [1]. In this work, we are interested in the use of deep learning to solve PDEs that model incompressible and miscible flows encountered in petroleum engineering and hydrogeology applications. More precisely, the studied problem is modeled by a coupled system composed of an elliptical equation (1), and a diffusion-convection-reaction type equation (2). Let Ω be a polygonal open set with boundary $Gamma$ composed of two parts such that $\Gamma = \bar{\Gamma}_1 \cup \bar{\Gamma}_2$.
Velocity-pressure equation :

$$\begin{cases} \operatorname{div} \vec{q} = 0, \quad \vec{q} = -\frac{K(x)}{\mu}\nabla p & \text{in } \Omega\times]0,T[\\ \vec{q}\cdot\vec{n}\,|\Gamma_1 = p_1; \quad \vec{q}\cdot\vec{n}|\,\Gamma_2 = p_2 & \text{on }]0,T[\end{cases} \tag{1}$$

Concentration equation :

$$\begin{cases} \Phi(x)\frac{\partial c}{\partial t} - \operatorname{div}(D(x,\vec{q})\nabla c - c\vec{q}) + R(x)c = f(x,t) & \text{in } \Omega\times]0,T[\\ c\cdot\vec{n}\,|\Gamma_1 = c_1; \quad \nabla c\cdot\vec{n}|\,\Gamma_2 = c_2 & \text{on }]0,T[\\ c(x,0) = c_0(x) & \text{on } \Omega \end{cases} \tag{2}$$

Where p and $\vec{q}$ are the pressure and the Darcy velocity of the fluid, Φ and K are the porosity and intrinsic permeability of the porous medium. The fluid viscosity μ is the viscosity of the fluid, R is the reaction term, and f is the source term. c_0 is the initial concentration. The diffusion-dispersion tensor D is given by : $D(x,\vec{q}) = d_e I + |\vec{q}|\,[\alpha_l E(\vec{q}) + \alpha_t(I - E(\vec{q}))]$, with $E_{ij}(\vec{q}) = \frac{q_i q_j}{|\vec{q}|^2}$, d_e is the effective molecular diffusion coefficient, α_l and α_t are the longitudinal and transverse intrinsic dispersivities respectively.

We propose to solve the coupled system (1)-(2) by approximating the solution with tow deep neural networks. The first network trained to satisfy the velocity-pressure equation (1) while the second network trained to solve the concentration equation (2).

The two networks are trained using the algorithm of Deep Galerkin Method (DGM)[2]. The numerical simulations to predict nuclear waste management will be discussed and presented.

Keywords : Nuclear waste, Porous media, Deep neural network, Deep Galerkin Method.

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Bayesian Neural Networks

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Abstract :
Neural networks are connectionist systems that interconnect a set of virtual neurons, allowing the machine to learn on its own to perform a specific task using a large amount of data. However, standard neural networks only provide point estimates for weights and predictions, which perform well for large datasets but quickly overfit for small datasets. They also fail to express uncertainty in regions with little or no data, leading to overconfident decisions. To address these issues, the Bayesian approach has been adopted to train neural networks. It provides a probabilistic interpretation of deep learning models by expressing all its components as stochastic variables. The Bayesian approach produces good results, even with small data sets, by reducing overfitting and allowing us to capture model uncertainty. However, inferring the Bayesian posterior for neural networks using the Bayes formula is frequently challenging. Therefore, approximations of the true posterior with another simple distribution are often employed. This technique is known as the variational inference method. This paper provides an overview of Bayesian Neural Networks using current variational inference methods, as well as an exploration of the tools required to create, implement, train, and evaluate neural networks within a Bayesian framework.

Keywords : Bayesian Neural Network, Variational Inference, Uncertainty.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

The convergence analysis of batch gradient method with smoothing mask for pruning hidden nodes of feedforward neural networks.

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Abstract :

The main objective of this paper is to present an effective method for pruning hidden units of feedforward neural networks. Using a binary mask can be helpful in identifying the unimportant hidden nodes. However, It leads to an NP-hard combinatorial optimization problem. To overcome this issue, we propose a batch gradient training method with smoothing mask, where we use an appropriate sigmoid function as a mask. During the training process, The procedure drives the masks of unnecessary hidden nodes to zero. And can eventually be removed after the training. Under mild conditions, we prove theoretically the weak and strong convergence of the proposed pruning approach. Moreover, we supported the theoretical analysis with different numerical simulations.

Keywords : Feedforward neural networks, Pruning, Smooth mask, Batch gradient method, Convergence.

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Hyper-parameter optimization for convolutional neural network based on genetic algorithm

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Abstract :

In recent years, convolution neural networks (CNNs) have become deeper in order to achieve better classification accuracy in image classification. The performance of CNNs depends on their architecture and hyper-parameter settings. As a result, it is difficult to design optimal CNN architectures for a given image classification problem. In this work, the Genetic Algorithm (GA) is used to explore the architecture design space of convolutional neural networks. Therefore, an adequate variable-length encoding is proposed to represent the different layers in CNN. In this paper, we focus on optimizing the hyperparameters namely filters number, filters sizes for the convolutional layer, and the type of pooling for the subsampling layer. The proposed algorithm is evaluated and compared with five existing algorithms on the MNIST dataset, and the experimental results show that our developments give satisfactory results in terms of test accuracy.

Keywords : Convolution Neural Network, Genetic Algorithm, CNN hyper-parameters.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Lithium-Ion Battery Behavior Simulation Based On PDEs Models Solution

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Abstract:

With the widespread adoption of electric vehicles and the proliferation of electronic devices, lithium-ion batteries have emerged as a vital energy storage technology. This necessitates a better understanding of how batteries work, how they degrade, and how to optimize and manage their large-scale operation. As a result, battery mathematical models become a more viable option and an invaluable tool for battery designers and control because they offer a low-cost, safe, and quick alternative to experiments. More broadly, various simulation tools enable the engineers and designers of batteries and battery management systems to solve these models, allowing them to provide longer-lasting and more efficient energy storage systems. PyBaMM (Python Battery Mathematical Modeling) [4]is an open source multi physics battery modeling software package that provides reduced-order models for lithium-ion and lead acid batteries for fast and flexible simulation. The battery dynamics are defined with a set of coupled partial differential-algebraic equations (PDAEs) [3] to determine the intercalated lithium and electrolyte ion concentrations, as well as determine any other variable of interest from the bat tery electrochemical model's closed-form expressions [1]. In this work, Pybamm was used to simulate the behavior of lithium-ion batteries due to its ease of use, robustness, and diversity of models and submodels for the degradation mechanisms it provides. The Single Particle Model with Electrolyte (SPMe) [2] is selected as the Li-ion battery electrochemical model to represent the battery environment in PyBamm and run different charging strategies to optimize the charging time without violating its safety. The simulation results demonstrate PyBamm's ease of implementation and exploration, as well as its ability to approximate Li-ion battery dynamics with 1 significantly less computational cost and time.

Keywords: Lithium Ion Battery, LIB, PDEs, Pybamm, Deep Reinforcement learning, Electric Vehicule, EV, Modeling

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

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Distributed Artificial Intelligence model for optimizing the medical waste management process

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Abstract:

Purpose- The objective of this paper is to optimize the process of medical waste management (MWM) in the Moroccan public hospital. To this end, we propose a model for MWM that meets the challenges of sustainable development and the circular economy, especially in terms of preserving the environment and reducing hospital costs. The proposed model would allow the hospital to become increasingly independent from external suppliers, but also to develop this activity which is one of the inescapable levers of the hospital supply chain and consequently of hospital management.

Design/methodology/approach- Our work is motivated by the critical and complex nature of the MWM process. This complexity led us to use a Distributed Artificial Intelligence modeling approach, namely Multi-Agent Systems (MAS) to design and describe the proposed model in a rigorous way as it is one of the strong paradigms to understand the behavior of complex systems. To model the system, we have adopted essentially the object-oriented method and by extension the agent-oriented method, which remains one of the major approaches currently proposed for the specification of MAS behavior.

Findings- The multi-agent approach highlighted the complexity of the process studied, but the details provided allowed a better understanding of the proposed model for the target hospital. On the other hand, the agent-oriented method, as an extension of the object-oriented one, has allowed us to make clearer the relations and dependencies between the different agents through the class diagram. While the sequence diagram, it shows the interactions between the agents and gives the sequence of the messages exchanged between them.

Research limitations- This work is a case study; it is realized from a hospital to solve a factual problem. Thus, a simulation of the proposed model is necessary to confirm its reliability, which we will try to do soon.

Originality/Practical implications- The target hospital of the study is a medium to large care facility (350 beds). Therefore, after simulation and validation of the results, the proposed model could well be adopted by a wide range of national and even foreign hospitals, if they are convinced of its reliability as a decision support tool in the field of hospital management.

Keywords: Optimization, Modeling, Distributed Artificial Intelligence, Multi-Agent System., Medical Waste Management, Moroccan Public Hospital.

International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Improving Pedestrian Segmentation with detection-based Region Proposals : An Experimental Study

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Abstract :

Segmentation using CNN has become an important research topic in recent years. One such application is pedestrian segmentation. However, segmentation models may have limitations when it comes to images with non-homogenous backgrounds. To address this problem, we propose to incorporate a region proposal-based framework as input to the segmentation model. The region proposals are bounding boxes generated by a detector. In our experiments, we use YOLO as the detector and a compressed version of UNet called "SqueezeUNet" as the segmentation model. The results show that incorporating region proposals significantly increases segmentation accuracy and decreases false positive pixels in the background, demonstrating the impact of this approach on the overall performance of the segmentation model for pedestrian segmentation.

Keywords : Convolutional Neural Networks, Compressed CNNs , Pedestrian segmentation, Pedestrian detection, Region proposals.

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A Study of Network Roads Landslides and their Stabilization Methods in the North of Morocco

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Abstract :

Landslides are affecting roads and transport networks in northern Morocco, posing a major economic, human, and service dilemma. To assess the latter, we look forward to conducting a detailed analytical study of the main factors contributing to landslides. To achieve this goal, we collected 319 landslides spread across all Northern provinces of Morocco. We have also categorized the contributing factors into 6 main sections (hydrology, hydrogeology, and geology, geometry of the ground, Climatology, and topography). Then we use the input data with the advanced statistical program SPSS to get an accurate result. Consequently, we classify our types of landslides into eight categories: 1- Debris Flow, 2- Solifluction Flow, 3- Circular Slide, 4- Planar Slide, 5-Earth Topple, 6-Fall of Blocks, 7-Debris Fall and 8- Pavement cracks and irregularities in the longitudinal profile of roads.

Our results showed that hydrological factors are one of the most important triggers of landslides in northern Morocco. The results of our study showed that circular landslides are the most common type of landslides in this area. Finally, our proposed solution to stabilizing landslides in this region is proper drainage of surface water from hills or roads. The objectives of this work are aimed at helping civil engineers, geotechnical engineers, designers and decision-makers to better plan and implement road and transport networks and to avoid the dangers and large-scale damage caused by landslides.

Keywords : Landslides, Debris flow, Fall of Blocks, Solifluction flow, Earth Topple, Circular slide, advanced statistical program SPSS, Debris Fall.

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Multivariate Approximation and Interpolation with Applications

International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Generalized Solutions For Fractional Heat Equation with Singular Potentials

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Abstract :
This paper, focuses on the following Cauchy problem for the heat equation

$$\begin{cases} D^c_\psi u(t,x) - \Delta u(t,x) + v(x)u(t,x) = 0, \quad t \in [0,T] \quad x \in \mathbb{R} \\ u(0,t) = u_0(x) = \delta(x) \\ v(x) = \delta(x) \end{cases} \tag{1}$$

Where u_0 and v are singular distribution in particular, with a δ-function, D^c_ψ is $\psi-$Caputo derivative of order α, $\alpha \in [n-1;n] \quad n \in \mathbb{N}$ which we will prove to be inside Colombeau algebra. In Colombeau's algebra, The existence and uniqueness of the solution are demonstrated using the Gronwall lemma. The cases of positive and negative potentials are studied and numerical simulations are given.

Keywords : Heat equation, Caputo derivative, Colombeau algebra, semigroup.

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February 20-22, 2023, Mines School of Rabat, Morocco

Estimation of the bivariate distribution function by using spline approximation

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Abstract :

The aim of this work is to present a new spline estimator for the bivariate distribution function F, and its density f on a cube, namely the theoretical properties and some numerical simulations to demonstrate the performance of the proposed method.

Keywords : Distribution function, spline method, asymptotic properties, MSE.

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Scattered Data interpolation on the 2-dimensional surface through Shepard-like technique

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Abstract :

In this paper, we present an interpolation problem of a function given on arbitrarily distributed points on the general surfaces in $\mathbb{R}^3$, by proposing an extension to Shepard method and its modified version to surfaces.

Each proposed operator is a linear combination of basis functions whose coefficients are the values of the function or its Taylor of first order expansions at the interpolation points using both functional and derivative data. Numerical tests are given to show the interpolation performance, where several numerical results show the good approximation accuracy of the proposed operator.

Keywords : Scattered data interpolation, Shepard methods, Manifolds approximation.

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Mathematical modeling of a fractal contact law in granular materials

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Abstract :

In this paper, we study a dense network in $\mathbb{R}^2$ generated by an Apollonian loading of granular elastic discs [1]. We suppose the discs are compressed together to generate tiny straight contact regions with perfect attachment on thinner sections [2]. The goal is to use Γ-convergence methods to investigate the structure's asymptotic behavior in respect to a parameter characterizing the thickness of the perfect contact lines between the materials [3, 4]. On the resultant residual fractal interface, we get an effective limit condition that represents the potential elastic energy of this balancing network under external stresses.

Keywords : Elastic material, boundary layers, Γ-convergence, fractal interface.

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February 20-22, 2023, Mines School of Rabat, Morocco

On the use of the spectral element method for the modeling of fluid-structure interaction problems

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Abstract:

This work deals with a fluid-structure interaction problem that models a flow in a channel. The geometry is illustrated in Figure 1. The simulations were done to study the case of the method with a real obstacle. That is, the obstacle is actually represented in the mesh and is therefore not fictitious. This approach will be used to solve the Navier-Stoks equation by the spectral-Fourier approach, which is a coupling of the Chybechev and Fourier polynomials.

Keywords:Fluid-structure interaction, Chybechev-Fourier, Spectral element.

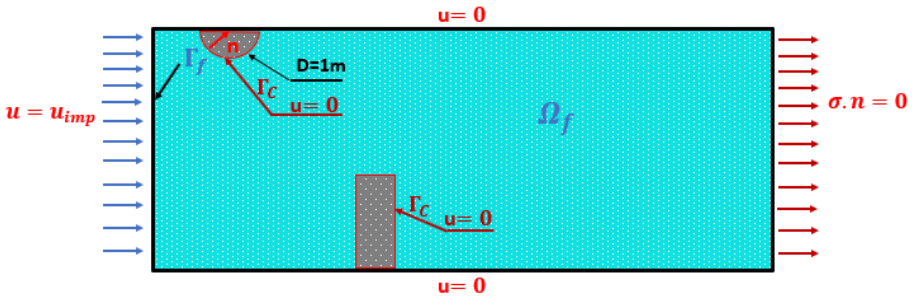

Figure 1: Model problem considered.

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New method for reversing the symetric tridiagonal quasi-Toeplitz matrices

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Abstract :

In this paper, we present a new method to reverse the special symmetrical tridiagonal Toeplitz matrix. By exploiting the special Quasi-Toeplitz structure, we give a new form to the main matrix using a simple decomposition technique. Based on this factorization and combined with the Sherman-Morrison formula, we will get the reverse of the concerned matrix. Numerical examples are given to illustrate the effectiveness of our algorithm and to compare these results with other existing direct methods.

Keywords : Quasi-Toeplitz matrices, Toeplitz matrices, Sherman-Morrison formula.

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Study of Numerical STABILITY AND BIFURCATION ANALYSIS IN A SYSTEM OF NEUTRAL DIFFERENTIAL EQUATIONS

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Abstract :

Neutral Delay Differential Equations (NDDEs) is a natural generalization of Delay Differential Equations (DDE) and, also there is a wide classes of partial Differential Equations witch can be transformed as a NDDEs (for example [1] and the references therein). In this communication, we a present studies numerical asymptotic and Hopf bifurcations occurs at the origin in certain system neutral delay differential equations by θ -Method discretization for θ in $(0, 1)$. We give necessary and sufficient conditions on the parameters, to obtain the numerical asymptotic stability, preserving the theories asymptotic stability conditions in [2] and [3]. Finally, some numerical simulations examples are carried out to support the analytic results.

Keywords : Neutral differential equation. System neutral delay differential equations. Asymptotic stability and Hopf bifurcation.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

A numerical methods for all kind Fredholm integro-differential equation using higher-order splines interpolants

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Abstract :

In this work, we propose to develop a numerical collocation method for solving all kind Fredholm integro-differential equation. Integral terms or integro-differential equations, as well as how to deal with them, are encountered in a variety of scientific and engineering fields to solve significant problems. An approximation method based on higher-order splines basis function is used to solve a such integral equa- tions. In particular, the Pocklington's integro-differential equation is also treated in this work[1]. The such equations are used to treat the signal reconstruction inside the wire antennas. Several technique based on quadrature computational methods are employed to approximate the solution of the considered problem. Moreover, the splines interpolate function is proposed to solve the Fredholm integral equation. Some numerical results are presented to indicate the convergence orders, accuracy, successfulness, and robustness of the method.

Keywords : Fredholm integral equation, -Splines approximation, Fourier Transform, Quadrature methods, Convergence orders, Pocklington's integral equation, Signal reconstruction..

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

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Modeling Beam Displacements governing by coupled Timoshenko vibrating equations based on Galerkin variational projection

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Abstract :

In this work, we solve the dynamic deflection of beam deformation model. We use the frequencydomain method to solve the considered transport problem, as a partial differential equation with nonhomogeneous boundary conditions. The method employs the Fourier transform and consists of two stages. In the first stage the equations are transformed into an elliptic problem for the frequency variables. The numerical solutions of this problem are approximated using a Galerkin projection based on the higher-order Spline finite element method. In the second stage a several quadrature procedure are proposed for the computation of the solution of the inverse Fourier transform, and then we gives a comparison report between the various numerical computations of this integral. The frequency domain method avoids the discretization of the time variable in the considered system and it accurately resolves all time scales in deflection of beam deformation regimes. A similarly frequency-domain method and Splines finite element analysis are used to solve the coupled Timoshenko transverse vibrating equations with non-homogeneous boundary conditions. Finally, several test examples are presented to verify high accuracy, effectiveness, good resolution properties for smooth and discontinuous solutions and plots of field of displacements of the beam.

Keywords : Coupled partial differential equations, Timoshenko transverse vibrating equations, frequencydomain approach, Spline finite element analysis, interpolation, Quadrature method, and numerical analysis.

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A novel quantum information based computational approximate solution of the Schrödinger partial differential equation

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Abstract :
In this work, we solve the Schrödinger partial differential equation

$$\mathrm{i}\hbar\frac{\partial\phi}{\partial t}(t,X)+\frac{\hbar^2}{2\,m}\triangle\phi(t,X)-V_0(X)\,\phi(t,X)-V_1\ast_t\phi(t,X)=f(t,X),$$

for all $(t,X)\in[0,+\infty[\times\Omega$, with the initial conditions $\phi(0,X)=\phi_0(X)$ and the following boundary conditions

$$\phi(t,\xi)+\frac{\hbar^2}{2\,m}\frac{\partial\phi}{\partial\vec{\mathrm{n}}_\xi}(t,\xi)=g(t,\xi),\quad (t,\xi)\in[0,+\infty[\times\partial\Omega,$$

We use the frequency-domain method to solve the considered problem, as a partial differential equation with non-homogeneous boundary conditions. The method employs the Fourier transform Discrestization (FTD) and consists of two stages. In the first stage the equations are transformed into an equivalent problem for the frequency variables. The numerical solutions of this problem are approximated using a Galerkin projection based on the higher-order Spline finite element method. In the second stage a several quadrature procedure are used for the calculation of the solution of the inverse Fourier transform, and then we gives a comparison report between the various numerical computations of this integral. The frequency domain method avoids the discretization of the time variable in the considered problem. Finally, several test examples are presented to verify high accuracy, effectiveness, good resolution properties for smooth and discontinuous solutions and plots of field of displacements of the waves.

Keywords : Quantum information, Schrödinger partial differential equation , frequency-domain approach, Spline finite element analysis, interpolation, Quadrature method, and numerical analysis.

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Smoothing splines Galerkin approxiamation for solving Black-Scholes PDE as a model in Asiatic option

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Abstract :
In this work, we solve the Black-Scholes equation, considered a successful model in the financing area. We use the Fourier transform method to solve the considered problem as a partial differential equation with initial and final conditions and non-homogeneous boundary conditions. The method employs the γ-spline kernel and consists of two stages. In the first stage, we use a classical characteristic function as a solution of an ordinary differential equation to find the theoretical solution of an intermediate transport equation. Using the finite difference technique with respect to the time variable, the governing advection-diffusion-reaction problem is transformed into a discrete scheme. In the second stage, the numerical solutions of the Black and Scholes problem are obtained using a Galerkin projection based on the γ-spline finite element method. Finally, several test examples are presented to verify high accuracy, effectiveness, and good resolution properties for smooth and discontinuous solutions.

Keywords : Asiatic options, Black and Scholes model, Galerkin approximation, Smoothing γ-spline, Data analysis.

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Computational and variational problems in Optimization with applications

International Conference of Numerical Analysis and Optimization Days (JANO'14)
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A Sequential Upper Parametric Approximation Method for for Generalized Fractional Programs

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Abstract :

The majorization approximation procedure consists in replacing the resolution of a nonlinear optimization problem by solving a sequence of simpler ones, whose objective and constraint functions upper estimate those of the original problem. For generalized fractional programming, i.e., constrained minimization programs whose objective functions are maximums of finite ratios of functions, we propose an adapted scheme that simultaneously upper approximates parametric functions formed by the objective and constraint functions. This notion is defined for continuously differentiable functions. For directionally convex functions, that is, functions whose directional derivatives are convex with respect to directions, we will establish that every cluster point of the generated sequence satisfies Karush-Kuhn-Tucker type conditions expressed in terms of directional derivatives. By specifying the generic algorithm to particular problems we obtain new methods. In particular, for generalized fractional programs with continuously differentiable functions that have Lipschitz gradients a new sequential quadratic method, and a new gradient type method are obtained.

Keywords : Generalized fractional programming, Nonconvex optimization, Optimality conditions, Successive majorizations methods.

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Successive Upper Approximations Methods for Generalized Fractional Programs

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Abstract :

The majorization approximation procedure consists in replacing the resolution of a nonlinear optimization problem by solving a sequence of simpler ones, whose objective and constraint functions upper estimate those of the original problem. For generalized fractional programming, i.e., constrained minimization programs whose objective functions are maximums of finite ratios of functions, we propose an adapted scheme that simultaneously upper approximates parametric functions formed by the objective and constraint functions. This notion is defined for continuously differentiable functions. For directionally convex functions, that is, functions whose directional derivatives are convex with respect to directions, we will establish that every cluster point of the generated sequence satisfies Karush-Kuhn-Tucker type conditions expressed in terms of directional derivatives. By specifying the generic algorithm to particular problems we obtain new methods. In particular, for generalized fractional programs with continuously differentiable functions that have Lipschitz gradients a new sequential quadratic method, and a new gradient type method are obtained. New methods also result from explicit applications for problems with ratios of difference of convex functions and difference of convex functions in the constraints.

Keywords : Generalized fractional programming, Nonconvex optimization, Optimality conditions, Successive majorizations methods, Difference of convex functions, Successive quadratic approximation, Gradient method.

Références

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Optimality conditions for vector fractional programming problems with ratios of convex functions

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Abstract :

In this work, necessary conditions of KKT type for (weak) Pareto optimality are derived by first reducing the vector fractional mathematical programming with ratios of convex functions, to a system of scalar parametric problems and then using convex analysis tools.

Keywords : Pareto optimality, Multiobjective programming, Fractional programming, DC programming, Convex programming, Dinkelbach algorithms.

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A combined Ant Colony Optimization with Levy flight mechanism for the Probabilistic Traveling Salesman Problem

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Abstract :

The probabilistic traveling salesman problem (PTSP) is an extension of the well-known traveling salesman problem (TSP), which has been extensively studied in the field of combinatorial optimization [1]. Such as the TSP, a set of customers and distances between these customers are given. Moreover, the presence of customers is modeled stochastically. The goal of the PTSP is to minimize the expected length of the tour where each customer requires a visit only with a given probability, at which customers who do not need a tour are just ignored without further optimization.
Since the PTSP is NP-hard, the usage of metaheuristic methods is necessary to solve the problem. We present the Ant Colony Optimization (ACO) algorithm combined with the Levy Flight mechanism (LFACO) [2], which is based on Levy distribution to balance searching space and speed global optimization. Experimental results on a large number of instances show that the proposed Levy ACO algorithm on the probabilistic traveling salesman problem obtains better results compared with the classical ACO algorithm.

Keywords : Stochastic combinatorial optimization, probabilistic traveling salesman problem, Levy's flight.

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An improved method in shape optimization problem for Stokes equation

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Abstract :

In this work, we carry out a numerical study of a shape optimization problem governed by Stokes system. More precisely, we propose an effective numerical approach based on the shape derivative formula with respect to convex domains using Minkowski deformation (Boulkhemair and Chakib in J Convex Anal 21(1) :67–87, 2014). Then, we present some numerical tests including comparison results showing that the proposed algorithm is more efficient, in term of the accuracy of the solution and central processing unit (CPU) time execution, than the one involving the classical shape derivative formula massively used in literature.

Keywords : Stokes equation, Shape optimization, Shape derivative, Minkowski deformation, Support functions, Convex domain.

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Relationships between bilevel variational inequalities and bilevel optimization problems

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Abstract :

In this paper, we establish relationships between bilevel variational inequalities (BVI) and bilevel optimization problems (BOP) in terms of convexifactors. We establish the relationship between the vector efficient points of (BOP) and the solutions of (BVI) under convexity, pseudoconvexity and quasiconvexity assumptions.

Keywords : Bilevel optimization, bilevel variational inequalities, convexificators.

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Optimum design for slip/no-slip configuration of hydrodynamic fluid film using Gradient method

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Abstract :
This study aims at optimizing the location and the size of boundary slip area on bearing sliders to improve its tribological performances taking into account cavitation. In this work, we consider a lubricated contact equivalent to a lower plane moving in the x direction with a velocity s_r and an upper rectangular stationary surface. The gap between the two surfaces is denoted by $z = h(x, y)$. On a part of the upper surface a Navier slip boundary condition is imposed. This boundary model assumes that the velocity of slip is proportional to the applied shear rate at the wall by a constant b (slip length). On the other part of the upper surface and on the lower surface, a no-slip condition is assumed.

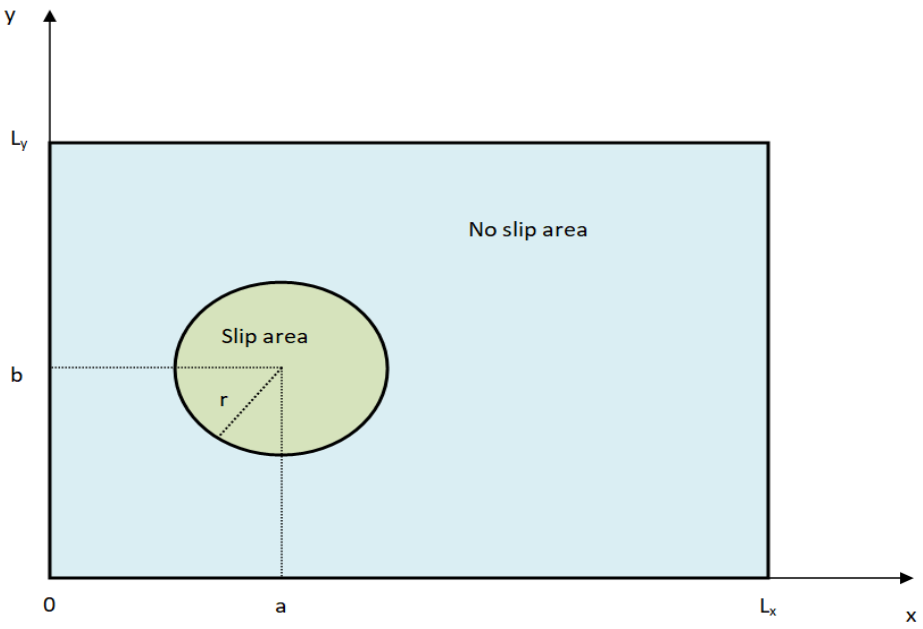

FIGURE 1 – Geometry on the stationary surface for a two-dimensional lubricated contact.

Let's $\Omega =]0, L_x[\times]0, L_y[$. Introducing the convex set $CV = \{\varphi \in H_0^1(\Omega),\ \varphi \geq 0\}$ and assuming zero pressure boundary conditions, the incompressible Swift–Stieber (or Reynolds) cavitation model with Navier slip boundary condition can be written as the following variational inequality

$$\text{(P)} \begin{cases} \text{Find } p \text{ in } H_0^1(\Omega) \text{ such that} \\ \\ \int_\Omega h^3(1+3K)\nabla p \cdot \nabla(\varphi - p)dxdy \geq 6\mu s_r \int_\Omega h(1+K)\frac{\partial}{\partial x}(\varphi - p)dxdy \quad \forall \varphi \in CV, \end{cases}$$

where the coefficient $K(x, y)$ is defined by 0 in no-slip area and $K(x, y) = \frac{\lambda\mu}{h(x,y)+\lambda\mu}$ in slip area, in which μ is the constant viscosity and $\lambda = \frac{b}{\mu}$.
The two-dimensional lubricated sliding contact optimization problem is defined as : finding the optimal location of the slip zone (i.e the optimal disposition of the slip no-slip areas) so that the load carrying capacity is maximized. The slip area is assumed to be a disk of center (a, b) and radius r. So, the optimazation problem is written as :

$$(M)\ \text{Find } c^* = (a^*, b^*, r^*) \in U_{ad} \ \text{ such as } \ J(c^*) = \min_{c\in U_{ad}} J(c) = \min_{c\in U_{ad}} -\int_\Omega p(c)dxdy,$$

where $p(c)$ is the solution of the problem (P), and

$$U_{ad} = \{c = (a, b, r) \in [0, L_x] \times [0, L_y] \times \mathbb{R}^+ :\ r \leq a, r \leq b, a + r \leq L_x, b + r \leq L_y\}.$$

The mathematical analysis of the minimization problem (M) represents some difficulties related essentially to the non differentiability of the application $c \longmapsto p(c)$. To overcome this difficulty, a sequence of penalized and regularized problems (P^ε) associated to (P) and a minimization problem (M^ε) are introduced. The existence of an optimal solution is proven and optimality conditions are derived.
To solve the optimization problem, an algorithm based on the Gradient method is presented. Numerical computations are made for two-dimensional slider bearings. The finite element method is used to compute both the hydrodynamic pressure and the solution of the state adjoint problem. Numerical results show that the proposed method (Gradient method) is faster than the parametric study and the genetic algorithm.

Keywords : Slip, Navier condition, Variational inequality, Reynolds cavitation model, Optimization, Gradient method, Genetic algorithm.

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Fast Computational Methods in Image Processing

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Abstract :

When computing dense solutions to a variety of image processing problems, variational approaches are one of the most frequently used methods. A key challenge in applying variational methods is the real-time computation of the solution. Two approaches can be employed in this aspect. The first has been classically adopted and consists to derive the 1st order optimality conditions and then discretize the resulting Euler-Lagrange equations. The second approach does the opposite by first discretizing the continuous variation optimization problem and then apply numerical optimization methods to solve a large-scale but finite problem. Our aim is to show how fast computation methods can be applied using the two approaches by considering two fundamental problems : image denoising [1] and optical flow [2]. In the first problem, one aims at recovering an original image from a noisy version. The second treats the estimation of the motion of brightness patterns in a video sequence. The two problems have sparked major research efforts due to their numerous applications such as visual tracking, video coding, robot navigation, radar imaging and medical image registration. I will focus in this talk on the computational aspects of these two problems [3–10], explain known difficulties and discuss possible solutions.

Keywords : Keyword one, keyword two, keyword three.

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Bayesian optimization for RFID network planning

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Abstract :

Radio-frequency identification (RFID) is a technology used to automatically identify and track objects. The RFID system consists of an electronic tag attached to an object, reader and middleware. Due to the rapid development of this technology, the deployment of RFID readers become a challenging problem in this field and which is known by the name RFID network planning problem (RNP). This problem consists in finding simultaneously the optimal number of readers deployed in the network and their coordinates, such that all the tags of the whole space are covered, and minimizing interferences. Moreover, complexity appears when we take into consideration uncertainty on uncontrollable variables and parameters in the system. Therefore, we propose a Bayesian optimization approach to solve the RFID network planning problem under uncertainty. The simulation results show the performance of our proposed approach and obtain robust optimal solutions that are insensitive to uncertainties.

Keywords : Radio-frequency identification, Uncertainty, Bayesian optimization.

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Proximal Point Algorithm for Equilibrium Problems

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Abstract :

We reformulate equilibrium problems in a less constrained equivalent form. Then we associate to the latter a less constrained optimization problem for which we propose a proximal point algorithm that can solve the equilibrium problem. Convergence is established under Lipschitz type conditions on the equilibrium function.

Keywords : Equilibrium Problems, Proximal Point Algorithm.

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Scheduling trucks in a multi-door Cross-docking system with storage zones

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Abstract :

Nowadays, new principles of logistics and intermodality have emerged, in order to adapt to the evolution of international trade. Cross-docking is one of the most popular methods that have attracted several researcher's attention in the past few years, which can eliminate the intermediates step of product storage. Optimizing the planing of cross-docking operations has been the subject of several researches. The number of articles on this subject has grown very rapidly, but largely detached from industry practice. Cross-docking is a very useful logistics strategy that distributes products directly from inbound to shipping docks, reducing transportation costs and storage time. This paper focuses onscheduling trucks problems in a multi-door cross-docking system considering several storage zones, which is very common in many industries, but is less concerned by existing researches. The study presents a mathematical model for scheduling, storage, assignment and sequencing of trucks at receiving and shipping docks. The objective of the model is to minimize the overall tardiness for inbound and outbound trucks.

Keywords : Cross-Dock, Operation Research, assignment, scheduling, storage.

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Stochastic Vehicle Routing Problem

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Abstract :
The vehicle routing problem (VRP) with deterministic data has been widely studied and applied in many real-world situations (logistics, business or urban transportation). However, usually not all the problem data is available in advance. This has led to an increased interest in stochastic VRP. As regards the type of stochastic components, the SVRP can be divided into the following classes. The most common one is the VRP with stochastic demand (VRPSD) in which the exact quantities demanded by each customer are only known upon the vehicle's arrival at the customer location (uncertain). The second class is the VRP with stochastic customers (VRPSC), in which each customer has a deterministic demand and a probability p of being present. However, in practical situations, one may not know the travel and service times in advance. For example, weather or traffic conditions may result in the uncertainty of travel times between two vertices. Furthermore, service times may be affected by distribution technology, the driver's skills, the parking conditions… In this case, we're talking about the VRP with stochastic travel and/or service times (VRPSTS).
Furthermore, a SVRP can't be modeled as a deterministic optimization problem, in which all problem parameters are assumed to be known exactly. However the SVRP can be cast within the framework of stochastic programming. In general, there are three common ways of modeling stochastic problems : as a chance constrained program (CCP) or as a stochastic program with recourse (SPR) or as multi-stage dynamic reoptimization. In the case of CCP, the SVRP is solved ensuring that the probability of route failure is below a certain level and the cost of failures is typically ignored. On the other hand, in SPR, one allows route failures, but the decision-maker must define a recourse policy, describing what actions to take in order to repair the solution after a failure. The expected transportation cost (travel cost + recourse policies cost) is optimized. The most common recourse policies is detour to depot (DTD), in which the vehicle returns to the depot to restock when capacity is attained or exceeded. and then resumes the service from the point of failure. In other SVRP formulations the recourse policy does not involve routing decisions, but a penalty for late/early arrivals or the extra time cost of the driver can be part of the expected cost when time windows and/or stochastic service time are taken into consideration. Finally, we mention that most of the problems found in the SVRP literature can be cast as two-stage stochastic programming problems. In the first stage, the priori set of vehicle routes is determined. After random are realized, the expected correction costs of route failure are then considered in the second stage.
In this study, we will examine in detail the largest types of SVRP studied in the literature, as well as the different approaches of stochastic programming used to model them.

Keywords : stochastic vehicle routing problem, stochastic programming.

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Birth Allocation Problem in A Container Terminal : Real Case Study

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Abstract :

The shipping operations are considered one of the most important port operations. They are having great impacts both on vessels' service time and service quality. The variation of terminal layouts implies a large variety of approaches for solving port logistics problems. This paper tackles an optimization approach for the fundamental problem of berth allocation (BAP) at a heavily solicited container terminal. The assignment problem of berths to incoming ships is complicated by the fact that various vessels have varied service level needs. Terminal operators are looking for an effective decision support solution to help them with the assignment challenge while keeping service objectives in mind. As a result, this study proposes a linear programming model that is solved in Python using the PuLP Package to calculate the mooring time and initial berthing location along a single continuous quay of the X-Port container terminal, a private port operator in Casablanca. A time-space diagram was used to display the results of the Python program. This approach will enhance the port's management and boost the port's operational quality of service by making more effective allocation decisions inside a cargo terminal.

Keywords : Birth Allocation, logistic, mathematical model, optimization.

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Mathematical models in the life sciences, medicine and biology

International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Fractional-order SIR mathematical model of COVID-19 pandemic

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Abstract :

In this paper our aim is to formulate and study an SIR fractional-order differential mathematical model of COVID-19 disease dynamics. Each compartment of our model involves a long memory effect that is modeled by a Caputo fractional derivative. First, we start with the investigation of some basic analytical results. Next, we establish the well-posedness of the mathematical model in terms of proving the existence, positivity and boundedness of solutions. We present the different problem steady states depending on some reproduction numbers. After that, the paper moves to the stage of proving the global stability of the steady states. To evaluate the theoretical study of the global stability, we apply a numerical method based on the fundamental theorem of fractional calculus as well as a three-step Lagrange polynomial interpolation method. It is observed that the numerical simulations and the founding theoretical results are coherent.

Keywords : COVID-19, SIR, Stability, Fractional-order model, Numerical simulation.

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The dynamical behavior of a fractional-order prey-predator model in the presence of the harvesting, competition and toxicity

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Abstract :

In this paper, we study the dynamic of a fractional-order prey-predator model with Holling type I and Holling type II functional responses in an aquatic environment of two competing species. We incorporate the effect of harvesting and toxic substances by external agents into system. For the proposed model, we research the existence, uniqueness, non-negativity and boundedness of the equilibria. We discuss the local stability of these equilibria by using Matiginon's conditions, while the global stability is investigated by formulating an appropriate Lyapunov function. Finally, numerical simulations are provided to validate our theretical results and to investigate the influences of each parameter on the dynamic behavior of the model.

Keywords : prey-predator model, Toxicity, Equilibria, Stability, fractional-order, fractional-order prey-predator model, functional response.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Dynamics of a fishery on two fishing zones with nonlinear harvesting : control and price variation

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Abstract :

We present a dynamical model of a spatial fishery describing the time evolution of the fish stock, the fishing effort with a variable price. The market price is fixed by the gap between the supply and the demand. The nonlinear harvesting function is assumed depending upon stock size as well as fishing effort. Assuming two time scales, we use "aggregation of variables methods" in order to derive a reduced model governing fish density and fishing effort at a slow time scale. The aggregated model of fishing effort distribution were explored. The reduced model is based on a set of 2 ordinary differential equations describing the time evolution of the fish biomass and the fishing effort. The mathematical analysis of the two models is shown. Under some conditions and in a special case, we obtain a stable equilibrium and an over-exploitation leading to fish extinction. Finally we introduce a control parameter to maintain the system at a sustainable equilibrium .

Keywords : stability, aggregation of variables, numerical simulations, varying price, stock-effort dynamics.

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Asymptotic behaviour of a delayed system describing immune response to virus infection spreading

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Abstract :
In this work we study stability analysis of the virus spreading model with delayed immune response described by a couple of two reaction-diffusion partial differential equations with two delays. Using monotone dynamical systems theory, we give sufficient conditions of asymptotic stability of given equilibriums. The obtained results are applied to a class of special forms of the immune system efficiency function. Numerical simulations came to support the analytical results.

Keywords :delay differential equations ; monotone dynamical systems ; reaction-diffusion equations ; stability, immune response modelling.

We are particularly interested in the model presented in 2017 by G. Bocharov et al. [2] modelling immune response to viral infection dynamic and described by the following system of delayed partial differentiel equations :

$$\begin{cases} \frac{\partial v}{\partial t} = D_1.\frac{\partial^2 v}{\partial x^2} + k.v.\left(1-v\right) - \sigma.v.c \\ \frac{\partial c}{\partial t} = D_2.\frac{\partial^2 c}{\partial x^2} + \left(c_0 + \Phi(v_\tau).c\right).(1-c) - \Psi(v_\nu).c \end{cases} \tag{1}$$

We denote v and c the virus and immune cells concentrations respectively.
The variable x describes the spatial position of the immune cell and the virus in the tissue and t the temporal variable.
$v_\nu\left(x,t\right) = v\left(x,t-\nu\right)$ and $v_\tau\left(x,t\right) = v\left(x,t-\tau\right)$, for all $x,t \in \left(\mathbb{R}^+\right)^2$.
The terms $D_1.\frac{\partial^2 v}{\partial x^2}$ and $D_2.\frac{\partial^2 C}{\partial x^2}$ represent the spatial diffusion of viruses and immune cells.
D_1 and D_2 are the viruses and immune cells diffusion coefficients respectively. The positive number k is the virus replication rate assumed to be constant.
Under suitable assumptions, the system is reduced to the following delay differential equation

$$\frac{dv}{dt}\left(t\right) = k.v\left(t\right).\left(1-v\left(t\right)\right) - \sigma.v\left(t\right).f\left(v\left(t-\tau\right), v\left(t-\nu\right)\right) \tag{2}$$

Where f specifies the efficiency of immune response-mediated virus elimination.
The, stability conditions of the infection-free equilibrium and the pandemic equilibriums are investigated in term of the immune effeciency function f and the delays τ and ν.

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REMEDIABILITY PROBLEM IN LINEAR FRACTIONAL ORDER TIME-INVARIANT DISTURBED SYSTEMS

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Abstract :

In this work, we consider a class of finite dimension time invariant fractional order control systems described by a linear state equation as follows :

$$\begin{cases} {}_0^cD_t^\alpha z(t) = Az(t) + Bu(t) + f(t)\ ;\ 0 < t < T\ ;\ 0 < \alpha \leq 1 \\ z(0) = z_0 \end{cases} \tag{1}$$

where $A \in M_n(\mathbb{R})$, $B \in M_{n,p}(\mathbb{R})$, $u \in L^2(0,T;\mathbb{R}^p)$, $f \in L^2(0,T;\mathbb{R}^n)$ and ${}_0^cD_t^\alpha$ denotes the Caputo fractional order derivative, where

$${}_0^cD_t^\alpha z(t) = \begin{cases} \frac{1}{\Gamma(1-\alpha)} \int_0^t (t-s)^{-\alpha} \dot{z}(s) ds, & 0 < \alpha \leq 1 \\ \dot{z}(t) & \alpha = 1 \end{cases}$$

The system (1) is augmented by the output equation :

$$y(t) = Cz(t)\ ;\ \ 0 < t < T \tag{2}$$

with $C \in M_{q,n}(\mathbb{R})$.

We study with respect to the observation, the possibility of finite time compensation of known or unknown disturbances. Under convenient hypothesis, we show how to find the optimal control ensuring the compensation of a disturbance, by bringing back the corresponding observation to the normal one. This concept is also examined as minimization problem with a decent cost function. A comparison between the two approaches is given and the relation with the notions of controllability is studied. Various situations are also examined.

Keywords : Fractional linear disturbed systems, Dynamical systems, remediability, observation, optimal control, disturbance..

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Control to COVID-19 Spread with Vaccination -a viability aproach-

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Abstract :

We examined a controlled SIR model that describes the dynamics of the COVID-19 pandemic. Most of the formal studies and analyzes on this subject employ optimal control approaches. Here we used another framework based on viability theory [1]. The main goal of this approach is not to maximize the objective function, but to focus on the role of constraints and characterize the allowed paths and decisions. Vaccine served as control. We have defined some restrictions, including guaranteed levels of vaccination. A central finding of the analysis is that the combined tactics of sensitization and vaccination can significantly reduce the number of infected people, despite limited vaccine resources.

Keywords : Control Theory , Viability Theory , Epidemiology , SIR model , COVID 19 , vaccination control.

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Spatio-temporal epidemic model with non linear Robin boundary condition

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Abstract :

The present paper handles spatio-temporal SIR model with nonlinear Robin boundary condition and lockdown. The presented model stipulate the lockdown policy when the number of infected individuals in given region exceeds given threshold. Moreover, we prove the well posedness of this model as well as the asymptotic behaviour of the solutions. Numerical experiments are effectuated to emphasize the theoretical results.

Keywords : SIR Model, Lockdown, Reaction diffusion system.

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A Mathematical Model For Trichoderma Fungi Kinetics

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Abstract :

Trichoderma are fungi that grow in almost all soils and have a key role in the production of a wide range of diverse and varied enzymes, such as cellulase, which are involved in the repression of plant diseases. Inspired by the model of Lijuan Ma et al [1] and the Luedeking-Piret model [2], we develop an unstructured mathematical model describing the kinetics of growth and enzyme production of the filamentous fungus Trichoderma in the rhizosphere by integrating the hydrolysis step (substrate preparation step that converts organic matter into a new liquefied substrate) of organic matter and taking into account the formation of a product (cellulase). This model is a system of Ordinary Differential Equations (ODE) and is more complete than the models of [1] and [2]. By introducing the diffusion of each component, this model can be spatialized to obtain a system of Partial Differential Equations (PDE).

Moreover, using the theorem of stable and unstable varieties, and Barbalat's lemma, we show that our system of ODE evolves towards a global attractor consisting of non-hyperbolic infinite equilibria according to the initial conditions. Numerical simulations with data from the literature confirm the theoretical study and validate the model. We expect that the system of PDE has a similar asymptotic behaviour as the system ODE.

Keywords : Modeling, Ordinary Differential Equations, Partial Differential Equations, Kinetic models, Trichoderma, Enzyme production, Cellulase, Non-hyperbolic equilibrium, Hydrolysis, Global attractor.

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Mathematical model of anaerobic digestion with hydrolytic process by means of leachate recirculation in landfills

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Abstract :

Controlled landfilling, also known as Technical Landfill Center (TLC), has become one of the major solid waste treatment or disposal systems in developing countries. A TLC is a highly dynamic environment [3]. During the waste degradation processes, the water contained in the waste and the percolation water [5, 6, 7] (mainly from precipitation) mix with organic and mineral matter to form a juice, called leachate. This leachate is contaminated and can, if not controlled, pollute the soil and groundwater. Mathematical modeling is of great interest for decision making in the field of waste treatment and recovery. It allows to analyze the underlying complex systems and to predict the behavior of the different components. Many new technologies have been developed to optimize energy yields [4, 8], in particular the anaerobic digestion process. The mathematical model proposed in this work is inspired by [1] where the authors introduce a landfill model with biomass recirculation in which the organic fraction is decomposed during an anaerobic digestion process . We present a model that describes the same process but takes into account an additional phenomenon which is the solubilization of the insoluble or slowly biodegradable fraction [2] through a recirculation of the leachate. We also consider that a part of the dead bacteria is a new soluble substrate while the other part is transformed into carbon dioxide [9]. The dynamic system obtained allowed us to predict the evolution of the quantities of methane and carbon dioxide over time. The system admits an infinite number of non-hyperbolic equilibria but a qualitative analysis allowed us to characterize its global attractor. We also examine the case of an inhibition in the growth function wich impacts the connectivity of the attractor. The simulations carried out confirm these theoretical results, and also make it possible to highlight the influence of the leachate recirculation on the performance of the system.

Keywords : leachate recirculation, mathematical modeling, biogas, non hyperbolic equilibria.

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2 - Numerical methods applied to a class of SEIR epidemic models described by the Caputo derivative

Numerical methods applied to a fractional SEIQHR epidemic model

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Abstract :

In this article, we consider a fractional $SEIQHR$ model which aims to predict the outbreak of infectious diseases in general. In particular, we study the spread of COVID 19. Furthermore, the errors generated during the FDE approximation using our proposed method are analyzed. By comparing the approximate and exact solutions, it can be seen that the new numerical method is very efficient and quickly converges to the exact solution. Finally, we will apply this proposed method on the fractional $SEIQHR$ model.

Keywords : Numerical Method , Fractional differential equations, Caputo fractional derivative.

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February 20-22, 2023, Mines School of Rabat, Morocco

Near-synchronization of predator-prey complex networks

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Abstract :

In this talk, we propose a complex network to model a heterogeneous geographical habitat of species which is perturbed by an anthropic extension, being fragmented in several patches, where the fragmentation is likely to alter the equilibrium of the ecological system. The complex network is constructed by coupling several patches on which interacting wild species are living and where, for each patch, the ecological inter-species dynamics are modeled by a Lotka-Volterra predator-prey model with Holling type II functional response. An important feature of the complex network is that each patch can admit its own dynamic and migrations of biological individuals in space, between each component of the fragmented environment, are taken into account by coupling the patches of the network. We prove sufficient conditions for the near-synchronization of the complex network, which guarantees that the complex network remains in a neighborhood of a synchronization state, provided the coupling strength is strong enough, even if the local behaviors are non-identical. This result allows us to modify the local dynamic of extinction of the species, by increasing the couplings with patches on which persistence, with or without oscillations, is ensured.

This is a joint work with Guillaume Cantin, see [1].

Keywords : Complex network, Non-identical systems, near-synchronization.

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Optimal Control Strategy in Blood Flow Modelling

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Abstract :

One of the main challenges of blood flow modeling in large arteries consists of properly surrogating the remaining of the vascular system, upstream and downstream of the vascular district under study. We will introduce this topic, provide a brief overview of several approaches may be addressed, and present a potentially successful approach consists of controlling boundary conditions while minimizing fitting type functionals ([1, 2, 3]). We will present recent mathematical and numerical results neglecting, at a first step, the interaction of blood with the artery wall. The chosen type of boundary conditions, for our blood model, although not being the most commonly used in numerical simulations, is nevertheless suitable to be considered with the more general FSI model ([4]).

This is a joint work with I. Marin-Gayte and T. Guerra.

Keywords : Blood flow, optimal control, numerical simulations.

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Mathematics applied to medicine, ecology and economics

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Technical and Economic optimization parameters in PV Battery Systems

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Abstract :

The world is facing major energy challenges that must be addressed urgently. These challenges have consequences on the environment, which explains the increasing use of renewable energies. Morocco stands as a good example in this sense by aiming at the use and integration of renewable energies in the response to energy needs with a rate of about 52 percent even before 2030. In our study, a focus is attributed to photovoltaic systems with storage dedicated to the residential and housing sector. The reason is justified by the ease of integration of this type of energy for simple users and consumers, the presence of solar rays especially in most regions of Morocco is also an encouraging factor.We will consider additionally the presence of the storage and the grid, the first one that contributes mainly in the technical optimization and the second on the economic optimization.

Keywords : PV Systems,Solar storage, Optimisation.

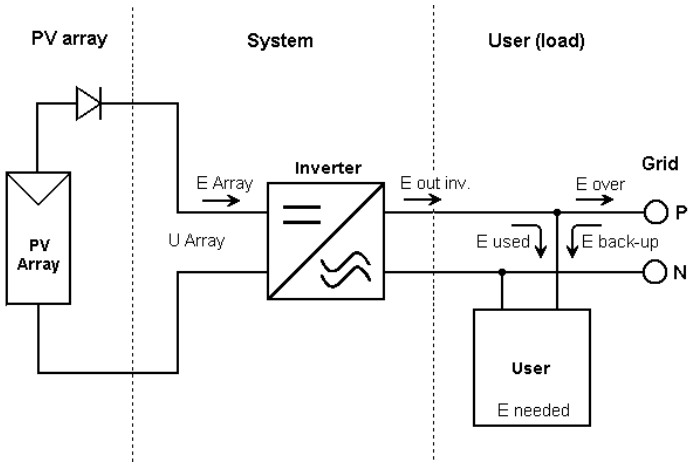

Figure 1 :Simplified diagram of a Grid connected PV system

Therefore, a grid-connected photovoltaic system has been studied with a photovoltaic field of about 5.3 Kwp and a storage of about 1400 Ah. The PV system and the battery storage are operated as follows during the year.

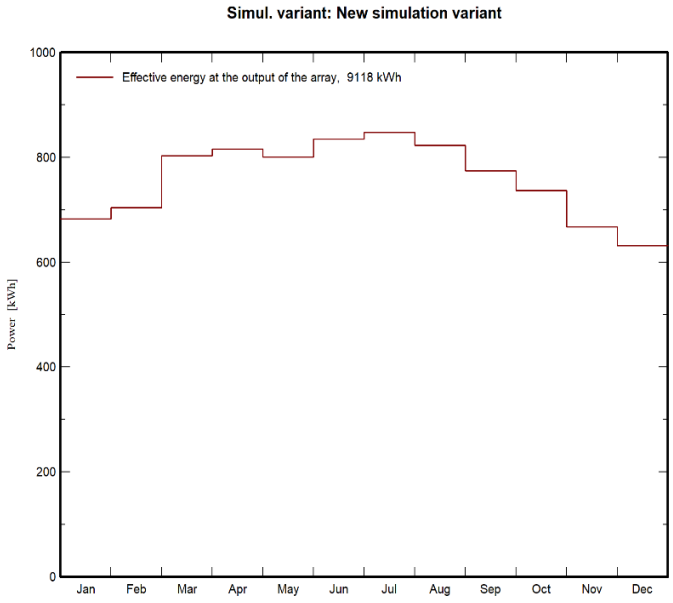

Figure 2 :Effective energy at the output of the array

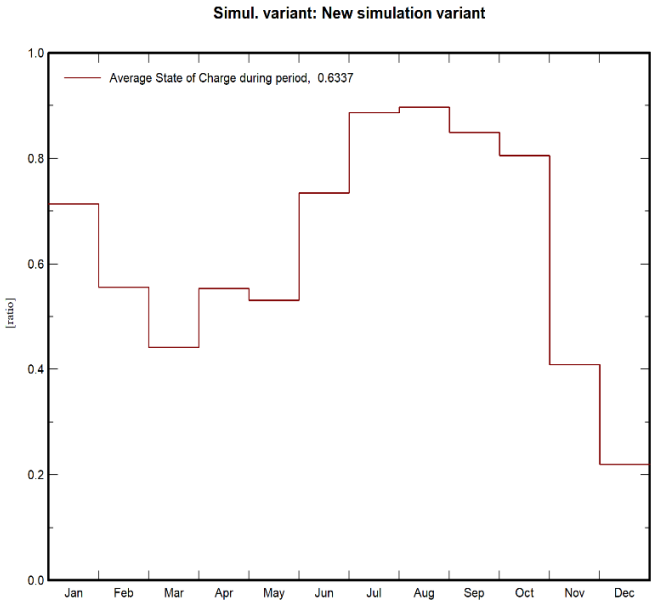

Figure 3 :Average state of charge

The aim of our study is to optimize certain priority parameters :

Maximum independence of the system : The first parameter to be optimized is to ensure a fairly independent system in the response to energy needs. Taking into account the presence of the network and also the presence of the battery, the goal is to use one and the other based on an optimal method minimizing the energy loss.
Interaction with external factors : Several factors contribute in the degradation of the solar plant and affect the performance of the system directly or through time. Two parameters are analyzed in our case, the temperature and the energy requirement that can be considered as variables.
Economic gain : Any energy savings generated through the optimization of the two previous parameters will contribute to the generation of a cost gain which is estimated.
The present work aims to demonstrate the impact of simple parameters and their appropriate choice in the optimization of the whole system and in the generation of energy and cost savings.

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Mathematical analysis of a spatio-temporal dynamics of a delayed IS-LM model in economics

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Abstract :

The aim of this work is to propose and analyze a spatio-temporal dynamics a delayed IS-LM model with general investment and interest rate function. Firstly, we show that our model is economically and mathematically well posed. Secondly, the stability analysis and the existence of Hopf bifurcation are investigated. Finally, we illustrate our analytical results by numerical simulation.

Keywords : Economics, IS-LM model, macroeconomic aggregates, asymptotic stability, Hopf bifurcation.

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A mathematical model of economic cycle using new fractional order derivative

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Abstract :

This work develops a new mathematical model for business cycle with general investment and variable depreciation rate by using the recently generalized Hattaf fractional (GHF) derivative. First, we study the existence of unique solution and economic equilibrium of our model. Next, we establish the stability of economic equilibrium and the existence of Hopf bifurcation.

Keywords : Economic cycle, depreciation rate, fractional derivative, Hopf bifurcation.

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A generalized age-structured HBV infection with two treatments : pegylated interferon and lamivudine drugs

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Abstract :

In this work, we develop a generalized age-structured hepatitis B virus model with DNA-containing capsids. The developed model incorporates two treatments that are pegylated interferon and lamivudine drugs. The well posedness and the existence of equilibria are fully established. Moreover, the qualitative properties including uniform persistence, local stability of equilibria as well as the global behavior of the model are rigorously investigated.

Keywords : Treatment, HBV DNA-containing capsids, age-structure, uniform persistence, stability.

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Modeling of atmospheric dispersion by the Eulerian models

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Abstract :

A cloud of pollutants released into the atmosphere is subject to various processes among them we have the two main processes: advection and diffusion, the combination of these two processes produces a phenomenon called turbulent dispersion. An atmospheric dispersion model is a tool that can be used to simulate the atmospheric phenomena involved in the turbulent pollutant dispersion processes. There are multiple of models: Gaussian, Eulerian (SGDH, GGDH, AFM, DFM …), and Lagrangian models. In this work we are interested to the Eulerian models which are based on the resolution of the advection-diffusion equation on a scalar field corresponding to the concentration of pollutant. In this work the objective is to present the different approaches of Eulerian models and the difference between them. In addition, we will present an application case; this is the case of the continuous release of a pollutant using the Code_Saturne.

Keywords: the atmosphere atmospheric dispersion, Eulerian models, Code_Saturne.

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Mathematical modeling of cancer under combined therapy using oncolytic viruses and inhibitors

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Abstract :

In this work, we present a mathematical model to treat cancer with two different therapies, oncolytic viruses and MEK inhibitors. We show that our model is biologically and mathematically well-posed through the existence, the non-negativity and the boundedness of solutions. Furthermore, we study the equilibrium points as well as the stability of these equilibria. Finally, we use numerical simulations to illustrate the effect of this combined therapy on tumor cells.

Keywords : MEK inhibitors, oncolytic virus, mathematical modeling.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Global properties of a generalized Ebola virus disease model with death transmission and vaccination

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Abstract :

In this work, we propose three strategies to control Ebola virus disease (EVD). We construct a mathematical model that takes into account the treatment of infectious and the vaccination of susceptibles. We consider two modes of transmission, one from an infectious individual who is still alive and the other from dead to the living during funerals. Both modes of transmission are modeled by two general incidence functions that cover the classical incidences existing in the literature. The dynamical behavior of the proposed model is investigated. The optimal strategies are determined by Pontryagin's minimum principle. A numerical method is proposed to solve the optimality system.

Keywords : Ebola, death transmission, vaccination, stability, optimal control.

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Global dynamics of a diffusive SARS-CoV-2 model with antiviral treatment and fractional Laplacian operator

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Abstract :

In this work, we propose and investigate the global dynamics of a SARS-CoV-2 infection model with diffusion and antiviral treatment. The proposed model takes into account the two modes of transmission (virus-to-cell and cell-to-cell), the lytic and nonlytic immune responses. The diffusion into the model is formulated by the regional fractional Laplacian operator. Furthermore, the global asymptotic stability of three equilibria is rigorously established.

Keywords : Antiviral treatment, SARS-CoV-2 , fractional Laplacian operator, stability.

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Modeling the dynamics of HIV-1 infection under highly active anti-retroviral therapy

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Abstract :

Highly active antiretroviral therapy (HAART) is a treatment that uses a combination of three or more drugs to treat human immunodeficiency virus type 1 (HIV-1). On the other hand, immunological memory is an important characteristic of humoral immunity. In this work, we propose a mathematical model that takes into account immunological memory to describe the dynamics of HIV-1 infection in the presence of such therapy. We first show that the developed model is mathematically and biologically well posed. Furthermore, we discuss the existence of equilibrium points and their stability. Both effects of HAART and memory on the dynamical behavior of our model are rigourously investigated.

Keywords : Therapy, HIV-1 infection, humoral immunity, generalized Hattaf fractional derivative, global stability.

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Dynamics of an ecological prey-predator model based on the generalized Hattaf fractional derivative

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Abstract :

In this work, we propose a fractional prey-predator model with generalized Hattaf fractional (GHF) derivative that includes many special cases in the literature. We prove that our proposed model is ecologically and mathematically well-posed. Furthermore, we show that the proposed model has three equilibrium points. Moreover, we analyze the stability of these equilibria. Finally, we present some numerical simulations to illustrate the analytical results.

Keywords : Ecology, mathematical modeling, prey-predator, fractional derivative, numerical simulations.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Aide à la décision multicritères basée sur l'intelligence artificielle appliquée au problème d'infertilité

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Abstract :

Au cours des deux dernières décennies, la recherche dans le domaine de l'aide à la décision multicritère pour le traitement des maladies a conduit au développement d'un grand nombre de méthodes. Parmi les approches développées, il y a celles utilisant l'intelligence artificielle. L'objectif principal de notre travail est de prédire le nombre d'embryons à implanter, par les experts médicaux, dans l'utérus de la femme infertile en utilisant la technique de reproduction assistée (ART) dans le but de produire une grossesse réussie. Un ensemble de critères est utilisé, les données biologiques de la femme et de l'homme de chaque couple sont collectées à partir de la littérature. La construction de notre modèle a été faite sur la base des travaux de J.R. Figueira, où il a appliqué la méthode multicritère d'aide à la décision ELECTRE TRI-C afin d'assigner chaque couple à une catégorie de transfert d'embryons, tandis que dans le présent travail, nous avons implémenté un modèle de réseau de neurones artificiel pour la prévision du nombre d'embryons qui seront transplantés dans l'utérus de la femme. En utilisant le langage de programmation Python, nous obtenons des résultats satisfaisants, dont la précision égale à plus que 90%.

Keywords : Réseaux de neurones artificiels, infertilité, aide à la décision.

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A Low-Cost Estimation Method for Conditional Probabilities in Resource-Constrained Environments

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Abstract :

The use of conditional probabilities has become increasingly popular in a variety of fields such as medicine, finance, and image processing. This is due to the availability of large datasets, which allow the extraction of the full potential of estimation algorithms. However, these large datasets also come with a significant need for computational capacity and a prolonged compilation time. In this article, we suggest a low-cost estimation method based on the stochastic approximation, first proposed in Robbins Monro [6] and developed by Professor Bennar [3], as an alternative to the classical estimation method outlined in [5] and developed in [4, 1, 2]. Our method utilizes a stochastic approximation algorithm to estimate conditional probabilities while reducing the computational burden and compilation time compared to traditional methods. This makes it particularly useful in situations where resources are constrained, such as experimental environments or cases where the number of observations is limited. To demonstrate the effectiveness of our method, we first establish its theoretical foundation by providing a theorem and analytical evidence of its convergence to the desired probability through mathematical analysis. We then conduct simulations on real-life data of diabetic patients, showing the ability of our method to predict the probability of a patient having diabetes. Our proposed method offers a promising solution for fields that rely on the calculation of conditional probabilities, regardless of the availability of large datasets or the number of observations. It allows for accurate estimates with minimal resource usage, making it a practical and efficient solution for various applications.

Keywords : Conditional probability, Stochastic approximation, Low-cost estimation, Diabetes.

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Improved Decision Aid and predictive models using ML and Optimisation techniques

International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

A comparative study of game theory techniques for Blind Deconvolution

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Abstract :

The main purpose of this paper is to lay emphasis on the potential of the use of Game-Theoretic framework to deal with concurrent Blind image Deconvolution.

We consider a static game of two players. The first one controls the image intensity while the other one controls the blur kernel. In this game each player's goal is to minimize his own functional.

Solving the game amounts to finding a pair of strategies : the best possible estimation of the original image and PSF (point spread function) or blur kernel, that minimizes the two functionals.

We determine the optimal image deblurring using two particular game theoretic approaches, recently introduced : the Nash method [1] and the Kalai-Smorodinsky method [2].

We evaluate the performance of the two techniques through numerical experiments and using some objective quality metrics. We found that the KS method compares favorably with the Nash one in most experiments in terms of the image quality indicators.

We also observed that the Nash equilibrium rarely make it on the Pareto front and the Kalai-Smorodinsky and Nash solutions never coincides in all experiments.

Keywords : Multi-objective Optimization ; Game theory ; Nash Game ; Kalai Smorodinsky solution ; Concurrent Optimization ; Blind Deconvolution.

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February 20-22, 2023, Mines School of Rabat, Morocco

Searching for similar images using Nash Game and Machine learning

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Abstract :

The objective of our subject is to study, define and set up a system of indexing and retrieval of images by content based on global descriptors, multiple groupings, and on multi-criteria optimization problems using game theory. Note that each image is symbolized by three vectors which represent the low-level visual characteristics, which are color, using the 'compressed' color histograms and the shape represented by the compression algorithm entitled : Segmentation-based Fractal Texture analysis (SFTA) and finally the Gist descriptor based on Zernike moment. We propose a new optimization variable sharing approach that numerically determines the strategies between three players. The first player minimizes his cost function by acting on the color, the second by acting on the texture, and the third by acting on the shape. Finally, we determine the similar images as a Nash equilibrium.

Keywords : Optimization, K-means, Image retrieval, color, Gist and Zernike.

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Deblurring image by the total fractional order variation using the Nash game

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Abstract :

In this work, we propose a fraction-order model to overcome the weakness of the total variation for image deblurring. The total-fractional order variation yields from the fractional derivative, which tends to reduce the staircase and provides a much more effective reconstructed image. Forced by our successful results of nonlocal blind deconvolution image-based total variation to reduce staircase, we analyze and test a novel blind deblurring model-based α-order fractional using the Nash game. And we subsequently compare this approach with our last work that uses local and nonlocal blind deconvolution total variation Nash game using the same type of players (each player has his strategy to find an optimal solution). Moreover, we compare it with other order fraction methods with different parameters of α. Our numerical results prove that our method achieves better effectiveness and quality than existing reconstruction methods.

Keywords : Fraction order, Total variation, Nash game.

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Similar Images Retrieval using Nash Equilibrium and Machine Learning

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Abstract:

The vast number of images available on the internet makes it difficult to find similar images. In our work, we proposed a Content-Based Image Retrieval (CBIR) system designed as a Nash game and based on multiple image representations, where each image is represented by three vectors: color, texture, and shape, and reinforced by two machine learning algorithms: K-means and K-nearest neighbors (KNN) algorithms. As a result, we have a multicriteria optimization problem in which the optimization variables are split into three players. The first player acts according to his objective function using the first strategy (color descriptor). A second player uses a second strategy (Zernike descriptor) and a third player uses a third strategy (SFTA descriptor). We propose to define the classes of membership of the query image as a Nash equilibrium.

Keywords: Image retrieval, Nash equilibrium, multicriteria optimization, Machine Learning, Color, Zernike and SFTA descriptors

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A Fuzzy Holdout Method for models' selection in Cancer Prediction

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Abstract:

Cancer is leading cause of death worldwide, with millions of new cases diagnosed each year. Many research papers have discussed the potential benefits of Machine Learning (ML) in cancer prediction, including improved early detection and personalized treatment options. The literature also highlights the challenges facing the field, such as the need for large and diverse datasets as well as interpretable models with high performance.

The aim of this paper is to suggest a new approach in order to select and assess the generalization performance of ML models in cancer prediction, especially for size-limited datasets. The estimates of the generalization performance are generally sensitive to several factors during the training testing process. These factors include and are not limited to the effect of both the training-testing ratio as well as the random selection of the training and testing datasets.

Keywords: Cancer prediction, Machine Learning, Holdout method, MCDM, Hesitant Fuzzy Logic

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An Interactive Intuitionistic Fuzzy approach for Socially Responsible Portfolios Selection : A Multi-Objective Optimization Approach

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Abstract :

This paper proposes a decision aid tool for selecting portfolios for socially responsible investment (SRI) stocks according to the preferences of the SRI investor. The selection of such portfolios is based, in addition to traditional financial variables, on environmental, social, and governance (ESG) criteria. Therefore, we try to enable investors to custom-tailor their asset allocations and incorporate all personal preferences regarding return, risk and social responsibility, also simultaneous definition of the degrees of acceptance and rejection. In particular, we consider socially responsible portfolio selection as an optimization problem with multiple objectives before applying interactive intuitionistic fuzzy method to solve the portfolio optimization. In this work, a sample of the top 10 Stocks for environmental, social, and governance (ESG) values was selected to test the robustness of our approach.

Keywords : Multi-objective optimization, socially responsible investment, Fuzzy Programming Problem, Portfolio optimization, Fuzzy set.

Auto-adaptive numerical methods and applications

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Constant free a posteriori error estimates in finite element methods for general Friedrichs' systems

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Abstract :

In this paper we develop and analyse a new a posteriori error estimator for general Friedrichs' systems valid for most classical finite element approximations. This error estimator is based on comparison between an appropriate norm of the exact error, and the L^2-norm of the residuals of the approximate solution. We prove that the estimator is independent of the dimension of the space and of the numerical approximation method used. Moreover the global majoration and local minoration constants are independent of the shape of the mesh.

Keywords : Friedrichs' systems, finite element methods.

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An explicite a posteriori error estimate to multidimensional Cauchy Problem

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Abstract:

We consider a data completion method for the Cauchy problem of Laplace equation in multidimensional space, that is known as a highly ill-posed problem. For an approximate solution given by any data completion method, we define an explicit a posteriori error estimates. We use this explicit a posteriori error estimate to define an iterative method for solving data completion problem. This method is used as a regularization procedure, to improve the approximate solution and to accelerate the rate of convergence. We prove the convergence and stability results and we give algorithms of resolution. Numerical experiments are provided to illustrate the efficiency of the proposed methods.

Keywords: Cauchy problem of Laplace equation, multidimensional space, explicit a posteriori error estimates, iterative method.

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Computational comparison of some a posteriori error estimators for nonconforming finite element methods

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Abstract :

We propose to compare three a posteriori error estimators namely equilibrated, star-based and residual error estimators for the Poisson problem and the Stokes problem with lowest-order Crouzeix-Raviart finite element discretization. The numerical results are presented to compare the performance of the three estimators in an adaptive refinement strategy.

Keywords : Nonconforming finite elements ; Adaptive finite element method ; Comparison ; A posteriori error estimates.

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Comparison of a posteriori error estimators

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Abstract :

The aim of this talk is to compare two types of a popsteriori error estimation, considering several approximations. It is about the classical residual error estimations [7, 1] and the estimations based on reconstruction [6, 3].
The idea of a posteriori error estimates based on the reconstruction of the equilibrated potential and/or equilibrated flux goes back to the Prager-Synge equality [5] for the Poisson equation $-\Delta p = f$. This identity is valid for all $v \in H_0^1(\Omega)$ and all $\mathbf{u} \in H(\mathrm{div}, \Omega)$ such that $\mathrm{div}\mathbf{u} + f = 0$, and given by

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

It follows that, to obtain such estimate, we need to reconstruct a so-called equilibrated flux ; $\mathbf{u} \in H(\mathrm{div}; \Omega)$ satisfying the equilibrium condition $\mathrm{div}\mathbf{u} + f = 0$ and such that $\mathbf{u} - \nabla p$ is as small as possible, and/or reconstruct a potential v in $H_0^1(\Omega)$.
In all cases, to have an estimate, which is said "by reconstruction", it is necessary to have at the end an equilibrated, flux and potential. Now, the question is : is it better to work with a numerical method that allows us to have an equilibrated quantities and in this case there is no need to reconstruct, or else, do we use a method where, we do not have an equilibrated solutions such as the Discontinuous Galerkin method, and in this case it is necessary to reconstruct the two variables ? By using various finite elements methods, for a diffusion problem, we will first compare, these various estimates by reconstructions, then we compare them with the classical residual estimates where no reconstruction is required. Finally, we represent an application of these two types of estimates [2, 4] for a 2d/1d coupled problem.

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

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Multi-directional structure tensor with multiple applications

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Tensor Splitting and Krylov Subspace Methods for Multilinear PageRank Computing

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Abstract :

Multilinear PageRank is a powerful tool for analyzing and ranking the importance of nodes in a complex network. However, the computation of multilinear PageRank can be computationally intensive, especially for large-scale networks. In this work, we present a novel approach for efficiently computing multilinear PageRank using tensor splitting and Krylov subspace methods. Our approach decomposes the multilinear PageRank tensor into a sum of simpler tensors, which can be computed and stored more efficiently. We then use Krylov subspace methods to approximate the action of the decomposed tensors on a vector, resulting in a significant reduction in computational complexity.

Keywords : Tensor splitting, Krylov subspace methods, Multilinear PageRank.

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Solving tensor compressed sensing problem using the Einstein productk

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Abstract :

Compressed sensing is a new technique that propose to reconstruct a signal from compressed data, by exploiting the fact that the most natural signals are sparse in some generic basis. The CS literature has mostly focused on one and two dimensional signals, however many interesting applications of CS involve higher dimensional signals. In this work we propose a new model of higher order compressed sensing using Einstein product, the Einstein product can be seen of as a natural extension of the matrix product to higher order arrays, which gives linear algebra tools a natural extension to the higher dimensions.

Keywords : compressed sensing, sparse reconstruction, tensors, multilinear decomposition.

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High-order stochastic principal component analysis algorithm

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Abstract :

In this work we describe VR-PCA (variance reduced principal component analysis) algorithm which is one of the stochastic algorithms that deals with pca problem in matrix case, and we aim to generalize this problem to the tensor case where the data is a high order tensor $\mathcal{X}$. In stochastic setting when the data is a matrix $X \in \mathcal{R}^{d\times n}$, the aim is to recover its top k left singular vectors (where $k \ll d$). Specifically, we are interested in finding a k-dimensional subspace (specified by a $d \times k$ matrix W), on which the projection of the data has the largest possible variance. Equivalently, we aim to find the top k eigenvectors of the covariance matrix $A = \frac{1}{n}XX^T$. We are seeking the block W that maximizes $trace(W^TAW)$ where $A \in \mathcal{R}^{d\times d}$ is a large, symmetric, SDP matrix and $W \in \mathcal{R}^{d\times k}$ is a block vector with orthonormal columns. When the dimensions of the data is large, VR-PCA is an inexpensive method with high accuracy solution, compared with some deterministic algorithms (power method, lanczos method...) and stochastic algorithms (Oja's method, random projections...). Many important applications hold several parameters, so that we aim to generalize this problem in the multidimensional case.

Keywords : Tensor, VR-PCA, variance reduced, principal component analysis, Oja's algorithm.

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Tensor decompositions for missing multi-dimensional data completion and its application in network

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Abstract :

One common approach for completing missing data in a multi-dimensional array, or tensor, is to use tensor decomposition techniques to find a low-rank approximation of the tensor that can be used to fill in the missing entries. There are several tensor decomposition techniques that can be used for this purpose, including : Singular value thresholding (SVT) or tensor ring low rank factorization (TR). Those method decompose a tensor into a sum of rank-1 tensors. They can be used for various applications such as image processing, networking...etc.
We are interested here in studying network completion which is the task of inferring missing or unobserved links in a graph or network based on some available information. We consider a large data network where we do not observe all nodes and edges. We then work with an observed subgraph that we complete using mathematical completion methods. These methods allow us to accurately determine the missing nodes and edges in the network.

Keywords : Tensor decomposition, Tensor completion, The SVT algorithm, The TRLRF algorithm, Network Competion.

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Multilayer networks analysis using a tensor representation and the Einstein product

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Abstract :

Complex systems that consist of different kinds of entities that interact in different ways can be modeled by multilayer networks. This paper uses the tensor formalism with the Einstein tensor product to model this type of networks. Several centrality measures, that are well known for single-layer networks, are extended to multilayer networks using tensors and their properties. In particular, subgraph centrality based on the exponential and resolvent of a tensor are considered. Krylov subspace methods are introduced for computing approximations of different measures for large multilayer networks.

Keywords : multilayer networks ; centrality measures ; adjacency tensor ; tensor functions ; Einstein product ; Krylov subspace method

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Acceleration of tensor sequences using generalized extrapolation methods

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Abstract :
It's well-known that vector extrapolation methods such as Minimal Polynomial Extrapolation method (MPE) and Reduced Rank Extrapolation method (MPE) are widely used in scientific computation. Our purpose in this work is to present a generalisation of these methods for tensor sequences. The proposed methods involve only the terms of sequences that result from iterative methods. Our approach is based on the notion of the n-mode minimal polynomial of a matrix with respect to a tensor. This polynomial will be used, through the iterative solution of some tensor linear systems, to introduce the tensor version of MPE and RRE. The implementation of these methods on some sequences of tensors confirms the effectiveness and applicability of our approach.

Keywords :N-mode product, Tensor Extrapolation method, Convergence acceleration.

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On some supersymmetric tensor properties

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Abstract :

The raise of data from different real-world applications is constantly increasing, which therefore makes their representations by vectors and matrices insufficient [2]. Tensor representations of data are among the most promising strategies in the last ten years. Tensors are multidimensional arrays which are a generalization of matrices and vectors. In this work, we focus and discuss some properties of the supersymmetric tensors which occur in several applications [1, 3]. Some numerical appropriate examples are also presented.

Keywords : Supersymmetric tensor, CP decomposition, Krylov subspace.

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Some concepts and numerical approaches in epidemiology

International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Time delay and nonlinear incidence effects on the stochastic SIRC epidemic model

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Abstract:
This paper presents theoretical and numerical investigations of a stochastic SIRC epidemic model with time delay and nonlinear incidence. The existence and uniqueness of a global positive solution are proved. The Lyapunov analysis method is used to obtained sufficient conditions for the extinction and the existence of a unique stationary distribution under certain asymptions. Numerical simulation is also elaborated for the considered stochastic model to support the theoretical results.

Keywords: Stochastic SIRC model, Time delay, Nonlinear Incidence, Lyapunov function, Stationary distribution.

1 Mathematical model formulation

Mathematical models are frequently used to study both the transmission dynamics and the epidemiological characteristics of diseases [1, 2]. The disease reinfection, the increasing cross-immunity, and the multiple virus strains of the diseases are justifications for including on the classical SIR epidemic model, a new intermediate compartment called cross-immune between a susceptible and a recovered individuals. This new class allows susceptible individuals to be exposed to the disease more than once, and individuals naturally lose immunity, among other features that bring it closer to a real-world application than the SIR model. This leads to a new model called SIRC [2, 3, 4, 5]. In the considered SIRC model, the population is divided into four distinct classes, the susceptible $S(t)$, the infected $I(t)$, the recovered $R(t)$, and the cross-immune $C(t)$ individuals. The proposed model yields the following stochastic epidemic problem, which is obtained by incorporating stochastic perturbation into the deterministic SIRC epidemic model.

$$\left\{\begin{array}{ll}
\mathrm{d}S(t) & = \left[\gamma(1-S(t)) - \dfrac{\beta S(t)I(t-\tau)}{\phi(I(t))} + \eta C(t)\right]\mathrm{d}t - \sigma_1 S(t)\mathrm{d}W_1(t) - \sigma_5 \dfrac{S(t)I(t-\tau)}{\phi(I(t))}\mathrm{d}W_5(t), \\
\mathrm{d}I(t) & = \left[\dfrac{\beta S(t)I(t-\tau)}{\phi(I(t))} + \mu\beta C(t)I(t) - (\gamma+\alpha)I(t)\right]\mathrm{d}t - \sigma_2 I(t)\mathrm{d}W_2(t) + \sigma_5 \dfrac{S(t)I(t-\tau)}{\phi(I(t))}\mathrm{d}W_5(t), \\
\mathrm{d}R(t) & = [(1-\mu)\beta C(t)I(t) + \alpha I(t) - (\gamma+\delta)R(t)]\,\mathrm{d}t - \sigma_3 R(t)\mathrm{d}W_3(t), \\
\mathrm{d}C(t) & = [\delta R(t) - \beta C(t)I(t) - (\gamma+\eta)C(t)]\,\mathrm{d}t - \sigma_4 C(t)\mathrm{d}W_4(t).
\end{array}\right. \tag{1}$$

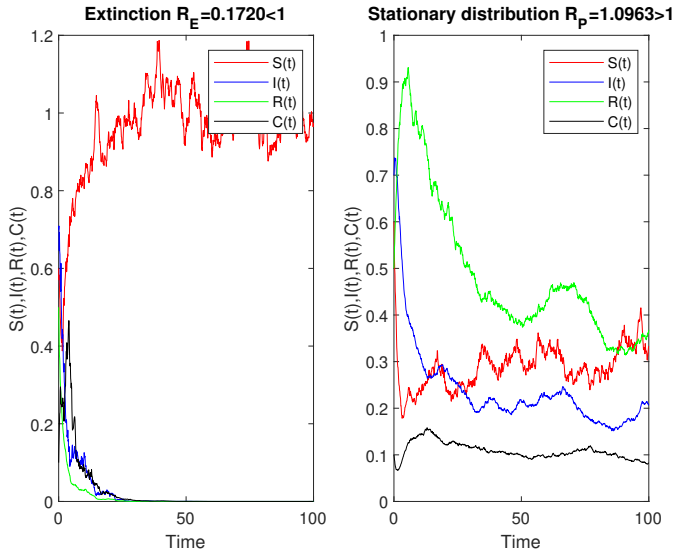

Figure 1: The graphical results show the extinction and stationary distribution of the SIRC epidemic model

In which $W_i(t)$, $i = 1, 2, 3, 4, 5.$ are mutually independent standard Brownian motions defined on a complete probability space $(\Omega, \mathcal{F}, \mathbb{P})$ with a filtration $\{\mathcal{F}_t\}_{t\geq 0}$ satisfying the usual conditions (i.e., it is increasing and right continuous while $\mathcal{F}_0$ contains all $\mathbb{P}$-null sets), σ_i^2, $i = 1, 2, 3, 4, 5.$ denote the intensities of the white noise.

With specified initial and boundary conditions, this model is theoretically analysed and some theorems about the existence of the global and positive solution, extinction of disease, as well as the existence of a unique ergodic stationary distribution are proved. A numerical code is elaborated for numerical solution and here after some of the obtained numerical solutions of the considered SIRC epidemic model with specific parameters. The figure 1 presents the sample paths for the stochastic SIRC model solutions, which shows that if the threshold $R_E < 1$, then the epidemic disease will go to extinct, and if the value $R_p > 1$, then the stochastic model has a unique ergodic stationary distribution.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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HARVESTING OF A PREDATOR-PREY MODEL WITH TWO EFFORT FUNCTIONS AND HOLLING TYPE IV RESPONSE FUNCTION

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Abstract :

In this paper we propose a Mathematical model for a two prey and one predator system. Two fishery zones are considered one reserved and one unreserved. The model considers a type IV Holling response function as well as two fishing effort functions that are considered to be time-dependent. First, we find the region of attraction for all solutions initiating in the interior of the positive octant, then we discuss the existence of positive equilibria of the proposed system. We discuss the local and global stability of the equilibrium points. Furthermore, an optimal harvesting policy is investigated by applying Pontryagin's Maximum Principle. Finally, to justify our theoretical findings, we perform numerical simulations.

Keywords : predator–prey system ; equilibria ; stability ; functional response ; optimal harvesting policy.

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February 20-22, 2023, Mines School of Rabat, Morocco

Global dynamics, optimal control and numerical simulations of a vaccination age-structured SVIQR model for Chickenpox disease with a generalized nonlinear incidence.

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Abstract :

Theoretical and applied research papers on all topics within the scope of the conference are invited to submit an abstract, stating the objectives, results, conclusion and references of the work to be presented in the conference. All abstracts will be reviewed by the Scientific Committee.Vaccination and isolation are the two most commonly used in public health strategies to control the spread of infectious diseases. The role of vaccination consists of protecting a healthy individual against infection with an infectious disease by stimulating their immune system with a vaccine suitable for the disease. However, the isolation is a strategy for disease control by removing infectious individuals out of the population and which is the stage that follows diagnose of infectious case. For some severer diseases, infected people can be isolated and are forced to take drugs (if there are drugs capable of curing the disease) in hospital or in isolation camps without contact with susceptible individuals.

In order to explore the vaccination effects on the disease transmission, a variety of compartment epidemic models where integrating vaccination schemes are studied and developed. In 2014, Duan et al. formulated an SVIR epidemic model with age of vaccination and a bilinear-type of incidence rate (See [1]). Thereafter, Yang et al. studied the same model with saturated-type of incidence rate (See [2]). In this talk, we propose a modified version of the SVIR model mentioned above with age of vaccination, where we introduce the incidence rate in its very general form. Furthermore, to understand the impact of isolation in the disease spreading in addiction to vaccination, we introduce the dynamics of isolated individuals. We prove the existence, uniqueness and positivity of solutions of our model by using integrated semi group theory. Based on the basic reproduction number $\mathcal{R}_0$, we investigate the existence of equilibrium points, compact attractor and the persistence of disease. Moreover, using the Lyapunov functional approach, we investigate the global stability of the equilibrium points in a threshold type. We also investigate the optimal control of the model studied ; we use an objective functional with a suitable control. By using the techniques of weak derivatives and a general principle of Pontryagin, we obtain the form of the optimal control. Finally, we illustrate our theoretical results by numerical simulations and we take the Chickenpox disease as an application.

Keywords : Chickenpox, age-structured SIQVR epidemic model, vaccination, generalized nonlinear incidence rate, Lyapunov functional, persistence, global stability.

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Analysis of a Multi Degree of Freedom by Numerical Methods.

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Abstract:

The dynamic analysis of structures is a very complex task that requires a very tedious or even impossible calculation. The challenge lies in determining the response of single-degree of freedom (MDOF) structures when subjected to different types of loading like harmonic loads, earthquake loads, etc. To ensure the safety and stability of a building, it is important to perform structure dynamic analysis. The main objective of this work is to study the dynamic performance of reinforced concrete structures subjected to harmonic loads using numerical methods namely Nemark's approach and Wilson method.

Keywords: Dynamic analysis, Python, MDOF.

Introduction:

Civil engineering is the field dedicated to design, build, and maintain structures in the natural environment. Its main priority is the construction of buildings and structures that are safe and capable of withstanding the elements to which they will be exposed such as wind, waves, traffic, earthquakes, and blasts, etc. Indeed, these different dynamics loads are the main issue on the durability of constructions and buildings, and it's necessary to carry out a series of studies and calculations.
In this paper, a numerical method presented to study the dynamic response of 4 story building under damping excited by a harmonic force characterized by amplitude F and a frequencyω_f.

Our study:

The numerical study of the Newmark and Wilson methods involves the implementation of these methods in a computer program to solve the equations of motion of a system and obtain the dynamic response. The Newmark method is generally implemented using a numerical integration technique, to solve the equations of motion. The Wilson method, on the other hand, is implemented by solving systems of differential equations and superimposing the solutions to obtain the overall response of the structure [1,2].

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

A nonlocal coupled model for tumor growth during metastasis

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Abstract :

Nonlocal balance laws are becoming widely used recently in parallel with the theoretical advancement in this type of equations. They give a realistic description to convection systems such as pedestrian flow, supply chains, and particle movement, by adding the collective behavior and the non local decision-making in the model. We consider here a coupled model, the first equation is a nonlocal hyperbolic equation representing the growth of the metastasis, and the second equation is a parabolic equation representing the diffusion of nutrients in the tissue. A result of existence and uniqueness will be established using a fixed point method.

Keywords : Nonlocal balance laws, nonlinear PDEs, tumor growth.

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February 20-22, 2023, Mines School of Rabat, Morocco

Total and Partial Observation-Detection for Linear Dynamical Systems

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Abstract :

In this work, we consider the partial observation-detection problem for finite dimensional dynamical linear systems that are not necessarily observable or detectable. This consist to study the observability and detectability of a system in the same time. To achieve that we introduce the so called "observation-detection" and "partial observation-detection" which consist in reconstructing a the totality or just a part of the system state and source reacting on the system even if the system is not observable or detectable. Some characterizations of "observable-detectable system" and "observable-detectable spaces" have been provided. The reconstruction of the part of the state and the source on the observable-detectable subspace is obtained by the orthogonal projection. In this case, we consider some algebraic structure of the given finite dimensional system which permits to extract the reconstructible part of the system state and the source reacting on the system. We also give some examples to illustrate our approach.

Keywords : Detection, Detection, Partial Observation-Detection, Dynamical Systems.

Example and Problematic

Lets consider the system defined in the interval [0,T] given by the following equation :

$$\begin{pmatrix} \dot{z_1}(t) \\ \dot{z_2}(t) \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 0 & 2 \end{pmatrix} \begin{pmatrix} z_1(t) \\ z_2(t) \end{pmatrix} + \begin{pmatrix} f_1(t) \\ f_2(t) \end{pmatrix} \tag{1}$$

with output equation

$$y\left(t\right) = z_2\left(t\right) \tag{2}$$

general solution of this system can be written as

$$\begin{pmatrix} z_1(t) \\ z_2(t) \end{pmatrix} = \begin{pmatrix} e^t z_{0,1} + \left(e^{2t} - e^t\right) z_{0,2} + \int_0^t e^{t-s} f_1(s)\mathrm{ds} \\ e^{2t} z_{0,2} + \int_0^t e^{t-s} f_2(s)\mathrm{ds} \end{pmatrix} \tag{3}$$

then output function is given by the following equation :

$$y(t) = z_{0,2}e^{2t} + \int_0^t f_2(s)e^{2(t-s)}\text{ds} \tag{4}$$

This system is not observable and not detector. In deed, if we take the two following initial states,

$$z_0 = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \quad \text{and} \quad \tilde{z}_0 = \begin{pmatrix} -2 \\ 0 \end{pmatrix}$$

and the following two sources :

$$f(t) = \begin{pmatrix} t \\ 0 \end{pmatrix} \quad \text{and} \quad \tilde{f}(t) = \begin{pmatrix} -2t \\ 0 \end{pmatrix}$$

the corresponding output functions to (z_0, f) and $(\tilde{z}_0, \tilde{f})$ are y and $\tilde{y}$ successively with,

$$y\,(t) = \tilde{y}\,(t) = 0 \tag{5}$$

for all $t \in]0, T[$, then the system is not observable and cant detect the totality of source function.
We have :

$$y(t) = e^{2t}z_{0,2} + \int_0^t e^{t-s}f_2(s)\text{ds} \tag{6}$$

then

$$\dot{y}(t) = 2e^{2t}z_{0,2} + \int_0^t 2e^{2(t-s)}f_2(s)\text{ds} + f_2(t) \tag{7}$$

then

$$\frac{1}{2}\dot{y}(t) = e^{2t}z_{0,2} + \int_0^t e^{2(t-s)}f_2(s)\text{ds} + \frac{1}{2}f_2(t) \tag{8}$$

by substracting 6 from 8, we obtain the following equation,

$$\frac{1}{2}f_2(t) = \frac{1}{2}\dot{y}(t) - y(t). \tag{9}$$

then

$$f_2(t) = \dot{y}(t) - 2y(t). \tag{10}$$

hence we did reconstructed f_2 the second component of the source f. This result lead as to think to possibility of doing the same think to all non observable linear system in the kind of (3),(2). We can then ask the following questions :
If a system with the out-put equation can not detect the perturbation source, can we know some information about this source or not ?
If that is possible, how we can do it and characterize it ?
Whats the relation between detection (partial detection) and observation (partial observation) ?

Acknowledgement

This work is carried out within the framework of the Alkhawarizmi/2020/11 Project funded by MESRSFC, CNRST and ADD Morocco.

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Viability, co-viability and lifespan

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Abstract :
In this work we present an extension of the notion of viability, introduced by Aubin in [2] to the regional case for distributed parameter systems [1]. This consists in coupling recent works on regional analysis and those developed on viability. We introduce what we will call exact viability, weak viability and regional viability, as well as the notion of lifetime in both cases . We link the notions of viability and co-viability in a simple way. We also present a connection between regional viability and spreadability. To illustrate these concepts, some examples are presented.

Keywords : Dynamical systems, viability, co-viability, lifespan.

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This work is a result of the project PPR2 : OGI-Env funded by MESRSFC and CNRST

Mathematical modeling and simulation applications in finance

Journée d'analyse Numérique et Optimisation (JANO'14)

20-23 February 2023, Mohammed V University, Rabat Mines School, Morocco

A Novel Precision Marketing Model based on Banking Big Data Analysis and AI

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With the growth of the Internet industry and the informatization of services, online services and transactions have become the mainstream method used by clients and companies. How to attract potential customers and keep up with the Big Data era are the important challenges and issues for the banking sector. With the development of artificial intelligence and machine learning, it has become possible to identify potential customers and provide personalized recommendations based on transactional data to realize precision marketing in banking. The current study aims to provide a potential customer's prediction algorithm (PCPA) to predict potential clients using big data analysis and machine learning techniques. Our proposed methodology consists of five stages: data preprocessing, feature selection using Grid search algorithm, data splitting into two parts train and test set with the ratio of 80% and 20% respectively, modeling, evaluations of results using confusion matrix. According to the obtained results, the accuracy of the final model is the highest (98.9%). The dataset used in this research about banking customers has been collected from a Moroccan bank. It contains 6000 records, 14 predictor variables, and one outcome variable.

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Determinants of Financial Inclusion in Morocco : A Probit Model

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Abstract :

The importance of financial inclusion arises from the fact that close to one third of adults in the world are still unbanked. Leveraging the Global Findex database (World Bank, 2017), we analyze the determinants of financial inclusion in Morocco and understand the barriers to access financial services. Using a probit model, the analysis reveals that income, education, gender and religion can have a significant association with the level of financial inclusion. Also, being a rich, educated man increases the likelihood of resorting to formal account and mobile banking. Finally, women are more inclined to use informal saving channels. Our work therefore contains findings to help understand what shapes the Moroccan financial inclusion landscape and design policies to foster financial inclusion in Morocco.

Keywords : Financial inclusion, Probit model, Regression, Morocco, Financial institutions.

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Agent based modeling and simulation for decreasing partnership microfinance

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Abstract :

The microfinance industry plays a very important role in reducing poverty in developing countries. However, new methods and models are needed to assess the effectiveness and impact of the introduction of Islamic microfinance products in comparison with the conventional system. So we can consider the microfinance as a complex system in which both Islamic and conventional microfinance institutions exist and constantly interact with evolving customers. Furthermore engaging poor people through business partnership is an innovative approach being advocated these days in the form of social entrepreneurship and inclusive business models. The purpose of this paper is to implement an agent based model to compare the conventional and islamic microfinance in the NetLogo- platform. It semulates the behavior of different agents in a simplified environment and shows the outcome as a result of the interactions among agents The model is based on the Diminishing Partnership Contract which implies that the MFI serve as a partner or investor with the borrower as opposed to a mere lender. The utilization of agent-based models in partnership microfinance is crucial since all the most of existing models focus on conventional microfinance and on interest-based lending.

Agent-based modeling is an efficient way to get a lucid picture of the impacts of both conventional and Islamic microfinance in the same environment. We use three essential agents which are : Islamic Microfinance Institution(Genuinely involved in Musharaka partnership), Conventional Microfinance Institution and micro-entrepreneurs which we assume that they are sensitive to religion in a differentiated manner. The entrepreneur try to get microcredit either from MFI or IMFI to start a Microenterprise according to their score. The model creates an environment where different agents live and interact with each other. In the NetLogo program this space is represented by a black square, which is composed of a grid of patches. The agents can move in this spatial environment and interact with each other.The model starts with given number of people living in the space. Initially individual agents in the population are randomly distributed throughout the space. Every consumer gets a religiosity rate as a parameter. The data used to compute each consumer score is based on the article by AYOUCHE and all [6].This dataset comprises 620 cases which contains customer information related to personal characteristics (marital status, Age, etc.) and characteristics of the partnership project between microfinance institution and the micro-entrepreneur.

When a loan has been established between a consumer and a bank, there is then a chance that the consumer either pays it back, with interest, or defaults on the loan, which causes the bank to lose a portion of its reserves. We need also to identify the characteristics of Islamic and Conventional Contract for both IMFI, MFI and the entrepreneurs. We assumed that the amount is supposed to be the same for both MFI and IMFI. Each entrepreneur has a number of characteristics such as Personal characteristics (gender male, age, housing,occupation...), Consumer score, Consumer choice if the consumer want to choose to seek a loan from an Islamic bank or conventional bankt, Consumer-InitialFund and Profit.
The characteristics of IMFI are the payment which is formulas of Diminishing Partnership contract, the profits are shared as stipulated in the contract while losses are shared in proportion to capital shares, Micro-credit fund, bank prestige and late payment charges.. The characteristics of MFI are the interest rate which is fix and can be defined by the user, payment, microcredit fund which is amount of reserves to make sure that the bank can grant one credit at least and Bank-prestige.
Several simulations have been performed to understand the relationship between the different parameters of microfinance. The simulations showed the interest of customers to the Islamic banks. 407 of entrepreneurs choose Islamic microfinance institutions through a Diminishing Partnership Contract while 128 entrepreneurs choose Conventional microfinance institutions and 84 entrepreneurs choose neither bank. The simulations proved the efficiency of "the agent based simulation" method, for simulating entrepreneur behavior for choosing between Islamic and Conventional microfinance institutions ; and detecting agent's interactions. So the Diminishing Partnership Contract on microfinance has a positive effect in microfinance and in reducing poverty.

Keywords : agent based modeling and simulation, microfinance, diminishing partnership contract .

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Prévoir l'activité économique au Maroc : étude comparative entre les modèles VAR et ARDL en utilisant des variables financières.

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Abstract :

Modeling and forecasting economic growth is a major concern for economists. Over the last thirty years, a lot of work has been carried out on forecasting economic activity using financial variables. The objective of our contribution is to examine the ability of financial variables to forecast future economic growth beyond past economic activity in Morocco. We attempt to clarify possible differences in the forecasting of economic activity using ARDL and VAR models. A comparative study of the forecasts accuracy produced by the two approaches shows that financial variables can be used in an econometric model to produce robust forecasts of economic growth.

Keywords : Growth, Finance, ARDL , VAR, Forecasting.

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Agent-based Stock-flow consistent modeling : a survey

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Abstract :

The paper provides an overview of the current Agent-based Stock-flow-consistent (AB-SFC) literature. The aim is to give this nascent approach an updated summary of the new works and methodologies used but also to explain the interest of using this approach in finance. The paper is developed along the following lines. First, a brief historical analysis investigates the roots of the SFC approach with reference to the main work of Godley and Lavoie. Second, a sequential methodology of building an SFC model is presented with a description of the different steps from the conception of the matrix, the implementation of the functions to the calibration and the simulation of the models. Finally, we explore the transition to the AB-SFC modelling and we study the advantage of the combination of these two approaches through the literature.

Keywords : Mathematical modelling in finance, Agent-based models, stock-flow consistent models.

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Determinants of the Volatility of Energy Product Prices: The Case of WTI Oil

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Abstract:

Today, oil is more than just an energy raw material, black gold has undoubtedly become the most important strategic product in the world. Currently, the oil market remains a highly complex market, characterized by increased volatility and unpredictable price dynamics. The erratic nature of oil prices can result in potential imbalances in macroeconomic aggregates.

In this article, we conduct a literature review on the factors affecting the volatility of oil prices (WTI) and propose introducing an ARDL modeling to determine the fundamental causes of oil price volatility.

Keywords: Volatility; Oil prices; ARDL.

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Predicting Stock Market Price Movement using Machine Learning Techniques

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Abstract :
Due to the volatility of the financial stock markets, accurately predicting future values of the stock market index is a highly challenging task. In fact, a precise forecast aids brokers in selecting the right asset to buy or sell. Toward this aim, six Machine Learning (ML) techniques namely : Support Vector Regression (SVR), K-nearest Neighbor (Knn), Decision trees (DTs), Random Forest, Artificial Neural Networks (MLPs), Deep learning technique, were built to predict the future closing price for five companies that are part of the $S\&P500$ index and the closing price of $S\&P500$ index. Our employed models, which were constructed using the grid search optimization technique and evaluated using two performance criteria, were fed teen years of data as well as six newly developed variables. The findings demonstrate that there is no ideal machine learning technique that can be used to forecast the trends of a certain stock price. The MLP and LSTM approaches, which are part of the ANN family, may be regarded as the best methods, however all the created techniques produce highly promising results.

Keywords : Artificial Neural Networks, Support Vector Regression, Random Forest, Decision trees, Deep Learning, Stock market.

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Modelling, Control and optimisation : Theory and application

International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Controllability Result of Caputo Fractional Semi-Linear System with Diffusion on a boundary subregion.

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Abstract :

The main objective of this work is to investigate the regional boundary controllability problems for a class of semi-linear fractional sub-diffusion equations. In particular, sufficient conditions are derived for the regional boundary controllability by assuming that the associated linear system is approximately regionally boundary controllable. Further, the main result is obtained by using the fractional powers of operators and fixed point technique where we suppose that the associated linear system is approximately controllable on a suitable sub-region of the system's evolution domain. In addition, we present some numerical simulations worked out in the end to illustrate the effectiveness of our theoretical result.

Keywords :Fractional Calculus, Caputo Derivative, Semilinear systems, Regional controllability, Analytical semigroup theory.

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Mixed integer nonlinear programming approach for optimal placement and size of capacitors in radial distribution systems for voltage profile improvement and power loss reduction

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Abstract:

This paper presents a technique based on non-linear mixed integer programming (MINLP) to solve the optimal location and size of capacitors in radial distribution systems to improve the voltage profile and reduce the active and reactive power losses, correct the power factor, and the installation cost of capacitors. The proposed technique has two parts: the first part allows us to find the candidate buses for the location of the capacitors by calculating the modified loss sensitivity index (MLSI), and the second part, applies the MINLP method to estimate the optimal size of the capacitors to be installed in the candidate buses. The optimization problem is improved by adding constraints. The proposed approach was applied to the 10, 33, and 69-bus radial distribution systems to assess its effectiveness. For all three test systems, optimization results are compared with other methods, Multiverse Optimizer (MVO), Particle Swarm Optimization (PSO), Cuckoo Search Algorithm (CSA), Grey Wolf Optimizer (GWO), Dragonfly optimizer (DFO), Moth_Flame Optimizer (MFO), Crow Search Algorithm (CrSA), Genetic Algorithm (GA), Modified Cultural Algorithm (MCA), Hybrid Optimization (HO), and Particle Swarm Optimization with Quazi-Newton (PSOQN). The simulation results show that the proposed methods are better in terms of loss minimization, capacitor costs, and calculation time.

Keywords: Capacitor placement, MLSI, MINLP, radial distribution systems, voltage profile, cost, active loss.

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Deep Learning For Solving The Partial Differential Equations

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Abstract :

The Partial differential equations (PDEs) are indispensable for modeling many physics phenomena, including the fluids flow, the vibration of solids, the diffusion of chemicals or nuclear, the spread of heat, the structure of molecules, and so on. Solving a PDE is considered one of the most difficult tasks in mathematics. Many PDEs have no analytical solution, and numerical methods are widely used to solve PDEs. In recent years, deep learning has achieved good performance in different domains, such as image classification, and natural language processing. Several works show that deep neural networks are powerful to approximate the functions and have great potential in the study of PDEs.

In this correspondence, we will discuss the benefits and rationale behind utilizing deep learning techniques to solve PDEs. Additionally, we will provide an overview of well-known techniques based on neural networks for approximating PDE solutions.

Keywords : Partial Differential Equations, Deep Learning, Physics Informed Neural Networks.

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Integration and optimization workflow of heat pump through Pinch Method

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Abstract :

Integration of advanced utilities instead of conventional utilities is considered an attractive solution for the energy integration of industrial processes. Now-days, optimization has become a key approach to resource management, and rigorous solution for various issues. A combined Pinch and Mathematical Programming Methodology is suggested to systematically integrate and optimize heat pump (HP) and existing heat exchange network (HEN). The aim of this work is to provide a multi-objective optimization model on a Heat Exchange Network renovation with a heat pump. Based on this model, and taking into account the variation of the Minimum Temperature Approach as well as both capital and utility cost, the main objectives consists on maximizing the heat recovery (HR), minimizing the heat transfer area cost and CO_2 emissions as well as the optimal heat pump parameters are identified. The Composite Curves (CCs) and grand composite curve (GCC) are used to analyse the energy requirement of the whole system (HEN and HP). The variation of the utility consumption will be deduced first based on Pinch Analysis. Then the relation between T_{evap} and T_{cond} temperatures and HP coefficient of performance (COP) is analyzed. A HR-annual cost-COP (ΔH -Cost-COP-T) diagram is constructed to illustrate their variation, and intuitively target the optimal COP and corresponding parameters. The results indicate that integrating the HP into the HEN could compensate for the benefits of carbon reduction emissions through energy savings with minimum cost installation, in which the reduction of carbon emissions is limited by a critical power input and a critical temperature rise.

Keywords : Heat integration, Advanced utilities, Optimization, Heat exchange network, Heat pump.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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HMM-based supervised classifier algorithm using left inverse

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Abstract :
The Hidden Markov Model has been widely applied to many classification problems related to many areas, which include speech recognition, handwriting recognition,Cybernetics, bioinformatics and finance. The main objective of this work is to develop a supervised model using the Hidden Markov Model based on the observation equation to calculate posterior probabilities. The generalized inverse approach has been used for statistical issues as a means of resolving overdetermined systems of linear equations. In the paper, we present an iterative algorithm using the left inverse where the emission probability matrix is not full column-rank in the observation equation. We apply our method to many available datasets in the litterature. Numerical results demonstrate that the proposed model is efficient and suitable for different learning problems.

Keywords : Hidden markov model, Supervised Classification, Left Inverse.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

An efficient algorithm for customer Churn prediction using mathematical programming

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Abstract :

In this paper, we propose an alternative of statistical approach to predict customer churn in the telecommunications industry. The main concept of our proposed algorithm is to hybridize the Jackknife resampling technique with an efficient heuristic based on a variable neighborhood search algorithm using the mathematical programming technique. The goal is to find possible solutions (or weights) to minimize error distances and the number of misclassified points. Using a public imbalanced data set, we compared the proposed algorithm with some existing machine learning classifiers, the numerical results indicate that the proposed model out-performs the majority of machine learning classifiers used for the comparisons, both in terms of the solution quality and the execution time.

Keywords : Customer churn prediction, mathematical modeling, optimisation, VNS, Resampling Technique.

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Control and systems theories

International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Theoretical and Numerical Study of Regional Boundary Observability for Linear Time-Fractional Systems.

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Abstract :

The main goal of this research is to examine the regional boundary observability for a class of linear time-fractional systems involving the Riemann-Liouville fractional derivative ; for more details on regional boundary observability for classical systems, see [1, 2], and for fractional systems, see [3, 5]. To be more specific, the aim is to locate and reconstruct the starting state of the fractional system under consideration on a suitable or desired subregion of the evolution domains' boundary. The reconstruction problem is converted into a solvability problem with the form $AX = b$ using an adaptation of the Hilbert uniqueness method (HUM) introduced in [4]. For the purpose of demonstrating the effectiveness of the suggested strategy, some successful numerical examples were simulated and provided at the end.

Keywords : Control theory, Regional boundary observability, Fractional Calculus.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Optimal control for a class of linear infinite-dimensional systems using integral reinforcement learning

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Abstract :

In this work, we apply Reinforcement Learning (RL), which is a type of machine learning method for a class of linear infinite-dimensionnel system, such that the dynamics is unknown. We developed reinforcement learning to solve the Riccati equation in real time without full knowledge of the dynamics of this system.

Keywords : optimal control, reinforcement learning, linear systems in an infinite-dimensionnel.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Two metaheuristics for the no wait flow shop scheduling problem with total flow time criterion.

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Abstract :

In this work, our subject is to solve a flow shop scheduling problem under the constraint of no wait. In the industry manufacturing the constraint of no wait is very important. The goal is to minimize the total flow time of all jobs with a mixed integer linear programming model (MILP). for this we will use tow efficient metaheuristics ; The first is the iterative local search algorithm (ILS) and the second is the genetic algorithm (GA). We will choose different size of the instance and we will compare the result given by the metaheuristics. The numerical test show that the genetic algorithm give the best performance comparent with the the iterative local search algorithm.

Keywords : flow shop scheduling, total flow time, the iterative local search.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

An inverse optimal control problem for infinite-Dimensional semilinear systems

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Abstract :

An optimal control problem is to find a control that minimizes or maximizes a given functional cost under dynamical constraints. in our research, we address the inverse problem which consists of determining a functional cost such that the given linear quadratic control is optimal with respect to this new criteria over all trajectories of an associated infinite-dimensional semilinear system. The inverse optimal control problem has been applied in several fields (See [1, 4]).

The inverse optimal control problem has attracted much attention. It was first mentioned and partially solved for finite-dimensional linear systems in [3] and for semilinear systems, this problem is solved in [2]. The problem of reconstructing cost functions has aroused a lot of interest from many researchers. But, most studies of inverse optimal control problems reported in the literature are related to finite dimensional systems. Motivated by the fact that several phenomena are modeled by nonlinear or semilinear equations, we are focused an inverse optimal control problem for infinite-dimensional semilinear systems. We are looking for optimality conditions, such that the control law obtained by the standard linear quadratic problem of the linear part is optimal for the semilinear system associated to another adequate functional cost. The test of stability with respect to a bounded perturbation in open-loop dynamics is assured in terms of the gain and phase margins, once the semilinear closed-loop system's optimality is established.

Keywords : Linear quadratic problem, semilinear system, optimal control, stabilization.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

A Review of Flying Ad Hoc Networks: Main applications, Wireless Technologies and the routing protocols

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Abstract:

Flying Ad-Hoc Networks (FANETs) are becoming popular in many application domains including agriculture, environment, climate monitoring and military surveillance. If legislations permit UAVs to operate autonomously, one will see the skies become populated with many small UAVs, each one performing various tasks such as mail and package delivery, traffic monitoring, surveillance, search and rescue, and other applications.

Such networks provide reliability, ease of deployment, and relatively low operating costs by offering a robust communication network among the UAVs and base stations.

Although FANETs offer many benefits, there also exist a number of challenges that need to be addressed; the most significant of these being the communication.

These interesting new avenues for the use of UAVs are motivating researchers to rethink the existing research on FANETs.
Therefore, in this paper will provide a comprehensive and thorough review of the different types of UAVs used in FANETs, their main characteristics, their applications and the routing protocols used in this type of network.

Keywords : fanets, wireless network, communication.

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February 20-22, 2023, Mines School of Rabat, Morocco

AHP-Method and its applications : review

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Abstract :

Here we present the analytic hierarchy process (AHP),as a method of measurement with ratio scales, we then introduce the principe of this method and some of the central thoeretical . We also give application about a AHP method

Keywords : AHP, fuzzy-AHP, renewable energy.

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Numerical Method And Delay Differential Equation

International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Energy harvesting in a delay-induced parametric van der Pol-Duffing oscillator

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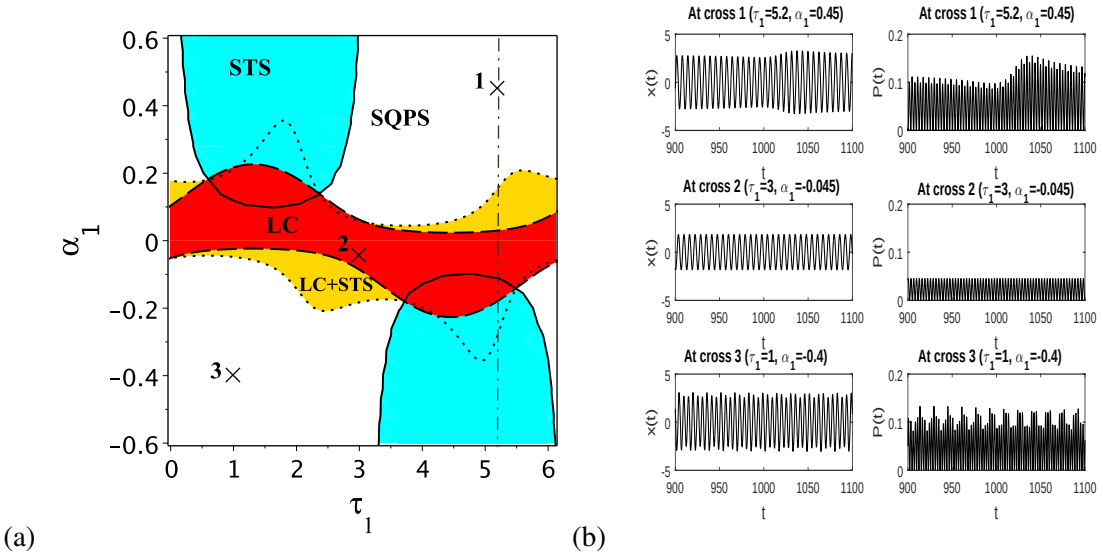
Abstract :

Quasi-periodic vibration-based energy harvesting is investigated in a delayed van der Pol-Duffing oscillator coupled to an electrical circuit through a piezoelectric device. It is assumed that the mechanical and the electrical components of the harvester are under a time-delayed feedback such that the governing equation for the harvester system can be written in the dimensionless form as

$$\ddot{x}(t) + x(t) - (\delta - \lambda x(t)^2)\dot{x}(t) + \gamma x(t)^3 - \chi v(t) = \alpha(t)x(t-\tau_1) \tag{1}$$

$$\dot{v}(t) + \beta v(t) + \kappa \dot{x}(t) = \alpha_3 v(t-\tau_2) \tag{2}$$



(a) (b)

FIGURE 1 – (a) Existence domain of periodic and QP solutions in the (α_1, τ_1)-plane for $\chi = 0.05, \omega = 2$, (b) time and power histories at crosses 1, 2, 3 picked from (a) corresponding to different regions. LC : limit cycle, SQPS : stable quasi-periodic solution, STS : stable trivial solution.

where $x(t)$ is the relative displacement of the rigid mass m, $v(t)$ is the voltage across the load resistance, δ and λ are the mechanical damping ratio, γ is the stiffness parameter, χ is the piezoelectric coupling

term in the mechanical attachment, κ is the piezoelectric coupling term in the electrical circuit, β is the reciprocal of the time constant of the electrical circuit, $\alpha(t)$ and τ_1 are, respectively, the feedback gain and time delay in the the mechanical component, α_3 and τ_2 are, respectively, the feedback gain and time delay in the electric circuit.

The delay in the mechanical part is assumed to be inherently present in the harvester as in milling and turning operations, whereas the delay feedback in the electrical circuit is introduced as a controller scheme for optimizing the output power of the harvester. It is supposed that the delay amplitude in the mechanical part $\alpha(t)$ is modulated around a mean value as

$$\alpha(t) = \alpha_1 + \alpha_2 \cos \omega t \tag{3}$$

where α_1 is the unmodulated delay amplitude and α_2, ω are, respectively, the amplitude and the frequency of the modulation. The case of a *delay-induced parametric resonance* for which the frequency of the modulation is near twice the natural frequency of the oscillator is considered. The first and second-step multiple scale method are applied to obtain approximations of periodic and quasi-periodic solutions as well as the corresponding output powers. Bifurcation analysis is carried out to locate regions of existence of these solutions Fig. 1. The effect of different system parameters on the performance of quasi-periodic vibration-based energy harvesting is examined. The advantage of using quasi-periodic vibrations to extract energy over a broadband of system parameters away from the resonance is illustrated. Numerical simulations is conducted to validate the analytical predictions.

Keywords : Energy harvesting, delayed Duffing-van der Pol oscillator, quasi-periodic vibration.

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Cone-Bounded Feedback Laws for Linear second order Systems

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Abstract :

Consider the following wave equation

$$\begin{cases} \frac{\partial^2 x}{\partial t^2}(s,t) = -A_0 x(s,t) - \gamma \frac{\partial x}{\partial t}(s,t) + Bu(s,t), & t \geq 0, s \in [0,1], \\ x(0,t) = x(1,t) = 0, & \forall t \geq 0, \\ x(s,0) = x_0, \\ \frac{\partial x}{\partial t}(s,0) = x_1, \end{cases} \tag{1}$$

where u is the control and A_0 is a self adjoint and coercive operator on a Hilbert space H. During the last decades many works have studied the wave equation. Indeed, there are several articles in the literature that studies this equation (see [1, 2]). In a spacial case where the operator $A_0 = \Delta$ and $\gamma = 0$, the problem of stabilization by linear feedback control laws is considered by many authors. A simple examples can be find [3], where the approach is based on standard C_0-semigroup theory on Hilbert spaces and linear quadratic techniques.

The objective of this article is to study the wave equation in the presence of nonlinear control laws in an infinite dimensional setting. As a first step, the well posedness problem of the closed loop in the presence of such nonlinearities is solved by using the Schauder's fixed-point Theorem and the C_0-semigroup theory. In the second step we use Theorem 2 of [4] to deduce the global asymptotic stability of the closed loop system. Another objective of this work is to apply these results to damped wave equation.

Keywords : Stabilization, Abstract control systems, Infinite dimensional systems, Nonlinear semigroups, Wave equation.

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On nonlinear elliptic equations with Hardy potential and L^1-data

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Abstract

This paper is devoted to the study of the following non-coercive elliptic problem

$$\begin{cases} Au + g(x,u,\nabla u) = f(x) + \frac{|u|^{p_0-2}u}{|x|^{p_0}} & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

in the anisotropic Soboelv space, where Ω is a bounded open set of $\mathbb{R}^N$ ($N \geq 2$) containing the origin, with $g(x,s,\xi)$ satisfying only some growth condition and $f \in L^1(\Omega)$. We prove the existence of renormalized solutions for our strongly nonlinear and non-coercive elliptic Dirichlet problem. Also, we will conclude some regularity results.

2010 Mathematics Subject Classification : 35J15, 35J25.
key words: Anisotropic Sobolev spaces, strongly nonlinear elliptic equation, non-coercive problems, renormalized solutions.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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General Intuitionistic Fuzzy Linear Systems

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Abstract :

In this paper, the main is to investigate $m \times n$ intuitionistic fuzzy linear systems. Based on the procedure introduced by Friedman to solve $n \times n$ fuzzy linear systems, a method is proposed to solve the intuitionistic fuzzy linear systems. The conditions of the existence for instuitionistic fuzzy solution are given. Finally, some numericals examples are solved to illustrate the proposed method.

Keywords : Intuitionistic fuzzy number, general intuitionistic fuzzy linear systems, intuitionistic fuzzy solution.

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Solution Method for Intuitionistic Fuzzy Delay Differential Equations Under Generalized Differentiability

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Abstract :
In this paper, we consider the intuitionistic fuzzy delay differential equations with local and nonlocal initial conditions using the concept of generalized differentiability. A new complete intuitionistic fuzzy metric space is proposed to investigate the existence and uniqueness of intuitionistic fuzzy solutions for these problems using the Banach fixed point theorem. Our results are demonstrated in some numerical simulations for α-cuts of intuitionistic fuzzy solutions, we give some representations of the surfaces of intuitionistic fuzzy solutions.

Keywords : Delay differential equations, intuitionistic fuzzy solutions, fixed Point, generalized differentiability.

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The Fuzzy–AHP Model for Energy Security Assessment of Morocco

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Abstract :

Morocco is a Maghreb country with few fossil energy resources. Ensuring its energy security is a major challenge that all governments, through several decades, have struggled to achieve. Morocco has tried to diversify its energy mix and limit its dependency on fossil fuels by developing mainly the share of renewable energies in the energy mix. In this paper, we present the energy security concept [1] and its various dimensions [2]. We determine the weight of each energy security dimension based on the Fuzzy-AHP [3] in order to optimize investments and actions required to inhance and improve the energy security situation of Morocco.

Keywords : Energy security, Fuzzy AHP ; Energy mix ; Energy Security Index in Morocco .

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Exponential and weak stabilization for constrained delayed semilinear systems using a class of feedback controls

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Abstract :

The objective of this paper is to study the exponential and weak stabilization of the following distributed semilinear system with time delay :

$$\begin{cases} \frac{dy(t)}{dt} = Ay(t) + p(t)By(t-r) + Ny(t), & t > 0, \\ y(t) = \phi(t), & t \in [-r, 0], \end{cases} \tag{1}$$

where A is the infinitesimal generator of a linear C_0- semigroup of contractions $S(t)$ on a real Hilbert space H, endowed with inner product $\langle ., . \rangle$ and its corresponding norm $\|.\|$, and $B \in L(H)$, whereas $p(t)$ is a scalar function which represents a class of feedback controls. $r > 0$ is the time delay and N is a nonlinear operator defined from H into itself, while $\phi \in C([-r, 0], H)$ is a given initial function.
The existence and uniqueness of the global mild solution are proved under sufficent conditions. Also, the exponential and weak stabilization of the system (1) are investigated. Finally, some illustrating examples are given.

Keywords : Class of feedback controls, Semilinear systems, Time delay, Exponential stabilization, Weak stabilization.

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Poster of ANO

International Conference of Numerical Analysis and Optimization Days (JANO'14)
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A Levy process approach coupled to the stochastic Leslie-Gower model

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Abstract :
In this work, theoretical and numerical analyses of a two-dimensional Leslie-Grower type continuous-time stochastic predatory-prey differential equation model with Levy jumps are elaborated. The environmental perturbation is modelled by a Levy process. Firstly, the uniqueness positive solution of the system with a positive initial value is demonstrated. Then, we established sufficient conditions for the mean stability and extinction of the considered system. Numerical simulations supporting the main results based on the associated Fokker Planck partial differential system and the Euler scheme are elaborated. The obtained results show that Levy jumps can significantly influence the properties of population systems.

Keywords : Leslie-Gower, SDEs, Itô's formula, Fokker-Planck equation, Euler scheme.

1 Introduction

The predator-prey interaction is one of the basic relationships in ecological models and is also a basic building block of the more complex food chain, food web and biochemical web structure[1]. In 1926, Volterra [2] proposed a differential equation model to explain the oscillatory levels of some fish catches in the Adriatic. Lotka [3] also derived the model to describe a hypothetical chemical reaction in which chemical concentrations oscillate in 1925. Inspired by the Lotka-Volterra equations, several ecologists and mathematicians have formulated and studied various realistic predator-prey, mutualistic and competitive models.
However, population systems may suffer sudden environmental perturbations, such as epidemics, earthquakes, hurricanes, etc. These phenomena cannot be modeled by a simple stochastic system excited by a Brownian motion. More recently, Bao et al. suggested that these phenomena can be described by a Levy jump process and they considered stochastic Lotka–Volterra population systems with jumps for the first time. Motivated by these, ascertainment and findings, we consider the following Leslie-Gower stochastic differential system with jumps :

$$\begin{cases} dH_t = H_t\left(r_1 - a_1P_t - b_1H_t\right)dt + \sigma_1 H_t dB_1 + \int_{\mathbb{Z}} H_{t^-}\gamma_1(u)\tilde{N}(dt,du), \\ dP_t = P_t\left(r_2 - \frac{a_2P_t}{H_t}\right)dt + \sigma_2 P_t dB_2 + \int_{\mathbb{Z}} P_{t^-}\gamma_2(u)\tilde{N}(dt,du) \end{cases} \tag{1}$$

where : $H(t)$ and $P(t)$ represent the densities of prey and predator populations at time t respectively, r_1 is the intrinsic growth rate of the prey, b_1 represents the effect of interspecific prey competition in the absence of a predator, a_1HP is the functional response of the predator to the prey, r_2 is the intrinsic growth rate of the predator, a_2 is a measure of the amount of food the prey provides for conversion to a predator birth, the term $\frac{a_2P}{H}$, called Leslie-Gowere term, $(B_1(t), B_2(t))$ are mutually independent Brownian motions, the parameters (σ_1, σ_2) represent the intensity of the perturbation, $\tilde{N}(dt, du) = N(dt, du) - \lambda(du)dt, \quad \gamma_i : \mathbb{Z} \times \Omega \to \mathbb{R}$ is bounded and continuous with respect to λ.

2 Main results

Theorem 1 *For any initial value $(H_0, P_0) \in R_+^2$, the model (1) has a unique solution (H_t, P_t) for $t \geq 0$ and the solution will remain in R_+^2 a.s*

Theorem 2 *Let (H_t, P_t) be the solution of the SDE (1) with initial values $(H_0, P_0) \in R_+^2$. Then for all $m > 0$, there exists $C(m) \in (0, \infty)$ such that*

$$\sup_{t \geq 0} \mathbb{E}\left(H_t^m + P_t^m\right) \leq C(m).$$

3 Numerical simulations

Numerical investigation of the stochastic system (1) is elaborated based on the associated Fokker Planck equation as well on the time discretisation Euler method

4 conclusion

In this work, a methodological approach to investing the stochastic differential equations excited by Levy processes is proposed. A study of Leslie-Grower models in which environmental perturbations are modeled by a Levy process was considered. We show that the model has a unique positive solution. Sufficient and necessary conditions for the stability in mean and extinction of each population are established. The obtained numerical result reveals that the Levy noise can change the properties of the population systems significantly and it can force the population to die out. This is not the case for the deterministic model, which persists in the positive steady state for all parameter values.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

A P^1-Lagrange Interpolation operator in $\mathbb{R}^d$ regarded as a neural network

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Abstract :

We study the problem of interpolating d-dimensional data with $\mathbb{P}^1$ polynomials by minimizing a convex data-fidelity cost function, involving the barycentric coordinates of the $d+1$-nearest neighbors. Data points distributions are not required to be structured, and the nearest neighbors are computed through a penalized minimization process in order to get a no degenerate d-simplex. The proposed interpolation operator is local, and a global one can be built which will be no more polynomial. Some numerical results are provided showing the efficiency of the proposed method.

Keywords : Learning neural network, $\mathbb{P}1$ Lagrange interpolation operator, Nearest neighbors strategy

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February 20-22, 2023, Mines School of Rabat, Morocco

Minimizing total tardiness and earliness for permutation flow shop scheduling problem, under the constraint of sequence independent setup time

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Abstract :

In this paper, we study one of the most important issues met in production management. It consists in minimizing total tardiness and earliness for permutation flow shop scheduling problem, under the constraint of sequence independent setup time. This constraint is found in several industries and permits to model and simulate the reality encountered in production management. To better tackle this problem, our approach consists first in modeling mathematically the studied problem as a mixed integer linear program (MILP) and solving it with LINGO software. Given that the exact methods are limited to solve just the problems of small size because of the great complexity of this kind of issues and the limited capacity of calculation machines, the approach consists also in developing three heuristics, based on Johnson and NEH procedures, after comparing the solutions got by these heuristics to the optimal solution got by the exact method of MILP. The computation tests results show that the heuristic, based on NEH procedure and using the rule of the earliest due date, is the best one in terms of solution quality, to approximately solve this type of scheduling problems.

Keywords : Flow shop, Scheduling, Optimization, Mathematical modeling.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

A new multi-strains epidemiological model : analytical study and neural network simulations‘

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Abstract :

In this paper, we investigate the asymptotic behavior of a two-group epidemiological model governed by a system of ordinary differential equations. The work has three principal goals. First, we will use Euler's method explicit method to generate training and test data sets corresponding to the solution of the (ODE). Second, we establish a deep learning framework for the state's simulation of the dynamical system associated with the model. Then, we simulate for different parameter values, the asymptotic behavior of the model. We compare, in a discussion section, the performances of the deep learning model with the classical Euler framework.

Keywords : Multi-strains epidemic models, Euler's method, Stability analysis, Neural network, neural-ode, Basic reproduction number, Covid-19 modeling.

Acknowledgment :

This work is supported by the "Partenariat Hubert Curien France-Maghreb : 22MAG22" project entitled : "Modélisation mathématique et Contrôle de la propagation des maladies infectieuses en zone méditerranéenne".

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
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Discrete superconvergent degenerate kernel method for Fredholm integral equations

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Abstract :

Approximate solutions of integral equations using methods related to an interpolatory projection involve many integrals which need to be evaluated using a numerical quadrature formula. In this paper, we propose the discrete version of the superconvergent degenerate kernel method for solving Fredholm integral equation of the second kind with a smooth kernel. Using sufficiently accurate numerical quadrature rule, we obtain optimal convergence rates for both approximated solution and iterated discrete solution. Numerical results are presented to illustrate the theoretical estimates for the error of this method.

Keywords : Degenerate kernel method, Interpolatory projection, Gauss points, Nyström approximation.

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Modeling and forecasting financial time series using Artificial Intelligence tools

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Abstract:

Forecasting plays an important role in the management of several fields including: industry, economics, management, meteorology, signal theory, biology, etc. The purpose of this work is to modelizer relationships between data in order to predict short or medium-term values of time series.

In this work, we talk about in the evolution over time of time-dependent indicators that can be modeled by time or chronological series, with the aim of describing them, explaining them and then predicting them in the future, especially: activity indicators, effectiveness indicators, efficiency indicators and performance indicators. Most time series and particularly financial series are very noisy and non-stationary. The presence of these two constraints leads, intuitively, to couple Artificial Neural Networks with KALMAN Filter or with Wavelet Transform for the prediction of these time series. Using MATLAB and R language, The prediction simulation results show that the proposed models are capable of producing reasonable accuracy.

Two contributions of this work have already been made for modeling and forecasting in the field of time series:

1. The use of the coupling of the **E**xtended **K**ALMAN **F**ilter (**EKF**) with the **N**on-**L**inear **A**utoregressive **A**rtificial **N**eural **N**etwork (**NLAANN**) to propose the 1st model named "**EKF-NLAANN**". This model was used, as an application, to predict the daily price of steel from steel prices between 2013 and 2016. Then, the realization of a comparative study between the proposed model and several other forecasting models. This showed that the "**EKF-NLAANN**" model improves the forecast results for the financial series studied.
2. The fusion of the **D**iscrete **W**avelet **T**ransform (**DWT**) with the **N**on-**L**inear **A**utoregressive **A**rtificial **N**eural **N**etwork (**NLAANN**) to propose the 2nd model named "**DWT-NLAANN**". This model was used to analyze and forecast the following three financial series:
   - **i.** Price of Brent oil from prices between 2015 and 2020;
   - **ii.** EUR/USD (Dollar) exchange rate from rates between 2015 and 2020;
   - **iii.** Price of the NASDAQ (National Association of Securities Dealers Automated Quotations) composite from prices between 2015 and 2020.

   The "**DWT-NLAANN**" model allowed to generate historical accurate results and it surpassed the efficiency of the other models proposed in the literature.

For the realization and the validation, we used a sample of size 819 for the 1st model "**EKF-NLAANN**" and a sample of size 1550 for the 2nd model "**TOD-RNAANL**" with 70% of data for training, 20 % of data for validation and 10% of data for testing.

As a conclusion, the two models presented in this work for financial time series forecasting are hybrid and improve forecasting. The performances of "**EKF-NLAANN**" model and of "**DWT-NLAANN**" model were evaluated. It has been verified that data processing using extended KALMAN filter, before training the nonlinear autoregressive neural network leads to better performance. A comparison of results of the "**DWT-NLAANN**" model with two other models confirms the interest of decomposing data using discrete wavelet transform before training the nonlinear autoregressive neural network.

As a results of simulations, the two proposed models clearly exceed those obtained, in the literature, using **A**uto-**R**egressive **I**ntegrated **M**oving **A**verage "**ARIMA"** model, **G**eneral **A**utoregressive **C**onditional **H**eteroskedasticity "**GARCH"** model and **N**on-**L**inear **A**utoregressive **N**eural **N**etworks "**NLANN**" model (inputs not decomposed).

Keywords: Forecasting, KALMAN Filter, MATLAB, Modeling, Neural Networks, R language, Time Series and Wavelet Transform.

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Influence du type de sol sur la réponse sismique de la structure en considérant l'interaction sol-structure

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Résumé :

L'objectif de cette contribution est d'étudier l'effet de l'intersection sol structure (ISS) sur la réponse sismique d'une structure en béton armé en considérant quatre vitesses des ondes selon les types de sol citées dans l'EUROCODE 8.

En effet cette prise en compte de l'interaction (sol-fondation) est traduite à partir des fonctions d'impédance associées à un système ressort-amortisseur, intégrant ainsi la flexibilité du sol.

En analysant premièrement l'effet de l'intersection sol et structure (ISS) sur la période de la structure, deuxièmement sur l'amortissement total de structure et finalement sur le déplacement de point de performance de la structure après une analyse statique non linéaire PUSH-OVER..

Mots clés : ISS, la réponse sismique, point de performance.

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DOCUMENT PROCESSING USING ROBOTIC PROCESS AUTOMATION TECHNOLOGY AND ARTIFICIAL INTELLIGENCE

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Abstract:

Currently, with the digital transformation of companies generating real commercial revolutions, institutions have focused on the fact that their employees must use the maximum of their time and energy to accomplish important tasks with added value and requiring the "human hand". ".

In this sense, Due to the large amount of documents (bills of lading, invoices …), also the are very different (PDF, Word, GIF) and come from diverse sources (email, OneDrive) a large number of rules had to be respected and the tasks are very error-prone.

As a result, our solution is increasingly popular in a context of digital transformation which consists of integrating Robotic Process Automation (RPA) technology and Automation Anywhere which seeks to automate and delegate document processing to robots to provide an enhanced experience to employees and increase their satisfaction rates. We also wanted to reduce the number of errors associated with the manual execution of tasks, the number of processing hours and the overall costs.

the Automation Anywhere Solution consists of creating robots and IQ robots to classify, extract and validate the documents and further helps in processing unstructured data using Artificial Intelligence Technologies such as Computer Vision, Machine Learning and Text Classification.

Keywords: *Digital transformation, document processing, Robotic Process Automation (RPA), Automation Anywhere, Artificial Intelligence, Machine Learning.*

International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Physics-Informed Machine Learning for Nuclear Engineering Problem

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Abstract :

We introduce a Physics-Informed Machine Learning approach (PIML) that is used to solve supervised learning tasks while respecting any given law of physics described by general nonlinear partial differential equations. In this work, the Physics-Informed Machine Learning method is applied to a case study of nuclear reactor physics with the neutron diffusion model. The PIML results was compared against the references ones for the neutron flux, Effective Multiplication factor and the power solutions.

Keywords : Physics-Informed Machine Learning, Neural Networks, Nuclear Reactor Physics, Neutron Diffusion Equation.

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Energy improvement of the steel slab reheating furnace : combustion of the fuel/waste oil mixture

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Abstract :

This study aims to improve combustion and minimize costly fuel consumption by taking into account its effect on the environment in a steel reheating furnace. It is essential to seek a solution that covers the technical and economic feasibility of the valorization of the fuel/waste oil mixture by combustion in the reheating furnace. Waste oil is a real competitor of heavy fuel oil although it is an excellent combustible, with a very competitive calorific value and a cheaper price as well as a low sulfur content which assimilates waste oil to fuel oil (< 1 by mass). It represents a very difficult structure to identify and therefore to use. Hence the importance of conducting analyses to guide treatment and use procedures. The energy contribution of waste oil depends on its physicochemical characteristics, as well as the combustion emissions.

Keywords : Fuel/waste oil mixture, reheating furnace, filtration process, combustion, physicochemical characteristics.

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Pedagogical Engineering

International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

Le Digital Learning pour une performance éducative des EPEF : Perception et Intention des élèves ingénieurs

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Abstract:

Digital Learning, also known as e-learning, has many benefits for students and teachers, such as flexibility, accessibility and the ability to personalize/customize learning. Digital learning has experienced significant growth in recent years which has been particularly accelerated by the COVID-19 pandemic, forcing many public education establishment (PEE) to adopt it in order to continue to deliver quality programs. However, there are still challenges to overcome to ensure equitable access and effective use of digital learning by students.

Understanding the factors that influence engineering students' perception and intention for digital learning is important to improve the efficiency and adoption of this form of education. This research aims to contribute to a better understanding of these factors, which can be taken into account when planning and managing digital learning programs in Morocco.

We will use Davis' TAM model and Ajzen's theory of reasoned action or intention to frame our analysis. The Technology Acceptance Model (TAM) is a widely used model in technology adoption research and aims to understand how individuals perceive and use a given technology. It postulates that acceptance and use of a technology depend on two key factors : perceived ease of use and perceived utility. Ajzen's intention theory, on the other hand, focuses on how individuals form intentions to act and how these intentions influence their behavior. By combining these two models, we can better understand how engineering students' perceptions of digital learning influence their intention to use it. This paper is based on a survey of a sample of engineering students whose data collected and modeled in structural equations (whose estimation method used is the Partial Least Square or PLS method).

Keywords : Digital Learning, Perception /Intention, Theory of Reasoned Action

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

Structuring the subject matter and organization of teaching to develop an intelligent tutoring system

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Abstract :
Educational systems evolve with the evolution of the multiple characteristics of the learner. The latter is the most important variable that is in direct interaction with the system and to which one must adapt during the learning sessions, to develop an intelligent and adaptive tutorial system. Each objective regroups the set of skills that a learner must acquire before moving on to the next purpose. Therefore, a division of the course is necessary, this can will be made using the CREAM approach. After applying this approach, the learning content is presented according to the learner's progression and responding to the didactic resources, in order to validate the objective to be evaluated, that's will be applied according to the concept of ZPD, which corresponds to the learning possibilities of a student.

Keywords : Educational systems, Intelligent Tutorial Systems (ITS), teaching subject, learning, CREAM, ZPD.

International Conference of Numerical Analysis and Optimization Days (JANO'14)

February 20-22, 2023, Mines School of Rabat, Morocco

E-Assessment of Mathematics in Higher Education: Practices, Challenges, and Opportunities

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Abstract:

The COVID-19 pandemic and the rapid growth of information and communication technologies (TIC) have led to a significant increase in digital transformation of learning in higher education in Morocco. As a result, the Ministry of Higher Education has developed several initiatives and projects to promote e-learning. However, there is still lack of understanding about how to effectively implement e-assessments for students. This research study aims to investigate this issue by analyzing the use and the practices of e-assessment in mathematics in Higher Education. The study will also focus on opportunities and challenges in implementing e-assessments in mathematics and provide recommendations for overcoming these challenges.

Keywords: e-assessment, e-learning, digital transformation, higher education, mathematics, practices, challenges, Opportunities, COVID-19, TIC.

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International Conference of Numerical Analysis and Optimization Days (JANO'14)
February 20-22, 2023, Mines School of Rabat, Morocco

An exploratory study of the reality and perspectives of using a video in distance learning mathematics

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Abstract :

The integration of the audiovisual in teaching certain branches of mathematics has shown its great effectiveness, given its different characteristics. This study examines the current reality and the potential future of the use of video in distance mathematics education. The aim is to examine the effectiveness of video teaching in comparison to traditional methods of teaching mathematics in a distance learning context. In addition, the study identifies the potential challenges and opportunities of using video in this context. The results of this study will provide valuable information for educators and educational institutions seeking to improve the effectiveness of distance learning for mathematics education through the use of video instruction. For example, we will present the analysis of some instructional videos recorded in the MathICs project activities, using a grid we have prepared in order to examine all the details of each capsule.Then we will close this presentation with a brief summry to the rules that make a well structured pedagogical video (scenario).

Keywords :Educational video capsule, audio-visual, learning support, Mathics.

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