Conference Proceedings

Report

Coordinators: Youssef EL FOUTAYENI & Chaouki AOUITI
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Conference Proceedings Report
The first International Conference on Differential Equations and Dynamical Systems DEDS’2021 is aimed to bring researchers and professionals to discuss recent developments in both applied mathematics and computer science and to create a professional knowledge exchange platform between mathematicians, computer science and other disciplines. This conference is the result of international cooperation bringing together African and European universities. It is a privileged place for meetings and exchanges between young researchers and high-level African and international decision makers in the fields of mathematics and applied computing.

This conference has several major objectives, in particular:

- To bring together doctoral students and research professors in the fields of applied sciences and new technologies.
- To consolidate the scientific cooperation between the university and the socio-economic environment in the field of applied sciences.
- To allow young researchers to present and discuss their research work before a panel of specialists and university professors.
- To contribute to the development of a database, which can help decision makers to opt for a better management strategy.

The abstracts of these conference proceedings were presented at the first International Conference on Differential Equations and Dynamical Systems DEDS’2021. These conference proceedings include abstracts that underwent a rigorous review by two or more reviewers. These abstracts represent current important work in the field of Mathematics and are elaborations of the DEDS conference reports.

We wish to acknowledge the conference program committee and reviewers, for their substantial contributions and our institutions, for their support.

Sincerely,
On behalf of Organizing Committee of DEDS 2021

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ABOUT DEDS’2021

The Analysis, Modeling and Simulation laboratory (Hassan II University of Casablanca, Faculty of Sciences Ben M’Sik, Morocco) AND The Geometry, Analysis and Applied Mathematics Laboratory (University of Carthage, Faculty of Sciences of Bizerte, Tunisia) organize the first International Conference on Differential Equations and Dynamical Systems DEDS’2021. We will be inviting our community to engage in new ways, and hope that DEDS 2021 will be an important space for discussion on the Differential Equations and Dynamic Systems.

The topics of the conference will be as follow
[1] Population dynamics, control and automation

Keynote speakers

Prof. BASSEM BEN HAMED
University of Sfax | Tunisia
Prof. MOHSEN MIRAOU
University of Kairouan | Tunisia
Prof. MUSTAPHA RACHIDI
INMA-UFMS, Campo-Grande | Brazil
Prof. CEMIL TUNC
Yediyuniversitesi Yil University | Turkey
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Mathematical study of harmful dinoflagellate phytoplankton model
I AGMOUR, N BABA, M BENTOUNSI, N ACHTAICH, Y EL FOUTAYENI
Laboratoire d'Analyse, Modélisation et Simulation (LAMS), Université Hassan II, Casablanca, Maroc

Abstract (between 15 and 30 lines)
The presence of populations’ potentially harmful dinoflagellate phytoplankton like Oxyrrhis marina requires vigilance and control, because these species, in high density or under certain conditions, can have serious economic consequences and a negative impact on public health. In this investigation, we formulate bioeconomic model of a prey and predator planktonic species. The positivity and boundedness of the solution are studied. The possible equilibriums and their local stability are analyzed; also the global stability of the system around the interior equilibrium is established. We examine the optimal harvesting policy to discuss the dynamical profit of the interacting planktonic species. To show the impact of the toxicity coefficient, we have made analytical estimates that are validated using simulations.

References
WELL-POSEDNESS OF PARABOLIC PROBLEMS WITH NON-AUTONOMOUS PAST IN THE HIGHEST-ORDER DERIVATIVES
S. Boujijane, S. Boulite, L. Maniar

Abstract (between 15 and 30 lines)
Partial differential equations with nonautonomous past present a generalized type of delay equations, in the sense that the historic function is modified by an evolution equation in the past time. This generalization was introduced for the first time by S. Brendle and R. Nagel in [2] and passed to the $L^p$ setting by G. Fragnelli and G. Nickel in [3].
This type of systems is motivated by many applications in real-life models, essentially in population dynamics and biology.
As for the simple delay, it presents more essential difficulties if one allows for unbounded operators to act on the delay terms with order less or equal to the order of the undelayed part.
In this talk, we study this type of equations, in which we allow unbounded operators with the same order as of the undelayed part to act on the modified delay terms.
Using time-invariant regular systems with feedback theory and semigroup theory, we show that this type of problems generate a strongly continuous semigroup in a restricted data space; by assuming the maximal regularity on the undelayed term and by the interpolation theory. Moreover, we study the asymptotic behavior of the solutions. This study is considered a generalization of the wellposedness in the case of simple delay equations, showed by Bátkai and Shnaubelt in [1].

References
The mathematical study of Scomber Colias and Thynnus Thunnus with presence of the parasites
Nossaiba Baba, Imane Agmour, Youssef El foutayeni, Naceur Achaich

Abstract (between 15 and 30 lines)
In the literature, we found that the authors consider either epidemic models or bioeconomic models but without treating the disease of fish populations. In this work, we have developed and studied a new model concept that combines the bioeconomic model, and the epidemiological model (bioeconomic-epidemiological model) of prey-predator marine populations is developed in which both susceptible and infected prey populations (Scomber colias) are exposed to the predator (Thunnus thynnus), with varying degrees of exposure. However, the predator feeds preferentially on the most numerous prey types. This implies a kind of switching from the susceptible class to the infected class, and vice versa, as these two types of prey change in numerical superiority.
So, the positivity, boundedness, equilibria, stability, and bioeconomic equilibrium are studied. Some numerical simulation of stability is cited. For giving a high yield and keeping the Scomber colias and Thunnus thynnus populations away from extension, we use the Maximum Principle of Pontryagin and to study the optimal control problem numerically, we use the forward-backward Rung-Kutta sweep method.

References
NEW AUTOMATED OPTIMAL VACCINATION CONTROL WITH A MULTI-REGION SIRS
Hamza Boutayeb, Sara Bidah, Omar Zakary, Imane Agmour, Mostafa Rachik

Abstract (between 15 and 30 lines)
Many mathematical models describing the evolution of infectious diseases underestimate the effect of the Spatio-temporal spread of epidemics. Currently, the COVID-19 epidemic shows the importance of taking into account the spatial dynamic of epidemics and pandemics.
So, we consider a multi-region discrete-time SIRS epidemic model that describes the spatial spread of an epidemic within different geographical zones assumed to be connected with the movements of their populations (cities, towns, neighbors...). [1,2,3]
Judging by the fact that there are several restrictions in medical resources and some delay in decision-making, the authorities and health decision-makers must define a threshold of infections in order to determine if a zone is epidemic or not yet.
We propose a new approach of optimal control by defining new importance functions to identify affected zones and then the need for the control intervention. This optimal control strategy allows reducing the infectious individuals and increasing the number of recovered ones in the targeted domain and this with an optimal cost.
Numerical results are provided to illustrate our findings by applying this new approach in the Casablanca-Settat region of Morocco.
We investigate different scenarios to show the most effective scenario, based on thresholds’ values.

References

H. MOUTAMANNI, A. LABZAI, J. BOUYAGHROUMNI, M. RACHIK.

Abstract (between 15 and 30 lines)

The prosperity in the marine fishing sector in Morocco in recent years has led to an increase in research efforts to reduce the kingdom’s expenditure. Understanding the process of structuring the exploited population and understanding the issues of exploitation and the marine environment are crucial to implementing management measures to sustain national fisheries. In this work we have built a discrete time multi-region model to describe the dynamic of fishing Sardine (Sardina Pilchardus) and Chub Marckel (Scomber Colias) in three zones in the Atlantic Coast. The control parameter proposed in this model will not only save the equilibrium between marine population and fishing effort, but it will also maximize profit. In order to calculate the optimal system we use a discrete version of Pontryagin’s principal maximum. The numerical simulation is carried out using Matlab. Consequently, the obtained results confirm the performance of the optimization.

The model that we will study is a discrete multi-region model, which describes the fishing of two competing pelagic species x (sardina Pilchardus) and y (Scomber Colias); Essentially these two species (Sardine and Chub Mackerel are found all along the Atlantic (North Zone, Center Zone and finally South Zone) We focus the study on the Atlantic since statistics in the Mediterranean are rare. Our model is a discrete multi region version of Auger model, we take also the general Cobb-Douglas harvestiong function of fishery.

References

Global threshold dynamics of an age-vaccination model with treatment and general nonlinear incidence rate.

A. Ouakka, A. El Azzouzi, Z. Hammouch

Abstract (between 15 and 30 lines)

Vaccination and treatment are the two of the most control strategies to minimize the burden of an infectious disease spread. The role of vaccination is protecting healthy individual from getting infected by a disease. However, treatment is cures a disease once it has developed and get rid of it, which is the stage that follows diagnose in order to remove all symptoms and causes of the disease.

In order to explore the vaccination effects on the disease transmission, a variety of compartment epidemic models were integrating vaccination schemes are studied and developed. In 2014, Duan et al. [1] formulated an $SIVS$ epidemic model with age of vaccination and a bilinear-type of incidence rate. Thereafter, Yang et al. [2] studied the same model with saturated-type of incidence rate.

We propose in this talk to study mathematically the $SVIR$ model mentioned above with a nonlinear incidence rate in its very general form and with a general function treatment. We prove the existence, uniqueness and positivity of solutions of our model by using integrated semi-group theory. Based on the basic reproduction number $R_0$ 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. Finally, we illustrate our theoretical results by numerical simulations and we exemplify the effect of the treatment and the vaccination on the disease prevalence.

References


Abstract (between 15 and 30 lines)
The main purpose of this article is to prove a logarithmic convexity estimate for the solution of a linear heat equation subject to the dynamic boundary conditions in a bounded convex domain, which is an estimate of the energy at a fixed time on the whole domain in terms of the energy at the same time but on a small subdomain. Using a new strategy combining the logarithmic convexity method and a Carleman commutator approach (see [1,2]).

As an application, we prove the impulsive null approximate controllability for an impulsive heat equation with dynamic boundary conditions, which consists of finding an impulsive control steering approximately the system from an arbitrary initial state to a final state in a finite interval of time. This type of control is very weak function, since it acts only in a subdomain $\omega$ and at one instant of time $\tau \in (0,T)$, which makes the problem of controllability for the heat equation with impulse control very challenging. Unlike the interior controllability for impulsive systems that have been extensively studied in the literature, see for instance [3,4,5] and the references therein, the problem of controllability with impulse controls has attracted less attention and not as many works are available in this area.

References
Delayed feedback control for the performance of a flow energy harvester

Zakaria Ghouli
Polydisciplinary Faculty of Taroudant, University Ibn Zohr, Morocco

Abstract
The present work examines periodic vibration-based energy harvesting in a delayed harvester device consisting of a delayed nonlinear oscillator subject to galloping excitation and coupled to an electric circuit through a piezoelectric coupling mechanism. The dimensionless governing equations for the system can be written as

\[ \ddot{x}(t) + \mu x(t) + \xi_1 \dot{x}(t) + \xi_3 \dot{x}(t)^3 + \gamma x(t)^3 - \kappa v(t) = \lambda(t)x(t - \tau) \]  
\[ \dot{v}(t) + \alpha v(t) + \dot{x}(t) = 0 \]

Here \( x(t) \) is the transverse displacement and \( v(t) \) is the voltage across the load resistance. The coefficients \( \xi_1, \xi_3 \) are, the mechanical damping components, \( \mu \) the naturel frequency of the harvester, \( \gamma \) the stiffness, \( \kappa \) the piezoelectric coupling term in the mechanical attachment, and \( \alpha \) the reciprocal of the time constant of the electrical circuit. The parameter \( \lambda(t) \) is the feedback gains in the mechanical attachment and \( \tau \) is the time delay. It is assumed that the delay amplitude is modulated such that the frequency of the modulation is near twice the natural frequency of the oscillator. Application of the method of multiple scales gives approximation of the amplitude of periodic vibrations and the corresponding power extracted from the harvester device. Results show that the presence of modulated delay amplitude in the mechanical component increases significantly the amplitude of vibrations and the output power in a certain range of the wind speed. Numerical simulation is conducted to support the analytical predictions.

References
On the existence of solution of an age-structured dynamics model of a pest insect population
Sidi Mohammed ABDERRAHIM, Ali MOUSSAOUI, Bedreddine AINSEBA

Abstract:
Les insectes ravageurs causent de gros dégâts dans l’agriculture moderne et entrainent un surcoût économique lié à l’usage intensif des pesticides.
Dans ce travail de thèse on se propose de tester via l’élaboration de modèles mathématiques décrivant le cycle de vie de l’insecte ravageur différents types de contrôles biologiques.
Ces contrôles doivent être positionnés d’une manière optimale pour diminuer les risques d’attaques et les surcoûts liés à l’usage intensif de pesticides.
Les modèles utilisés seront du type systèmes d’équations aux dérivées partielles hyperboliques d’ordre un chaque équation représente un stade important dans le cycle de vie pour cette insecte ravageur, avec des vitesses de développement dépendant des conditions environnementales (Températures, humidité, pluviométrie, disponibilité des ressources, …) et des taux de transition et de mortalité non locaux.

References
In this paper, we study a class of nonlinear parabolic problems whose simplest model is given by

\[(P_1) \begin{cases} u_t - \text{div}[a(t,x,u)(1 + |u|)^m|\nabla u|^{p-2}\nabla u] = \mu & \text{in } Q := (0,T) \times \Omega, \\ u(t,x) = 0 & \text{on } (0,T) \times \partial \Omega, \\ u(0,x) = u_0(x) & \text{in } \Omega, \end{cases}\]

where \(\Omega\) is a bounded open set in \(\mathbb{R}^N\) \((N \geq 2)\), \(T > 0\), the vector field \(\alpha \leq a(t,x,u) \leq \beta\) (for some constants \(\alpha, \beta > 0\)), \(m \geq 0\), \(u_0 \in L^1(\Omega)\) and \(\mu\) is a bounded Radon measure on \(Q\). We show, under which condition on \(m\), problem \((P_1)\) admits a solution and we prove some regularity results. Moreover, in presence of a lower order (perturbed) term with natural growth

\[(P_2) \begin{cases} u_t - \text{div}[a(t,x,u)(1 + |u|)^m|\nabla u|^{p-2}\nabla u] + (1 + |u|)^{r-1}u|\nabla u|^p = \mu & \text{in } Q := (0,T) \times \Omega, \\ u(t,x) = 0 & \text{on } (0,T) \times \partial \Omega, \\ u(0,x) = u_0(x) & \text{in } \Omega, \end{cases}\]

We prove some a priori estimates on weak solutions for \(m > r + 1\) \((r \in \mathbb{R})\). Our methods rely on compactness arguments and convergence results, which give evidence of the optimality of the results.

References

Analyse de la stabilité et de la bifurcation de Bogdanov-Takens du nouveau système de coronavirus (2019-nCov) avec retard
Achouri Houssem, Aouiti Chaouki

Abstract:
Dans cet article, le nouveau système de coronavirus (2019-nCov) avec retard est pris en compte : 
\[
\begin{align*}
\dot{S}(t) & = \sigma_1 - \mu S(t) - \alpha_1 S(t)(I(t) + \eta A(t)) - \alpha_2 S(t)M(t), \\
\dot{E}(t) & = \alpha_1 S(t)(I(t) + \eta A(t)) + \alpha_2 S(t)M(t) - [(1 - \gamma_1)\gamma_2 + \gamma_1\gamma_4 + \mu]E(t), \\
\dot{I}(t) & = (1 - \gamma_1)\gamma_2 E(t) - \beta_1 I(t - \tau) - \mu I(t), \\
\dot{A}(t) & = \gamma_1\gamma_4 E(t) - (\beta_2 + \mu)A(t), \\
\dot{R}(t) & = \beta_1 I(t - \tau) + \beta_2 A(t) - \mu R(t), \\
\dot{M}(t) & = \beta_3 I(t) + \gamma_3 A(t) - \sigma_2 M(t)
\end{align*}
\]
Où S (.), E (.), I (.), A (.) et R (.) représentent respectivement les personnes sensibles, exposées, infectées, asymptomatiquement infectées et les personnes rétablies. M (.) qui est désigné comme le réservoir ou la place ou le marché de fruits de mer. \( \tau \) est le délai dû à la période utilisée pour guérir la population infectée.

Dans un premier temps, on va discuter la stabilité locale au point d'équilibre sans maladie. Dans un second temps, en choisissant les deux paramètres joignant les personnes infectées et asymptomatiquement infectées aux personnes rétablies comme paramètres de la bifurcation, le point critique auquel une racine nulle de multiplicité deux apparaît dans l'équation caractéristique associée au système linearisé. Dans une troisième étape, on va étudier les zéros d'un polynôme exponentiel afin de nous assurer que, à part la racine double zéro, toutes les autres racines de l'équation caractéristique ont des parties réelles négatives. De plus, on retrouve les valeurs critiques pour garantir l'existence de la bifurcation de Bogdanov-Takens au point d'équilibre endémique. La forme normale est obtenue et ses comportements dynamiques sont étudiés après l'utilisation de la réduction sur la variété centrale et la théorie de la forme normale. Pour la démonstration de nos résultats, on va finir par donner un exemple numérique et ses simulations numériques.

References
Quelques Propriétés sur l'Ordre \([p,q]\) des Solutions Méromorphes des Équations Différentielles Linéaires

M. SAIDANI, B. BELAÏDI

Résumé
Dans ce travail, nous étudions la croissance des solutions méromorphes des équations différentielles linéaires

\[
A_k f^{(k)} + A_{k-1} f^{(k-1)} + \cdots + A_1 f' + A_0 f = 0,
\]

\[
A_k f^{(k)} + A_{k-1} f^{(k-1)} + \cdots + A_1 f' + A_0 f = F,
\]

où \(A_j(\neq 0)(j=0,\ldots,k),F\) sont des fonctions entières d’ordre \([p,q]\) fini. Nous étendons quelques résultats de Long et Zhu [3] et ceux de nos résultats dans [4], nous obtenons de nouveaux résultats sur l’ordre \([p,q]\) et le \([p,q]\)-exposant de convergence des zéros des solutions pour de telles équations.

2010 Mathematics Subject Classification: 34M10, 30D35.

Mots Clés:
Fonctions entières, ordre de croissance, équations différentielles linéaires.

References
A Fast Algorithm for Solving a Class of the Linear Complementarity Problem in a Finite Number of Steps

Y. Achik, A. Idmbarek, H. Nafia, I. Agmour and Y. El foutayeni

Abstract
A Linear Complementarity Problem LCP associated with a square matrix $M \in \mathbb{M}_{n \times n}$ and a vector $q \in \mathbb{R}^n$, consists in finding a vector $z \in \mathbb{R}^n$ that verifies the following three conditions: $0 \leq z \perp (Mz + q) \geq 0$. These problems are often NP-hard and therefore difficult to solve when the dimension $n$ of the problem becomes large. The combinatorial nature of the problem comes from the fact that one must determine which components of the solution are zero and there are $2^n$ possibilities to achieve this. For this reason, this problem is receiving a lot of attention and has been studied extensively. Recently, El foutayeni et al. have contributed many works that aim to solve this mysterious problem. However, many results exist and give good approximations of the linear complementarity problem solutions. The major drawback of many existing methods resides in the fact that, for large systems, they require a large number of operations during each iteration; also, they consume large amounts of memory and computation time. This is the reason which drives us to create an algorithm with a finite number of steps to solve this kind of problem with a reduced number of iterations compared to existing methods. If the solution of this linear complementarity problem exists, then we prove, under certain predefined assumptions on the matrix $M$ where we will introduce a new class of matrices called E-matrix, that the proposed algorithm converges to this solution. In order to clarify the speed of our algorithm as a function of time and the number of iterations, we apply this algorithm to some numerical examples, and also compare it to other methods.

References
Control of a reaction-diffusion system: application on a SEIR epidemic model

A. Alabkari, K. Adnaoui, A. Bennar

Abstract (between 15 and 30 lines)

In epidemiology, mathematical modeling has become an important tool for analyzing the causes, dynamics and spread of epidemics. Indeed, mathematical models provide a better understanding of the mechanisms underlying the spread of emerging infectious diseases, and allow authorities to make decisions about effective control strategies. One of the most basic procedures in disease modeling is to use a model, in which the population is divided into different groups depending on the stage of infection, with assumptions about the nature and rate of transfer time from compartment to another. Several diseases that confer immunity against reinfection have been modeled using SIR, SIS, SEIR ... etc.

In this work, we are interested in the study of a spatiotemporal SEIR epidemiological model, with no-flux boundary conditions. This model includes a constant inflow of new susceptible, exposed, infectious and recovered. In addition, it also incorporates a contact rate depending on the size of the population and another death related to the disease. Our objective is to characterize the optimal control pair, which minimizes exposed, infected individuals and the corresponding effort and treatment costs.

References
Abstract (between 15 and 30 lines)
Fluctuations in oil prices pose a permanent threat to oil producers because they place these operators at significant risk of financial loss. For this we proposed to use the American options as a tool to solve this problem. Our goal is to estimate the American put option prices through mathematical modeling, and more specifically by using the linear complementarity problem. In this context, we reformulated a problem of valuation of American put options to the linear complementarity problem. The model described in this presentation is the Black and Scholes model. This model assumes that the underlying asset does not pay any dividends during the term of the option, but in our work, we gave interest to the dividend payment by adding a dividend rate to the equation of Black and Scholes, and the impact of the change in the dividend rate on the price of the American put option was discussed. Space and time are discretized with the finite difference method in the Crank-Nickolson approach, which leads to present the American put option price as a unique solution to the linear complementarity problem. Regarding the uniqueness of the solution, we have shown that the matrix associated with the linear complementarity problem is a P-matrix. To solve this problem and evaluate the put option, we used a fast algorithm. We applied our study to an example on oil options.

References
Abstract (between 15 and 30 lines)
In this paper, we investigate a free terminal time optimal control applied to 6 ordinary differential equations which describe the spread of COVID-19 infection. We propose an extension of the classical Susceptible-Exposed-Infectious-Recovered (SEIR) model, where the infectious patients are divided into unreported (U) and reported cases (I). To have a more realistic model, we estimate the parameters of our model using real Moroccan data. We use Bootstrap as a statistical method to improve the reliability of the parameters estimates. The main goal of this work is to find the optimal control strategy and to determine the optimal duration of a vaccination campaign adequate to eradicate the infection in Morocco. For this, we introduce into the model a saturated vaccination function, which takes into account the limited resources on the COVID-19 vaccine, and we formulate a minimization problem where the final time is considered to be free. The existence of optimal control is investigated. The characterization of the sought optimal control and optimal final time is derived based on Pontryagin’s maximum principle. Using Matlab, we solve the optimality system with an iterative method based on the iterative Forward-Backward Sweep Method (FBSM). The numerical simulation results show the efficiency of a vaccination strategy on reducing the number of infectious individuals within an optimal period time.

References
Abstract (between 15 and 30 lines)
We propose to study an epidemic model structured by age for the demographic transition. Cultural norms that lead a population of high fertility (the susceptible) to a population of low fertility (the infected) are transmitted between individuals in the same way as infectious diseases (the demographic transition). We first formulate the basic model as a homogeneous abstract Cauchy problem in a Banach space to demonstrate the existence, uniqueness and well-posed character of the solutions. Then we study the existence of non-trivial exponential solutions. Finally, we study the linear stability of the system near exponential solutions by using asynchronous exponential growth. We study the global stability of the exponential solutions using the lyapunov function. The stability condition is formulated using the notion of reproducibility.

References
[1] H. INABA, R. SAITO, N. BACAËR, "Un modèle épidémique structuré par age pour la transition démographique"
Abstract (between 15 and 30 lines)
In this work we show the existence of solutions to second-order differential inclusion with \( \Phi \)-laplacian satisfying periodic boundary conditions: 
\[
\left( \Phi(x'(t)) \right) \in F(t,x(t)) \quad \text{a.e.} \quad t \in [0,T],
\]
we study the case where the right-hand side is a compact lower semi-continuous multi-valued map and has non-convex values, our approach is based on the existence of upper and lower solutions and on the topological degree, the proof rely on the Bressan-Colombo selection theorem and the Frigon-Granas lower semi continuous type theorem. This kind of inclusions has been study by several authors in the last few years, our problem is solved with Direchlet boundary conditions in case where the right hand side is a Carathéodory multi-valued mapping which verifies other strong conditions, and in the case where the right hand side is lower semi continuous and integrably bounded, see [4]. The method of upper and lower solutions has been successfully applied to study the existence of solutions for initial and boundary value problems for differential equations, this method will be generalized by several authors to resolve the problems where the right hand side is a multi-valued map.

References
Abstract

Infectious diseases have marked the history of human societies. Throughout the centuries and the world, they have always been the leading cause of death. To counter the ravages that infectious diseases can cause, public health decision-makers must have relevant tools to assist them in their decision-making. This work is considered in the framework of studies dedicated to the control problems, especially in epidemiology where scientists are concerned to develop effective control strategies to minimize the number of infected individuals. We set this problem as an asymptotic target control problem under mixed state-control constraints, for a general class of ordinary differential equations that model the temporal evolution of disease spread. The set of initial data, from which the number of infected people decreases to zero, is generated by a new type of Lyapunov functions defined in the sense of viability theory. The associated controls are provided via selections of an adequately designed feedback map. The existence of such selections is improved by using the Micheal selection theorem. Finally, an application to the SIRS epidemic model, with numerical simulations, is given to show the efficiency of our approach.

References

A mathematical model of fractional-order chaotic oscillations for the glycolysis phenomenon originated from periodic substrate supply

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Abstract
Glycolysis is a part of the energy-extraction process in living things. It has been studied for a long time. The glycolysis phenomenon attracts the attention of many scientists to this day and plays an important role in regulating metabolism. Selkov and Higgins [1] are the most significant contributors to this area. There are several models for glycolytic reactions, the first of which was introduced by Higgins. Next, in 1968, Selkov proposed a simple non-linear system of ordinary differential equations with a few main variables. This model is known as the Selkov model [2].

Fractional calculus is a suitable tool for modeling various phenomena in the natural sciences; it attracts the attention of scientists due to its importance in various fields of science such as physical phenomena, chemical processes, and engineering [4]. This work aims to study a mathematical model of glycolysis phenomenon arising from periodic substrate supply involving Caputo fractional-order derivative. We also discuss the existence and the uniqueness of a positive solution to this model as well as its stability and Hopf bifurcation. We show that the fractional Selkov model with periodic influx can depict a range of dynamic regimes, including regular, chaotic, and multi-periodic... The phase portraits, the bifurcation diagram, and the Lyapunov exponent were used to measure this model in numerical form. The dynamics of the fractional Selkov model with periodic influx demonstrated that this model more accurately reflects the glycolysis process than the classical model. The differences are presented by computational simulations, which are our main finding.

We conclude that when applied the fractional-order equation to real-life problems, we obtained better results than the integer-order equation.

References
Global stability for a two-strain SEIR model with bilinear and nonmonotonic incidence
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\textsuperscript{2}Laboratory of Systems Modelization and Analysis for Decision Support, National School of Applied Sciences, University Hassan First of Settat, University avenue, P.O. Box 218, Berrechid Morocco.

Abstract:
Multi-strain SEIR epidemic models are an important tool for studying several infectious diseases that have a long incubation period and diverse infection strains. The interest in studying multi-strain models is to discover the different conditions that allow all active strains to coexist.

A multi-strain SEIR epidemic model with both bilinear and non-monotone incidence functions. Under biologically motivated assumptions, is presented and studied in this paper. We show that the model has two basic reproduction numbers that we noted $R_{01}$ and $R_{02}$ are less than one then the disease-free equilibrium is Globally asymptotically Stable, thus the disease will be eradicated. However, if one of the two basic reproduction numbers is greater than one, then the strain that persists is that with the larger basic reproduction number. And finally, if both of the two basic reproduction numbers are equal or greater than one the total endemic equilibrium is globally asymptotically stable. A numerical simulation applied to the pandemic SARS-CoV-2 is also presented to illustrate the influence of the psychological effect, of people to infection, on the spread of the disease in the population.

Keywords:
SEIR; multi-strain; bilinear incidence; non-monotone incidence.

References
Identification of source terms in heat equation with dynamic boundary conditions

E. M. Ait Ben Hassi, S. E. Chorfi and L. Maniar

Abstract
We study an inverse parabolic problem of simultaneously identifying two source terms in the heat equation with dynamic boundary conditions from a final time overdetermination data. Using a weak solution approach by Hasanov [3], the associated cost functional is analyzed; especially a gradient formula of the functional is proved and given in terms of the solution of an adjoint problem. Then the Lipschitz continuity of the gradient of the cost functional is established. Next, the existence and the uniqueness of a quasi-solution are also investigated. In particular, we present a sufficient condition for the uniqueness of a quasi-solution. The underlying method relies on reformulating a quasi-solution problem as a minimization problem of Tikhonov functional, combined with an adjoint problem approach for calculating the gradient of the cost functional. This approach provides a monotone iteration scheme to reconstruct unknown parameters in ill-posed problems, which implies fast numerical results. Finally, the aforementioned method is implemented via the Landweber iteration algorithm for the numerical reconstruction of some heat sources in a 1-D equation to show the efficiency of the proposed algorithm.

References
The H2-norm of a Fractional-order Transfer Function of the Second Kind

A. LAKEB, Z. KAISSERLI, D. BOUAGADA

Abstract (between 15 and 30 lines)
The fractional linear invariant time dynamical systems can be presented by a fractional-order transfer function [1]. Moreover, the fractional-order transfer function is very useful in the analysis and the design of linear dynamical systems, which can be used to compute the impulse response energy, also known as the H2-norm [6, 7]. The H2-norm has great important in the field of dynamical systems theory, it can be used to measure the precision of the fractional-order transfer function [5, 7]. In addition, there are some analytic formulas to compute the H2-norm of a fractional-order transfer function [4, 5, 6]. For that, the aim of this study is to offer a new method for computing the H2-norm of a fractional-order transfer function of the second kind, which can be written as follows

\[ \forall s \in \mathbb{C}, G(s) = \frac{k}{(s^a + a)(s^a + \overline{a})}, \quad a, k \in \mathbb{C}^* \]

Unlike the previous researches on the H2-norm, the major advantage of this new process is the use of some important tools in systems and control theory, including the state-space model associated with the fractional-order transfer function of the second kind, parahermitian matrix, the integral transform [2, 3, 7] and some condition set out. Some examples are presented which shows the effectiveness of the proposed approach by the use of the MATLAB code.

References
BOUNDARY NULL CONTROLLABILITY FOR THE HEAT EQUATION WITH DYNAMIC BOUNDARY CONDITIONS
S. E. CHORFI, G. EL GUERMAI, A. KHOUTAIBI, AND L. MANIAR

Abstract (between 15 and 30 lines)
The aim of our paper is to prove the boundary null controllability of the heat equation with dynamic boundary condition, more precisely, we prove that the equation is null controllable at any positive time by means of a boundary control supported on an arbitrary subboundary. The proof of the main result relies on a new boundary Carleman estimate for the adjoint system.

As for the standard (scalar) heat equation, a well-known result states that the boundary null controllability and distributed null controllability are equivalent (see [3, Theorem 2.2]). This result is no longer valid for coupled parabolic systems. In our case, one can obtain the boundary null controllability from a distributed control by enlarging the domain. Nevertheless, this technique for dynamic boundary conditions requires more regular initial data than those in the Dirichlet or Neumann cases (see [27, Theorem 4.5]). Our boundary Carleman estimate allows us to recover the boundary controllability result without assuming any further regularity assumption.

In comparison with the classical parabolic equations, where the control acts by means of the Dirichlet condition on a part of the boundary of the domain, the present Carleman inequality requires a different technique to absorb a term of Neumann type (in terms of the normal derivative) by the left-hand side of the Carleman estimate. Absorbing this term turns out to be a main difficulty that will be overcome with help of some parabolic regularity estimates. Such regularity estimates can be very useful while doing Carleman estimates [4]. It is worth mentioning the paper [9] which is the first to deal with a Carleman inequality when a time derivative appears in the boundary condition (but without a boundary diffusion). However, it only considers the one-dimensional case and point out the difficulty of the controllability in higher dimensions for such equations (see Section 4 in [9]).

References
Mathematical study of the influence of pollution rate on the evolution of marine species
F. Bendahou, I. Agmour, Y. El Foutayeni,

Abstract

In this work, we propose a biological model for a migratory mammal species Balaenoptera physalus and the two small pelagic species Sardina pilchardus and Engraulidae. Phocoena is a cetacean species of the family Phocoenidae. The size of this population tends to decrease. The reasons for this decline may be due to marine pollution and death by drowning in fishing nets. This species has become very rare in the Mediterranean and has disappeared on other coasts. The two small pelagic species are also largely threatened by marine pollution.

We will extend our study by determining the equilibrium points of the biological systems in order to explain the behavior of the studied populations and to predict the stability of the equilibrium points of the system.

This work aim is to mathematically analyze the biological model of the predefined marine species taking into account the negative effect of pollution. In addition, we seek to clarify the influence of the pollution rate on the evolution of marine species by comparing the two situations, without the effect of pollution and with the effect of pollution.

References
A spatiotemporal mathematical model for scholar dropout with an optimal control
Ahmed Kourrad, Khalid Adnaoui, Fouad Lahmidi

Abstract
In this paper, we have proposed and analyzed a mathematical model for scholar dropout as a spatiotemporal mathematical model, by considering three variables, namely the numbers of school-age pupils who are in school, the numbers of school-age pupils who dropped out of school and the numbers of school-age pupils reinstated in school after dropping out. Our principal objective is modeling the problem of scholar dropout through parabolic partial differential equations with non-flux boundary conditions and characterize an optimal control that minimizes the number of school-age pupils who dropped out of school. The existence of solutions to the state system and the existence of optimal control is proved. An optimal control characterization in terms of state and adjoint functions is provided. Furthermore, the second condition of optimality is given. The optimality systems are solved based on an iterative discrete scheme that converges following an appropriate test similar to the one related to the forward-backward sweep method.

References
The τ-power stochastic Weibull diffusion process

M. BAHIJ, A. NAFIDI

Abstract (between 15 and 30 lines)

Stochastic differential equations are natural choice to model the time evolution of dynamic systems, which are subject to random influences. Our contribution concerns the development of new stochastic diffusion process. The first step is to define the τ > 0 order power of the Weibull diffusion process, which is considered as an extension of the existing stochastic Weibull diffusion process, by obtaining the probabilistic characteristics of this model, as the explicit expression of the process, its trends, and its distribution. The second step is to demonstrate the computational feasibility of the associated statistical inference by using the maximum likelihood method. Since the system of likelihood equations does not have an explicit solution, numerical methods are needed. To sort out the computational problems associated with the parameters, the simulation annealing method, which is a procedure for finding the estimators values and achieve the study, is proposed. Finally, the model is applied to real modeling data where we analyze the behavior of the results, according to the value of τ > 0 by modeling the age dependency ratio in Morocco. The proposed model adequately describes the change in the ratio trends, and analyzes the behavior of the results provided by the model producing the best statistical fit.

References

Optimization of the two Fishermen’s Profits in consideration of temperature and wind factors

C. RIAHI, Y. EL FOUTAYENI

Abstract
The optimization of a dynamical system that its elements are under biological or economical competition, referrers to a Nash equilibrium problem that maximize the profit of each competitor without manipulating the main strategy of exploitation in term of the protection of the biodiversity.
In our context, we study the bioeconomic equilibrium of three species in competition for food or space or fertility, exploited by two fishermen that tend to maximize their profits, in consideration of the preservation of biological resources [2], Althgout this system doesn't take in consideration factors that can affect the fishing effort as in reality, we can study some of them that can change the real results and improve the prediction of the profits and also consider the improbable factors that can as merging.
In this work we suggest to ameliorate the model of optimization of the biological exploitation resources of three species in competition [2] taking into consideration two factors: temperature and wind, these factors are studied by Markov chain process to guarantee the method of treatment of the different factors, based on the Data of past years, The main purpose of this work is to define the fishing effort that maximizes the profit of each fisherman taking into consideration of two factors.

References
Abstract (between 15 and 30 lines)
The excessive and unsustainable exploitation of our marine resources has led to the promotion of marine reserves as a fisheries management tool. Marine reserves, areas in which fishing is restricted or prohibited, can offer opportunities for the recovery of exploited stock and fishery enhancement. This study examines the impact of the creation of marine protected areas, from both economic and biological perspectives. The consequences of reserve establishment on the long-run equilibrium fish biomass and fishery catch levels are evaluated. We include reserve size as control variable to maximize catch at equilibrium. A continuous time model is used to simulate the effects of reserve size on fishing catch. The model includes two time scales, a fast one associated to quick movements of fish between sites in comparison to a slow one corresponding to the growth of the fish population and the change of the fleet size. We take advantage of these two time scales to derive a reduced model governing the dynamics of the total fish stock and the fishing effort. The objective of this work is to examine the effects of marine reserves size on the levels of fish biomass and the catch in the long term. Studying this aggregated model, we show the existence of an optimal size of reserve marine that maximizes the total fish catch at equilibrium. Simulation results suggest that the establishment of a protected marine reserve will always lead to an increase in total fish biomass, an optimal size of a marine reserve can achieve to maximize the catch at equilibrium.

References

Abstract

In this paper, we aim to investigate optimal control to a new mathematical model that describes agree-disagree opinions during polls, which we presented and analyzed in [2]. We first present the model and recall its different compartments. We formulate the optimal control problem by supplementing our model with a functional objective. Optimal control strategies are proposed to reduce the number of disagreeing people and the cost of interventions.

We prove the existence of solutions to the control problem, we employ Pontryagin’s maximum principle to find the necessary conditions for the existence of the optimal controls, and Runge-Kutta forward-backward sweep numerical approximation method is used to solve the optimal control system and perform numerical simulations using various initial conditions and parameters to investigate several scenarios. Finally, a global sensitivity analysis is carried out based on the Partial Rank Correlation Coefficient method and the Latin Hypercube sampling, to study the influence of various parameters on the objective function and to identify the most influential parameters.

References


Abstract (between 15 and 30 lines)

The main goal of this work is to present the importance of awareness programs and preventive protocols and the quality of the vaccine for COVID-19 to make sure comprehensive immunity for all the community. More than 3 million people died in the world due to the novel coronavirus COVID-19 up to April 16, 2021. Vaccination is critically important to prevent from this disease and save lives.

A mathematical model of the spread and control of the COVID-19 disease that involve vaccination formulated. The reproduction number $R_0$ was calculated as a threshold to find out when the outbreak will die out or expand. The sensitivity analysis applied to the model to discover which index has a high impact on $R_0$. The local and global stability of disease free equilibrium points analyzed under certain conditions that based on $R_0$.

Optimal control theory based on Pontryagin’s maximum principle applied to explore the characterizations of the three controls in our study. Hamilton and Lagrangian is formulated to investigate the existence and to find the solution of the optimal control. A numerical simulation is given to illustrate and compare the obtained results.

Keywords: The COVID-19, vaccination, basic reproduction number, local and global stability, optimal control.

References
A New Non-Homogenous Stochastic Gompertz Diffusion Process
A. Nafidi, N. Makhlouki, Z. Ouahabi

Abstract
The Stochastic Gompertz diffusion process (SGDP) is used to model stochastic phenomena in various fields of science. The homogenous case of this process was applied, for example, in the growth of cancer cells (cf. [1]) and stock of motor vehicles in Spain (cf. [2]). However, the non-homogeneous case in which only the intrinsic growth rate in the drift is affected by exogenous factors (functions of time and some parameters) and with a constant deceleration coefficient, was applied, for example, in the price of new housing in Spain (cf. [3]) and to the emission of CO2 (cf. [4]). In the present study, we define and examine a new non-homogeneous extension of the SGDP, based on the fact that both the intrinsic growth rate and the deceleration factor (cf. [5]) in the drift of this process are affected by exogenous factors. From the corresponding Itô stochastic differential equation (SDE), we obtain the probabilistic characteristics of the proposed process such as the analytical expression as the unique solution of the SDE of the process, the transition probability density function and their statistical distribution, the moments of different orders and, in particular, the conditioned and non-conditioned trends of the process. Finally, the problem of statistical inference of the parameter present in the process is studied by considering discrete sampling and using the maximum likelihood method.

References
A note on behaviors of solutions of integro-differential equations
Osman Tunç

Abstract
As we know Vito Volterra (1860-1940) was an Italian mathematician and physicist, known for his contributions to mathematical biology and integral equations. He is one of the founders of functional analysis. Volterra’s work on elasticity was the origin of his theory of integro-differential equations: He found that for certain substances, the electric or magnetic polarization depends not only on the electromagnetic field at that moment, but also on the history of the electromagnetic state of the matter at all previous instants. These physical facts are modeled by “integro-differential equations”.

In this work, a class of non-linear Volterra integro-differential equations are taken into consideration. For the considered Volterra integro-differential equations, qualitative behaviors of solutions such as uniformly stability, asymptotic stability, instability, integrability and boundedness of solutions are investigated by Lyapunov-Krasovkiĭ method. Here, five new results, theorems, are established on the mentioned concepts. We constructed two new Lyapunov- Krasovkiĭ functional and used them to prove the given new theorems. Finally, a few examples are provided to illustrate the obtained results. Our results have new contributions to the qualitative theory of integro-differential equations. We think they allow new useful information for researchers working on qualitative theory of integral equations and integrodifferential equations.

Keywords: Stability, integrability, boundedness, Lyapunov - Krasovkiĭ functional.
Subject Classification: 34D05, 34K20, 45J05.

References
The relationship between prey and predators by using the switching prey
A. Idmbarek, Y. Achik, I.Agmour, H.Nafia, Y. El foutayeni

Abstract (between 15 and 30 lines)
Linear complementarity problems occur in several scientific fields, in particular in economics. These problems, which are a special case of variational inequalities, consist in finding a vector \( z \in \mathbb{R}^n \) which satisfies the following three conditions:
\[
0 \leq z \perp (Mz + q) \geq 0
\]
where \( M \) is a square matrix of size \( n \) and \( q \) is a vector of \( \mathbb{R}^n \). The existence and uniqueness of the solutions of these problems, whatever, is obtained, if and only if, the matrix is a P-matrix. It is only recently that they have started to interest researchers in economics, and more specifically, researchers working on Nash's equilibrium problems, which it is considered to be a "solution" of a game, in the mathematical sense (solving a system of equations), but not necessarily if by “solution” we mean a prediction of what the players in the situation described by the game will actually do, assuming that they are rational. In particular, bioeconomic modeling leads to a generalized Nash equilibrium problem, to solve this problem, we transform it into a linear complementarity problem (LCP), then we show that the latter admits a unique solution which represents the generalized Nash equilibrium point of our problem. In this context, we model the relationship between prey and predators by studying the interactive behavior of this prey-predator model and using the change of prey (switching-prey). The objective is to maximize the profit function of each predator by seeking the strategy provided by each predator to maximize its profit. To do so, we maximize this utility function being constrained by balance equations between biomass and trophic, and we show that this last problem is completely equivalent to finding the Generalized Nash Equilibrium Point. To calculate it, we use the conditions of Karush-Kuhn-Tucker and we show that it is indeed a Linear Complementarity Problem.

References
Real normed algebras satisfying $x^2 = y^2$ if and only if $x = \pm y$

Elhassan IDNAROUR, Abdellatif ROCHDI

Abstract
Les algèbres non associatives occupent une place privilégiée dans le domaine de la recherche mathématique. Ceci est dû à leur connexion avec les sciences expérimentales comme la physique des particules et la biologie.

Un des résultats phares de la théorie des algèbres non associatives de division de dimension finie est celui de Kervaire-Milnor-Bott [BM 85], [Ke 58], [HKR 91]. Il affirme que la dimension d’une algèbre réelle non associative de division de dimension finie n est égale à 1, 2, 4 ou 8. La démonstration nécessite des outils puissants de topologie algébrique et de la K-théorie. Hopf [H 40], moyennant des arguments ingénieux de topologie algébrique, a prouvé auparavant que n est une puissance de 2 et que n $\leq$ 2 si, de plus, l’algèbre est commutative.

Nous étendons dans ce travail le Théorème commutatif de Hopf [H 40], en remplaçant « commutative de division » par « l’unicité de la racine carrée au signe prié (USRES) ». De plus, la classification des algèbres réelles de dimension 2 satisfaisant à USRES.

References


Abstract
Volatility forecasting becomes more difficult for both researchers and practitioners due to the presence of different stylized facts, mainly the asymmetry and the nonlinearity, in the financial time series.
In this study, we aim to use the Markov switching version of the asymmetrical GJR-GARCH (MS GJR-GARCH) to capture the asymmetry in the conditional variance process $\nu_t^{(k)}$ of the log-returns ($r_t$) where:

$$
\nu_t^{(k)} = \alpha_0^{(k)} + (\alpha^{(k)} + \beta^{(k)} \gamma 1(r_{t-1} < 0)) r_{t-1}^2 + \beta^{(k)} \nu_{t-1}
$$

The skewed Generalized Error Distribution (GED) was considered to be appropriate in describing the log returns. On the other hand, the artificial neural network as a class of machine learning algorithms is used as well to capture the nonlinearity.
The Markov Chain Monte Carlo (MCMC) method and the Back-propagation algorithm are used to estimate the MS GJR-GARCH parameters and to train the artificial neural networks model, respectively. The results reveal that the neural networks have succeeded to improve the forecasts according to different criteria.

References
Abstract

In the study of the behavior of many stochastic differential equations that model Loss networks or the ones modeling calls in telephone networks, a trunk reservation appear in many cases, exhibited by some priorities involved by the model.

In such a field, there were very interesting results concerning the study of dynamics of the system in the limit, the main works are based on the results done by Hunt an Kurtz in [1], where a large loss networks with and without trunk reservation was studied and considered in the limit where the arrival rates and link capacities become large with their ratio held fixed, an averaging principle is applied consisting in observing a separation of time scales between processes describing number of calls in the network and the process describing the free remaining capacity.

The separation of time scales used in this work leads, using a Functional Law of Large Numbers, to a limiting process where a stationary distribution is involved in the limit, and that leads to a description of the dynamics of such a network.

Based on the same idea, a new results concerning the study of dynamics of new limiting processes are given with an improvement that describe more slightly dynamics of the system.

References


Résumé
Cet exposé examine l’anti-synchronisation en temps fini des réseaux de neurones récurrents à valeur complexe (RNRC) avec des fonctions d’activation discontinues et des paramètres non identiques via le contrôle en mode glissant. Le modèle RNRC suivant sera considéré comme étant le système d’entrée:
\[ \dot{z}(t) = -C_1 z(t) + A_{11} f(z(t)) + A_{12} f(z(t - \tau(t))) + J_1 \]

où \( z(t) \) représente les variables d’état définies sur le domaine complexe, \( C_1 \) est une matrice diagonale, \( f(z(t)) \) et \( f(z(t - \tau(t))) \) sont les fonctions d’activation définies sur le domaine complexe, \( A_{11} \) et \( A_{12} \) sont les poids de connexion définis sur le domaine complexe, \( J_1 \) est les vecteurs d’entrée constants externes définis sur le domaine complexe, \( \tau(t) \) est le retard variable dans le temps avec \( 0 \leq \tau(t) \leq \hat{\tau} \). Le système de réponse correspondant doit être fourni par:
\[ \dot{\tilde{z}}(t) = -C_2 \tilde{z}(t) + A_{21} g(\tilde{z}(t)) + A_{22} g(\tilde{z}(t - \tau(t))) + J_2 + U(t) \]

où \( \tilde{z}(t) \) représente les variables d’état du système de réponse, \( C_2 \) est une matrice diagonale, \( g(\tilde{z}(t)) \) et \( g(\tilde{z}(t - \tau(t))) \) sont les fonctions d’activation définies sur le domaine complexe, \( A_{21} \) et \( A_{22} \) sont les poids de connexion définis sur le domaine complexe, \( J_2 \) est les vecteurs d’entrée constants externes définis sur le domaine complexe et \( U(t) \) est un contrôleur qui sera conçu.

En premier lieu, la théorie de l’inclusion différentielle peut traiter efficacement les problèmes discontinus. D’autre part, dans le contrôle et la synchronisation des réseaux de neurones, les méthodes de contrôle s’améliorent également beaucoup, comme le contrôle adaptatif, le contrôle en mode glissant, etc. In convient de souligner que le contrôle en mode glissant est une méthode de contrôle efficace, dont la principale caractéristique est de forcer les états du système, à partir des états initiaux, sur une surface de mode glissant prédéfinie. Par conséquence, on peut obtenir les avantages souhaités tels que la robustesse, la capacité de suivi et l’insensibilité aux perturbations externes. Par suite, nous concevons une surface glissante avec une structure intégrée et un contrôle discontinu. Deuxièmement, en construisant une fonction de Lyapunov et en utilisant la technique d’inégalité différentielle, certaines conditions suffisantes sont dérivées pour garantir l’anti synchronisation en temps fini des réseaux de neurones à valeur complexe retardé avec des fonctions d’activation discontinues et des paramètres non identiques. Enfin, un exemple de simulation est présenté pour illustrer les méthodes proposées.

References
Stabilisation en temps fixe des réseaux de neurones inertiels de type neutre avec retard mixtes
Chaouki Aouiti, Hediene Jallouli

Abstract
Cet exposé aborde le problème de la stabilisation en temps fixe pour une classe de réseaux de neurones inertiels avec retards mixtes

\[
\frac{d^2 y_i(t)}{dt} = -a_i \frac{dy_i(t)}{dt} - by_i(t) + \sum_{j=1}^{n} c_{ij} f_j(y_j(t)) + \sum_{j=1}^{n} d_{ij} f_j(y_j(t - \tau_j(t))) \\
+ \sum_{j=1}^{n} \eta_{ij} \int_{-\infty}^{t} K(t-s)f_j(y_j(s)) \, ds + \sum_{j=1}^{n} e_{ij} f_j(y_j(t - \tau_j(t))) + l_i(t), i = 1, \ldots, n
\]

avec \( n \) est le nombre de neurones, \( y_i(.) \) est la valeur de l'état de la \( i \)\Ème neurone, \( a_i \) et \( b_i \) sont des constantes positives, \( c_{ij}, d_{ij}, e_{ij} \) et \( \eta_{ij} \) sont des poids de connexion liés respectivement aux neurones sans retard et avec retard, \( f_j(.) \) représente la fonction d'activation de la \( j \)\Ème neurone, \( K \) est le noyau de retard et \( \tau_j(.) \) est le retard variable dans le temps de la \( j \)\Ème neurone.

Par une transformation de variable appropriée, les réseaux de neurones inertiels d'origine peuvent être réécrits comme étant une équation différentielle du premier ordre. En utilisant un nouveau théorème de stabilité en temps fixe pour les systèmes dynamiques, la fonction de Lyapunov, deux différents types de contrôles sont conçus pour assurer la stabilisation en temps fixe des réseaux de neurones inertiels neutres avec retards mixtes. Les résultats théoriques proposés peuvent conduire à une meilleure estimation du temps de stabilisation par rapport aux résultats existants. Enfin, un exemple numérique est fourni pour illustrer la validité des résultats théoriques proposés et montrer que notre travail inclut et prolonge certains travaux existants.

References
Application of pseudo almost automorphic functions to a new recurrent neural networks model with several delays

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Abstract
Qualitative analysis such as periodicity, almost periodicity and stability of neural networks has been studied extensively by many authors. So, in this paper, we consider a class of delayed neural networks (DNNs) belonging to the category of delayed differential equations (DDEs), which is more general than the recent neural networks with time-varying delays: bounded or unbounded (proportional) delays. In this work, we give a new assumption for the proof of generalization lemma for composition with several delays, and under some delay-independent and delay-dependent sufficient conditions, the existence, uniqueness and attractivity of pseudo almost automorphic solution for a new recurrent neural networks (RNNs) with time-varying coefficients and several delays are obtained. To do so, the theory of exponential dichotomy with the contraction mapping principle (the classical Banach’s fixed-point principle), inequality techniques and constructing suitable Lyapunov functional are used. As you will see, our results improve and generalize many previous known results in DRNNs. Finally, an example together with its numeric simulations show the feasibility and effectiveness of our main results.

References
Cryptocurrency Forecasting Using Deep Learning techniques

Khadija Ait derhem, Abdelkader El Alaoui, Achchab Boujamaa

Abstract (between 15 and 30 lines)
Cryptocurrency is a digital currency that can be used goods and services much of the interest in these unregulated currencies is to trade for profit. That’s why there is a growing interest in studying the general dynamics of Bitcoin and in general of digital currencies. Although stock price forecasting is a crucial step toward portfolio optimization and hedging, only a limited number of works have focused on this issue especially for the Bitcoin market. The purpose of our current study is fundamentally using deep learning via Long Short Term Memory (LSTM) with the rectified linear activation function to forecast the price of the three most widely traded digital currencies i.e., Bitcoin, Litecoin and Vechain. LSTMs are among the state-of-the-art at learning long-term dependencies that show up in different predictive sequence models. An LSTM has an internal cell state that is modified across time steps in an additive fashion. LSTM is an artificial recurrent neural network architecture used in the field of deep learning. The standard LSTM has three gates (input, forget and output).

To test consistency and robustness, an experimental comparison between LSTM and GRNN applied for the following three digital currencies: Bitcoin, Litecoin and Vechain from 28/10/2013 to 06/05/2018. In this study we used 1657 observations for each one. The first 1326 values of the observations are used for training purposes and the remaining 332 most recent ones, for testing and out-of-sample forecasting. In our work we use the rectified linear activation function denoted Relu because this function overcomes the vanishing gradient problem, allowing models to learn faster and perform better. The prediction algorithm based on LSTM has higher prediction accuracy. Finally, the forecasting performance is evaluated by using the root mean square error (RMSE) a standard way to measure the error of a model in predicting quantitative data.

References


Solving Job-Shop Scheduling Problem by recurrent neural networks

Lotfi Nohair¹, Abderrahim Eladraoui², Abdelwahed Namir³

Laboratory of Modelling and Information Technology, Faculty of Sciences Ben M’SIK, University Hassan II, Casablanca, Morocco.

Abstract. The deterministic job-shop scheduling problem, hereinafter referred to as JSSP, is a well-known combinatorial optimization problem in operations research [1]. Based on the research of Zhang [2] and Willems [3], this communication proposes a recurrent neural network to solve Job-shop scheduling problems [4]. Firstly, the problem was translated in an integer linear programming model which the objective is to minimize the makespan, subject to three types of constraints:

1) Starting time constraints (ST units): the starting time of each operation must be a positive integer number.
2) Sequence constraints (SC units): An operation can only be scheduled after the preceding ones have ended.
3) Resource constraints (RC units): Machine can process at most one job at a time

This integer linear representation has been translated to Hopfield neural network. The proposed network used two parts: main part and feedback part. The main part include neurons representing the starting time of corresponding operation. In the feedback part, we use the network structure for constraint violation. The feedback part consists of three layers: the first layer representing the ST units, the second layer representing SC and the third layer representing RC units. The network was implemented using MATLAB program. Our simulation results was to test the network with both small-size and big-size problems. The quality of results obtained, depends on the initialisation of the network. Therefore, we used simulated annealing as local search to improve the performance of the proposed network. The goal is to minimize the energy which includes the makespan and the energy that represents the constraint violation.

Keywords: Artificial Neural Network, Job shop scheduling, Heuristic, Hopfield network.

References

Numerical simulation of a class of periodic differential systems by Deep Learning
Hamza Alaa, Nour Eddine Alaa and Abdeslem Hafid Bentbib

Abstract (between 15 and 30 lines)
Periodic differential systems model numerous real-life problems, and therefore these represent a point of focus and interesting applications. The literature presents many theoretical methods for their solution, in particular the methods of compactness, fixed point and monotonicity etc. or numerical methods such as finite differences, finite elements, finite volumes etc... Recently a particular attention is given to solutions using Deep Learning (DL) techniques. We have noticed that little work has been done to adapt DL to problems with periodic solutions. Here we are presenting initial experiments attempting to shed light on different ways periodic solutions can be simulated using DL, as well as a first attempt at implementing a python library to serve this end. The presentation will tackle the existence and uniqueness problem, and will then go on to discuss different examples in terms of numerical simulation, particularly problems emanating from periodic phenomena such as enzymatic models where periodicity reveals the recurrence of biochemical rhythms of living organisms. Another example is that of coarsening processes in surface growth models, where the periodic phenomena is rather spatial and not temporal.

References
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Asymptotic behavior of Clifford-valued dynamic systems with D-operator

Chaouki Aouiti ¹, Imen Ben Gharbia ¹

¹Department of Mathematics, Faculty of Sciences of Bizerta, Research Units of Mathematics and Applications UR13ES47, BP W, University of Carthage, 7021 Zarzouna, Bizerta, Tunisia.

Abstract:
Dynamic analysis of recurrent neural network models has gained enormous research interest over the past decades. This is an important subject that has been addressed by many experts and academics in various research fields [1-2], such as physical science, natural science, communication, mathematics, and engineering. Especially, the Clifford-valued neutral neural network as one of the popular recurrent neural networks were investigated by many researchers [3]. As an extension of the real-valued neural network, the Clifford-valued neural network, which includes a familiar complex-valued neural network and a quaternion-valued neural network as special cases, has recently been an active area of research. On the other hand, due to the limited speed of signal propagation, time delays (either constant or time-varying) are often encountered in recurrent neural network models operating in real-world applications [4]. Time delays are the main source of various dynamics such as chaos, divergence, poor functionality and instability. Hence it is necessary to analyze the recurrent neural network that incorporate either constant or time-varying delays.

Recently, the pseudo almost periodic problem of nonlinear differential equations had arisen considerable attention [3],[5]. This motivates our present research, In this paper, we will discuss the existence and the global exponential stability of neutral Clifford high-order neural network with time-varying delays and D-operator. Such a model is described by the following form:

\[ x_i(t) - p_i(t) \int_0^\infty r_i(s)x_i(t - s)ds + \sum_{l=0}^{n} d_{ij}(t)g_j \left( x_j(t) \right) + \sum_{l=1}^{n} \sum_{j=1}^{n} a_{ij}(t)g_j \left( x_j(t - \tau_{ij}(t)) \right)g_l \left( x_l(t - \rho_{ij}(t)) \right) + \sum_{l=1}^{n} \sum_{j=1}^{n} b_{ij}(t) \int_0^\infty H_{ijl}(u)g_j \left( x_j(t - u) \right)du \int_0^\infty K_{ijl}(u)g_l \left( x_l(t - u) \right)du + l(t) \]

References
Kernel method and analytic continuation for a three-dimensional semi-martingale reflecting Brownian motion
Soukaina AIT YOUSEF, Abdelhak YAACOUBI, Abdelghani BEN TAHar

Abstract
In this paper, we consider a semi-martingale reflecting Brownian motions (SRBMs) in the non-negative three-dimensional orthant. The data of this process are a covariance matrix $\Delta$, a drift vector $\theta$ and a reflection matrix $R$ satisfying the positive recurrence conditions as shown in [1], [3] and [4].

We first define the conditions for the existence of stationary distribution of SRBM and the positive recurrence of this process; we provide a review on the kernel method, which is one of the options for characterizing the so-called exact tail asymptotic properties of the stationary distribution of SRBM. We apply this method for to determine the relationship between the moment generating function $\varphi$ for the stationary distribution and the moment generating functions $\varphi_1, \varphi_2$ and $\varphi_3$ for the boundary probabilities.

Furthermore, we study the analytic continuation of the moment generating functions $\varphi_i, i = 1, 2, 3$, and their asymptotic property at the dominant singularity in order to determine the asymptotic property of the boundary measures $V_i, i = 1, 2, 3$.

In the two-dimensional case [2] and [5] studied the tail asymptotic for the marginal and the joint stationary distribution by using other technics.

References
On the stability of time-varying systems and application to Cohen-Grossberg neural networks
Abdelfettah Hamzaoui, Nizar Hadj Taieb and Mohamed Ali Hammami

Abstract:
Practical partial stability is very important and very useful for analyzing stability for such systems, since, in many cases, controlling a system at an idealized point is either costly or even impossible in the presence of interruptions. It means that the solution converges to a small ball centered at the origin with respect to some of the variables. We divide the state $x$ into two components $(y,z)$, $y$-variables used to study the stability of a ball centred at the origin and the component $z$ is taken bounded. Conditions of stability and asymptotic stability of this type are obtained within the method of Lyapunov functions and generalize a number of existing results. In this paper, we investigate the practical partial exponential stability of time-varying nonlinear systems. In practice, we may only need to stabilize a system into the region of a phase space where the system may oscillate near the state in which the implementation is still acceptable. Thus the concept of practical stability is very useful for studying the asymptotic behavior of a system in which the origin is not necessarily an equilibrium point. In this situation, the analysis of the asymptotic behavior of solutions is in the sense that a small neighborhood of the origin is stable and attractive. With the help of the new notion of practical stable scalar functions, some differential sufficient Lyapunov inequalities conditions are derived which ensures the convergence of a part of the solutions towards a ball containing the origin of the state space as the radius of the ball can be made arbitrarily small. The established result provides the following question : if the system is practically exponentially $y$-stable, is there a Lyapunov function which satisfies the hypothesis of the obtained theorems. Therefore, we construct a converse Lyapunov theorem and prove robustness of uniform practical partial exponential dissipativity with respect to unbounded external perturbations. As an application, we consider the Cohen-Grossberg neural networks with variable coefficients and multiple delays to show the validity of the main result.

References
Artificial neural network-based control strategies for double stator permanent magnet synchronous generator associated with three-level NPC inverter

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Abstract

In this paper, double stator permanent magnet synchronous machine associated with two three-level NPC inverter integrated in a wind turbine system is described. The double star permanent magnet synchronous machine has two sets of three-phase stator windings spatially shifted up by an angle $\alpha=30^\circ$. The double star permanent magnet synchronous is used in areas of high power industrial applications such as electric vehicle, naval propulsion and renewable energy. In this work a simplified algorithm for controlled a two three-level NPC inverter SVPWM is used. Due to the geometrical symmetry of six sectors, there exist the close relationships in on time calculations and on time arrangement for switches between them. So it can complete the computation of the three-level SVPWM in one sector. A standard field oriented control (FOC) is used to control the generator and the speed control used artificial neural network models. MATLAB/SIMULINK simulation results are presented for the validity of proposed configuration.

References

Dissipativité globale des réseaux de neurones du second ordre flous à retards

C.Aouiti, F. Touati

Abstract
Notant que de nombreuses études précédents sont principalement concentrées sur les modèles de réseaux de neurones du premier ordre, alors il est également significative d'introduire les états de second ordre des réseaux de neurones inerties. En 1997, Wheeler et Schieve [1] ont proposé pour la première fois un modèle de réseau de neurones inerties du second ordre et ont discuté sa stabilité, sa bifurcation et son phénomène de chaos. Le terme inertiel peut être considéré comme étant un outil critique, qui est ajouté pour aider à générer le chaos. Par conséquent, il est très significatif d'introduire un terme inertiel dans un système neuronal.
De plus, dans la modélisation mathématique des problèmes du monde réel, l'incertitude ou l'imprécision est inévitable. Afin de prendre en compte le flou, la méthodologie de logique floue est considérée pour capter ces inconvénients et manipuler des données plutôt floues.
Dans cet exposé, on s'intéresse à l'étude de la dissipativité globale pour une classe des réseaux de neurones du second ordre flous à retards. En utilisant l'approche fonctionnelle de Lyapunov et la méthode des inégalités matricielles linéaires de nouvelles conditions suffisantes sont obtenues pour garantir la dissipativité globale et la dissipativité globale exponentielle de notre modèle de réseau proposé. En outre, deux exemples numériques avec leurs simulations sont proposée pour prouver l'applicabilité de nos résultats théoriques. Dans ce travail, nous visons à établir la dissipativité globale du système retardé suivant :

\[
\begin{align*}
    \dot{y}_i(t) + a_{ij} \dot{y}_j(t) &= -b_{ij} y_i(t) + \sum_{j=1}^{n} c_{ij} f_j \left( y_j(t) \right) + \sum_{j=1}^{n} d_{ij} f_j \left( y_j(t - \tau_j(t)) \right) \\
    &+ \sum_{j=1}^{n} e_{ij} \gamma_j(t) + \sum_{j=1}^{n} T_{ij} \gamma_j(t) + \sum_{j=1}^{n} \delta_{ij} f_j \left( y_j(t - \tau_j(t)) \right) \\
    &+ \sum_{j=1}^{n} \eta_i f_j \left( y_j(t - \tau_j(t)) \right) + \sum_{j=1}^{n} S_{ij} \gamma_j(t) + u_{i}(t)
\end{align*}
\]

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