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Editorial: Future challenges in the fractional-order dynamical systems: from mathematics to applications

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Editorial on the Research Topic
Future challenges in the fractional-order dynamical systems: from mathematics to applications

The concept of fractional calculus has been known to mathematicians since 1695 when L'Hôpital and Leibniz exchanged letters discussing the non-integer order of the derivative. However, it is only recently that fractional calculus has emerged as a cutting-edge Research Topic. The renewed interest is due to the fact that fractional calculus preserves nonlocality and long memory effects, which can be observed in various fields such as physics, mathematics, and engineering. In essence, fractional-order systems have the capability to remember their past, which makes them valuable in developing novel mathematical models ranging from living systems to artificial systems. In particular, the use of fractional derivatives has proven to be an elegant approach for describing physical phenomena with greater accuracy. The overall purpose of this Research Topic is to gather the latest scientific advances in the field of fractional-order dynamical systems from mathematics to applications. It focuses on the evolution and mathematical foundations of fractional calculus, as well as on the design, control, and electronic realization of fractional-order systems with engineering applications covering fractional calculus of constant order, general fractional calculus of variable order, local fractional calculus, and their extended versions.

In the paper "*Dynamical behaviors of an epidemic model for malware propagation in wireless sensor networks*," Zhou, Wang et al. analyzed network malware propagation and devised effective methods to control its spread. They proposed a susceptible-unexposed-infected-isolation-removed epidemic model, which was used to simulate the spread of malware in Wireless Sensor Networks (WSNs). Based on the results, they determined the optimal range of nodes required to control malware propagation.

In the paper "*Controllability of Hilfer fractional Langevin evolution equations*," Wang and Ku discussed the importance of exact controllability in control theory. This means a system can be steered from any initial state to an arbitrary desired final state through admissible control input. To study control problems for a class of Hilfer fractional Langevin evolution equations, they used the (α, β) resolvent operator along with three different fixed point theorems. As a result, the exact controllability of Hilfer fractional Langevin systems was established.

In the paper "*Malware propagation model of fractional order, optimal control strategy and simulations*," Zhou, Liu et al. proposed an improved Susceptible-Exposed-Infected-Recovered (SEIR) model of fractional order to describe how malware spreads in a wireless sensor network. They developed a fractional-order malware propagation model based on the classical SEIR epidemic theory to determine the unknown parameters of the propagation process. Additionally, they discussed an optimal control strategy. Simulation results showed that the proposed model was more effective than the integer order propagation model.

In the paper "*Modeling and analysis of the addiction of social media through fractional calculus*," Shutaywi et al. argued that social media addiction (SMA) can be defined as the excessive usage of social media platforms, leading to adverse outcomes for individuals. Then, they presented a mathematical model to conceptualize the transmission dynamics of SMA and explore the underlying mechanisms in the framework of fractional derivatives. Next, equilibrium points were identified, and the reproduction parameter R0 was computed to understand the dynamics of SMA spread to develop effective control strategies. This research may provide various recommendations to curb the prevalence of social media addiction.

In the paper "*Fractional-order projection of a chaotic system with hidden attractors and its passivity-based synchronization*," Serrano et al. presented the fractional-order projection of a chaotic system, which delivers a collection of self-excited and hidden chaotic attractors. Based on an integer-order chaotic system and the proposed transformation, a fractional-order chaotic system is obtained when the divergence of integer and fractional vector fields flows in the same direction. Apart from these results, two passivity-based fractional control laws were designed. Numerical experiments confirmed the usefulness of the proposed approach.

The Topic Editors are excited to present this Research Topic, which focuses on the latest research on fractional-order dynamical systems, from mathematics to applications. We expect that the works we have collected will inspire researchers to strive for further advances in the emerging fields of complex systems and their applications under fractional-order calculus. Additionally, the Topic Editors would like to thank the authors of all the papers submitted to this Research Topic. Also, we wish to thank the reviewers and the journal's Editorial Board for being very encouraging and supportive.

We hope you enjoy reading this Research Topic in this exciting and fast-evolving field as much as we have done!

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