Mathematical and Computational Applications

MDPI

Editorial

Significance of Mathematical Modeling and Control in Real-World Problems: New Developments and Applications

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Mathematical modeling and system control are employed in many research problems, ranging from physical and chemical processes to biomathematics and life sciences. Their theoretical description is closely connected with various areas of pure and applied mathematics, including nonlinear modeling, integro-differential equations, nonlinear dynamics, pattern formation, non-Markovian processes, nonlinear and anomalous transport, time-delay equations, and so on.

The aim of this Special Issue is to collect original and high-quality contributions related to the mathematical theory of such processes and phenomena, including dynamic models, applied and computational algorithms, controller design, and mathematical methods, regarded as new and prominent for understanding the problems that arise in natural phenomena.

This Special Issue will cover new perspectives of the recent theoretical developments in mathematical modeling and/or optimal control and their illustrative applications in biology, engineering, finance, and health sciences. It aims to highlight new techniques that can be applied to the real-life problems that are modeled and to introduce new constructed effective models for the accurate prediction of infectious diseases, financial crises, etc., into the literature by adopting suitable controls/control strategies. Moreover, it aims to provide new analytical and numerical methods to propose appropriate solutions to the real-life problems of both integer- and fractional-order differential equations and to understand their complicated behaviors in nonlinear phenomena.

The Special Issue also proposes the latest developments in nonlinear dynamical modeling, optimization, and solution strategies that can be applied to prominent problems in engineering and biological systems.

Additionally, we will the reader learn new theories and new methods of nonlinear dynamical systems with regard to modeling and controlling them. It will also help the reader find new solutions to complex engineering, biological, financial, and life science problems, providing readers with new insights for novel modeling and optimization processes and underlining the relation between theory and practice. The topics of this Special Issue include, but are not limited to, the following:

- Mathematical modeling in real-world phenomena;
- Optimal control strategies in biosystems;
- New analytical and numerical methods for fractional differential equations;
- Modeling of fractional-order systems with and without nonsingular kernels;
- Deterministic and stochastic differential equations arising in science;
- Applications in bioengineering, biology, and health sciences;
- Applications in finance and economic sciences;
- Optimal control problems of a fractional order;

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Citation: Yavuz, M.; Dassios, I. Significance of Mathematical Modeling and Control in Real-World Problems: New Developments and Applications. *Math. Comput. Appl.* **2024**, *29*, 82. https://doi.org/10.3390/mca29050082

Received: 9 September 2024
Accepted: 9 September 2024
Published: 18 September 2024

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- Modeling of diffusion, heat, mass, and momentum transfer (fluid dynamics);
- Biomechanical and biomedical applications of fractional calculus;
- Impulsive systems;
- Fuzzy differential equations and their applications.

In this Special Issue, the contents of the selected studies that contributed to the topics listed above can be synthesized as follows:

- **Fractional-order approaches** used to model and investigate several real-life problems:
  - Tariq et al. [1] established new fractional identities and employed them, exploring several extensions of the fractional H-H type inequality via generalized preinvexities. Then, they discussed some applications to the q-digamma and Bessel functions via their obtained results.
  - Adel M. Al-Mahdi [2] proposed a block triangular preconditioner as using the exact triangular preconditioner leads to a preconditioned matrix with exactly two distinct eigenvalues. In the algorithm they utilized, the authors used the flexible preconditioned GMRES method for the outer iterations, the preconditioned conjugate gradient (PCG) method for the inner iterations, and the fixed point iteration (FPI) method to handle nonlinearity. Fast convergence was found in the numerical results by using the proposed preconditioners.
  - Debbouche et al. [3] set up a class of nonlinear fractional differential systems with distributed time delays in the controls and impulse effects. The controllability criteria for both linear and nonlinear systems were discussed. They also provided an illustrative example supported by graphical representations to show the validity of the obtained abstract results.
  - Haq et al. [4] developed a within-host viral kinetics model of SARS-CoV-2 under the Caputo fractional-order operator. They proved the results of the solution's existence and uniqueness by using the Banach mapping contraction principle. Moreover, they provided approximate solutions for the nonlinear fractional model using the modified Euler method (MEM).
  - Rabah et al. [5] discussed a complex nonlinear fractional model of an enzyme inhibitor reaction where reaction memory was taken into account. Analytical expressions of the concentrations of the enzyme, substrate, inhibitor, product, and other complex intermediate species were derived using Laplace decomposition and differential transformation methods.
  - Clemence-Mkhope and Gibson [6] proposed four discrete models, using the exact spectral derivative discretization finite difference (ESDDFD) method for a chaotic five-dimensional, conformable fractional derivative financial system, incorporating ethics and market confidence.
  - Clemence-Mkhope and Clemence-Mkhope [7] used the property of the conformable fractional derivative (CFD) to show the limitation of the method previously used in the literature, together with the integer definition of the derivative, as well as to derive a modified conformable Euler method for the initial value problem that was considered. A method of constructing generalized derivatives from the solution of the non-integer relaxation equation was used to motivate an alternate definition of the CFD and justify alternative generalizations of the Euler method to the CFD.
- **Heat and Fluid Dynamics**
  - Eswaramoorthi and Loganathan [8] investigated the numerical computation of Ag/Al_2O_3 nanofluid over a Riga plate with injection/suction. The energy equation was formulated using the Cattaneo–Christov heat flux, nonlinear thermal radiation, and heat sink/source.
  - Hossain et al. [9] developed a model to discover the effects of heated cylinder configurations in accordance with the magnetic field on natural convective flow within a square cavity. In the cavity, four types of configurations—left

bottom-heated cylinder (LBC), right bottom-heated cylinder (RBC), left top-heated cylinder (LTC), and right top-heated cylinder (RTC)—were considered in the investigation.
  - Eswaramoorthi et al. [10] scrutinized the Darcy–Forchheimer flow of Casson–Williamson nanofluid in a stretching surface with nonlinear thermal radiation, suction, and heat consumption. In addition, this investigation assimilated the influence of Brownian motion, thermophoresis, activation energy, and binary chemical reaction effects.
- **Convection in Porous Mediums**
  - Ramchandraiah et al. [11] analyzed the thermal instability of rotating convection in a bidispersive porous layer. Linear stability analysis was employed to examine the stability of the system.
  - Reddy et al. [12] studied the effect of vertical rotation and the magnetic field on dissolution-driven convection in a saturated porous layer with a first-order chemical reaction. The system's physical parameters depended on the Vadasz number, the Hartmann number, the Taylor number, and the Damkohler number.
  - Tamilzharasan et al. [13] developed a mathematical simulation of the steady mixed convective Darcy–Forchheimer flow of Williamson nanofluid over a linear stretchable surface. In addition, the effects of Cattaneo–Christov heat and mass flux, Brownian motion, activation energy, and thermophoresis were also studied.

Therefore, as the editors of this volume, we wish to convey our profound gratitude for the opportunity to collaborate with MDPI to publish this Special Issue. Our acknowledgment extends with sincere appreciation to the *MCA* Editorial Office, whose unwavering support was invaluable throughout this process. It was a pleasure to work under such favorable conditions, and we eagerly anticipate the prospect of future collaborations with *MCA*.

Conflicts of Interest: The authors declare no conflicts of interest.

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