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Challenges in fractional dynamics and control theory

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Fractional integro-differentiation (or, non-integer order integro-differentiation) is a mathematical framework that leads to efficient tools for modeling and control many of physical systems. Nevertheless, the overall area is commonly refereed as Fractional Calculus (FC) and become popular during the last years. In fact, FC can be used to describe in a solid and compact form systems characterized by long-range temporal or spatial dependence phenomena. Furthermore, the extension of classical and modern control theories to the new perspective, allows the development of algorithms applicable both integer and non-integer order systems.

The application of fractional calculus can have a considerable impact on everyday life namely in technology, social and health issues. Therefore, important challenges are still posed to the scientific community that motivate researchers to explore new features of fractional systems.

The special issue *Challenges in Fractional Dynamics and Control Theory* includes a selection of nine papers addressing topics that recently emerged in this area and is organized as follows.

Lopes and Machado (2015) contribute with the manuscript entitled *State space analysis of forest fires*. Burnt area, precipitation and atmospheric temperatures are interpreted as state variables of a complex system and the correlations between them are investigated. The study sheds light about a complex phenomenon that needs to be better understood in order to mitigate its devastating consequences, at both economical and environmental levels.

Balachandran et al. (2015) present the paper *Controllability of nonlinear implicit neutral fractional Volterra integrodifferential systems*. The control problem of non-linear neutral fractional Volterra integrodifferential systems with implicit fractional derivative is established. Sufficient conditions for controllability are obtained by means of the notions of condensing map and measure of noncompactness of a set.

Meerschaert, et al. (2015) have the study *Anisotropic fractional diffusion tensor imaging*. Traditional diffusion tensor imaging (DTI) maps brain structure by fitting a diffusion model to the magnitude of the electrical signal acquired in magnetic resonance imaging (MRI). Fractional DTI employs anomalous diffusion models to obtain a better fit to real MRI data, which can exhibit anomalous diffusion in both time and space. The paper describes the challenge of developing and employing anisotropic fractional diffusion models for DTI.

Pinto and Carvalho (2015) develop the work *Fractional complex-order model for HIV infection with drug resistance during therapy*. They propose a fractional complex-order model for drug resistance in HIV infection. The fractional complex-order system reveals rich dynamics and variation of the value of the complex-order derivative sheds new light on the modeling of the intracellular delay.

Muresan et al. (2015) contribute with *Design and analysis of a multivariable fractional order controller for a non-minimum phase system*. Two control strategies for multivariable processes are proposed, based on a decentralised and a steady state decoupling approach. The designed controllers are fractional order PIs. The efficiency and robustness of the fractional algorithms is tested and validated using a non-minimum phase process.

Ventura et al. (2015) add the work *Fractional direct and inverse models of the dynamics of a human arm*. The paper presents a comparative study of both direct and inverse models of the human arm at the elbow joint.

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Models of integer and fractional order are identified from the experiments. Likewise, for comparison purposes, neural networks models are also obtained. It is shown that fractional models are more adequate to describe human arm behavior, than the integer counterpart.

Zheng et al. (2015) have the contribution *Fractional-order modeling of permanent magnet synchronous motor speed servo system*. System identification experiments are performed on the electromagnetic part and the mechanical part of the permanent magnet synchronous motor speed servo system, respectively. Experiments in open-loop and closed-loop are performed and the advantages of the proposed fractional-order model is demonstrated.

Jafari, et al. (2015) present *On comparison between iterative methods for solving nonlinear optimal control problems*. In the manuscript are compared the Adomian decomposition, homotopy perturbation and modified variational iteration methods, for solving a type of nonlinear optimal control problem. It is proved that these methods are equivalent and that they use the same iterative formula to obtain the approximate/analytical solution.

Bhrawy (2015) adds *A highly accurate collocation algorithm for 1 + 1 and 2 + 1 fractional percolation equations*. The study addresses two spectral collocation methods for fractional percolation equations (FPEs). The proposed collocation scheme, both in temporal and spatial discretizations, is successfully extended to the numerical solution of two-dimensional FPEs. Several numerical examples with comparisons are reported to highlight the high accuracy of the proposed method.

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