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EDITORIAL

Advanced computational methods and innovative applications in science and engineering

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The Special Issue entitled "Advanced Computational Methods and Innovative Applications in Science and Engineering" has aimed to publish selected high-quality papers presented at the "Third International Conference on Applied Mathematics in Engineering (ICAME'24)," which was held from June 26 to 28, 2024, at VE Hotels, Ayvalık, Balıkesir, Türkiye.

Modelling and numerical computation arise in many research problems ranging from physical and chemical processes to biomathematics and life science. Its theoretical description is closely connected with various areas of pure and applied mathematics including nonlinear modelling, integro-differential equations, nonlinear dynamics, pattern formation, non-Markovian processes, nonlinear and anomalous transport, time-delay equations, advanced AI techniques, and so on.

This Special Issue has collected original and high-quality contributions related to the mathematical theory of such processes and phenomena including the dynamical models, applied and computational algorithms, controller design and mathematical methods regarded as new and prominent for the understanding of the problems arising in natural phenomena.

It has covered new perspectives on the recent theoretical developments in mathematical modelling and/or optimal control and their illustrative applications in biology, engineering, and health sciences. It goals to point out new techniques that can be applied to the real-life problems which are modelled and to gain to the literature newly constructed effective models for the accurate prediction of infectious diseases, financial crises, etc., 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

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understand their complicated behaviors in nonlinear phenomena.

The topics of the Special Issue include, but are not limited to:

- Mathematical modelling in real-world phenomena
- Data Science-Artificial intelligence
- Optimal control strategies in biosystems
- New analytical and numerical methods for fractional differential equations
- Modelling of fractional order systems with and without non-singular kernels
- Financial mathematics
- Deterministic and stochastic differential equations arising in science
- Applications in bioengineering, biology, and health sciences
- Applications in finance and economic sciences
- Local fractional calculus and its applications
- Modelling in diffusion, heat, mass, and momentum transfer (fluid dynamics)
- Biomechanical and biomedical applications of fractional calculus
- Impulsive systems
- Fuzzy differential equations and their applications
- Operational research in mathematics and engineering

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

- **Heat and Fluid Dynamics**
  - Hristov [1] studied the approximate solutions of a non-linear (degenerate) diffusion equation with a power-law-type concentration-dependent diffusivity in a semi-infinite domain by the integral-balance method (double integration technique). The behavior and basic features of a modified function $Sinc_{\pi}\left(x^{n}\right)$ are addressed, highlighting how it is used in the generated approximate solutions. To demonstrate the suitability of the suggested technique, comparative examinations concerning well-known approximate analytical and numerical problem solutions have been developed.
  - Tezer-Sezgin and Aydın [2] examined the effects of curved boundary perturbations on the solution of steady magnetohydrodynamic (MHD) duct flow are investigated. Hartmann (upper and bottom) walls are perturbly curved and perfectly conducting while the side walls are insulated and plane. The results of the flow profiles due to the upper and lower perturbed Hartmann walls can be referenced in the liquid metal blanket design and the blood flow measurements in the constricted vessels.
  - Evcin [3] established the optimal control of unsteady natural convective flow of reactive viscous fluid with heat transfer. It is assumed that Newton's law governs the heat transfer within an exothermic reaction under Arrhenius kinetics and Navier slip condition on the lower surface of the channel. The flow is examined in a vertical channel formed by two infinite vertical parallel plates, with a distance (H) between them. Time-dependent natural convective slip flow of reactive viscous fluid and heat transfer equations are solved in a unit interval using the Galerkin-Finite Element Method (FEM) with quadratic finite elements in space and the implicit Euler method in time. Numerically simulated results show that the proposed approach successfully drives the flow to prescribed velocity and temperature profiles.

- **Fractional-order Investigations** used to model and investigate real-life problems:
  - Naim et al. [4] investigated a fractional viral model in this work, as fractional-order calculus

is considered more suitable than integer-order calculus for modeling virological systems with inherent memory and long-range interactions. The model incorporates virus-to-cell infection, cell-to-cell transmission, cure rate, and humoral immunity. Additionally, the non-lytic immunological mechanism, which prevents viral reproduction and reduces cell infection, is included. Caputo fractional derivatives are utilized in each compartment to capture long-term memory effects and non-local behavior. The numerical results are used to illustrate the effects of the fractional derivative order on infection dynamics.

  - Koca [5] examined the Cauchy problem for variable-order fractional differential equations incorporating the Mittag-Leffler kernel. The variable-order derivative is modeled as a bounded function that adapts to the underlying dynamics of the system. The existence of a solution by utilizing a fixed-point theorem along with an iterative series that converges to the precise solution is established. This study contributes to the broader understanding of fractional calculus and its applications in complex systems where classical models are insufficient.

- **Approaches to Financial Mathematics with Artificial Intelligence**
  - Öztunç-Kaymak et al. [6] analyzed Türkiye as a fragile economy with a high Credit Default Swap (CDS) premium. In this context, an artificial neural network (ANN) is combined with the fuzzy time series (FTS) in order to construct a novel model called FTS-ANN. Based on this novel model, the predicted results have been evaluated using different well-known statistical techniques.
  - Yıldırım et al. [7] studied the variables of the financial performance of 12 energy companies. Three different models are created with the return on assets, return on equity, and net profit margin as financial performance indicators of 12 firms. 12 financial ratios are used as input variables as determinants of financial performance. In the analysis, 37 quarterly data between 2014Q4-2023Q4 are used as the sample period. In machine learning, 17 different algorithms are considered in the selection of the appropriate model. The findings indicate that the Bagged Tree algorithm achieved successful outcomes for the ROA target variable, the Boosted Tree model demonstrated effective performance for the ROE model, and the Linear SVM algorithm yielded favorable results for the NPM model.
  - Cici Karaboğa et al. [8] used machine learning and deep learning methodologies to predict the prices of Turkcell stocks traded on Borsa Istanbul (BIST) and New York Stock Exchange (NYSE) between 4 January 2010 and 2 December 2023. The results of the analyses conducted with the Random Forest Regressor (RF) and Long Short-Term Memory (LSTM) algorithms, two machine learning and deep learning algorithms, respectively, indicated that both algorithms exhibited a lower error rate in predicting the closing prices of Turkcell stocks on the NYSE.

- **Mathematical Modelling in Biology**
  - Afroz et al. [9] analyzed the bifurcation and hysteresis phenomena of the Euler beam problem by focusing on the singularity theory viewpoint. Confirming the continuity of the problem is a necessary condition for performing a bifurcation and hysteresis analysis. A bifurcation problem is transformed from an infinite dimension to a finite dimension by applying the Lyapunov equations. A suitable central force minimizes our considered model and makes the problem stable. Moreover, they have performed numerical investigations and interpreted the results obtained from the bifurcation and hysteresis analysis geometrically with suitable values of the new unfolding parameters and with different lengths.
  - Kiemtore et al. [10] studied the impact of these control measures on the expansion of this virus. The paper has presented a mathematical model of vertically transmitted HBV that takes into account the progression to chronicity as a function of the age of the infected person,

as well as vaccination, treatment of chronic carriers, and media awareness. After formulating the model and carrying out the mathematical analysis, the authors simulated the proposed model in Matlab, taking into account the various involved parameters. Finally, they presented the results of sensitivity analysis and numerical simulation.

Therefore, as the editors of this Special Issue, we wish to convey our profound gratitude for the opportunity to collaborate with the journal Mathematical Modelling and Numerical Simulation with Applications (MMNSA) to publish the Special Issue. Our acknowledgment extends with sincere appreciation to the MMNSA 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 MMNSA.

Conflicts of interest

The authors declare that they have no conflict of interest.

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