Editorial: Mathematical modeling and optimization for real life phenomena

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Editorial on the Research Topic
Mathematical modeling and optimization for real life phenomena

In today's world, where complexity abounds and challenges are multifaceted, mathematical modeling and optimization emerge as essential tools for addressing real-life phenomena. These disciplines not only enhance our understanding of intricate systems but also empower us to devise efficient solutions for a wide array of problems. By representing real-world phenomena through equations and algorithms, mathematical modeling enables us to simulate and predict the behavior of complex systems. When combined with optimization techniques, we can seek the best solutions for challenges ranging from logistical planning to natural resource management.

In the realm of mathematical modeling and optimization, statistical processes like Markov Chain Monte Carlo methods play a crucial role in estimating posterior distributions for Bayesian computations. However, these methods often face challenges with slow run times when dealing with large datasets or complex parameter distributions. To address this, Suchoski et al. introduce the Multiple-Try Metropolis variant, optimizing the algorithm for faster convergence by running more parallel likelihood calculations to approach a parameter estimation for a Susceptible-Exposed-Infectious-Removed (SEIR) model and forecasting new cases of COVID-19. The recent pandemic situation highly affected our world, then the study of epidemic spread, exemplified by COVID-19, has attracted significant attention from scholars. By proposing the SEIRD (Susceptible-Exposed-Infected-Recovered-Dead) model based on the SIR (Susceptible-Infected-Recovered) propagation model, Chen et al. introduce specific parameters to simulate virus spread through objects, providing valuable insights for epidemic analysis and prediction.

Amid the current emphasis on sustainability, efficiency, and innovation, mathematical modeling and optimization are also indispensable in fields that include applications in humans and animal health. Netshikweta and Garira present a nested multiscale model that integrates within-host and between-host disease dynamics for Paratuberculosis in ruminants. Their study explores the influence of the initial infective inoculum dose on disease dynamics, revealing insights into pathogen replication and super-infection effects. Also, results on mathematical modeling in the case of health risk, for animals and humans in the agriculture exposed by pesticides result in an interesting topic. Aksüt and Eren studied the significance of personal protective equipment using a multi-criteria

decision-making approach to mitigate the risks of injuries and illnesses stemming from pesticide use. Emphasizing the utilization of personal protective equipment, particularly during pesticide application, will enhance the adoption rate of protective measures. Another real life phenomenon needing mathematical modeling and optimization arise in the formation of hydroxyapatite in biological tissues which is regulated by physicochemical factors not fully understood. In that sense, Poorhemati and Komarova utilize mathematical modeling to depict the intricate environment conducive to hydroxyapatite precipitation, enabling *in silico* studies of complex clinical scenarios.

The modeling of dynamical systems in the area of neural behavior and new technological devices, as new logical gates, has been growing in the last decade. Dynamical behavior in neural burst patterns is characterized by temporal heterogeneity across various domains. Lee et al. propose a Burst and Memory-aware Transformer (BMT) model designed to address bursty temporal patterns effectively, enhancing predictive performance. In the field of communications systems, new devices and logical gates are continually evolving to meet technological advancements. Dynamical systems displaying chaotic behavior are utilized to emulate logic gates for general-purpose computing. Rivera-Durón et al. present a methodology based on unstable dissipative systems capable of generating multi-scrolls and multi-stability, leading to the development of dynamic logic gates.

In the area of controlling dynamical systems, some examples about control and synchronization are mentioned, for which it is well known that when the synchronization topic is studied, it can develop emergent phenomena depending on the number of elements of the system. Research on optimal control using fractional calculus by Hailu and Teklu explores dynamics of rail passengers' negative attitudes, aiming to prevent and treat negative attitudes through optimal control strategies. The synchronization transition in the Shinomoto-Kuramoto model on networks of fruit-fly and human connectomes is investigated by Ódor et al. shedding light on critical behavior in the presence of external excitation. Their numerical solutions provide insights into non-universal scaling tails and compare well with experimental results obtained by fMRI. The Particle Swarm Optimization (PSO) algorithm is an effective optimization method known for its impressive performance in problem-solving. Research on the convergence analysis of this method is still ongoing, in that sense, Nigatu et al. introduce a method for regulating particle swarm velocity by incorporating a constriction factor into the standard swarm optimization algorithm, known as CSPSO. They also present a mathematical model of CSPSO with the time step attractor to analyze convergence conditions and stability. This adaptation of the standard particle swarm optimization aims to enhance the balance between exploration and exploitation, thus mitigating premature convergence issues commonly seen in PSO algorithms.

Fostering research and development in mathematical modeling and optimization is crucial for addressing current challenges effectively across diverse fields. By integrating these disciplines into our problem-solving approaches, we can advance toward a more sustainable, efficient, and impactful future. This Research Topic gathers important recent developments with promising future perspectives on mathematical models for real life phenomena.

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