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Editorial: Insights in Dynamical Systems 2022

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Editorial on the Research Topic
Insights in dynamical systems 2022

This Research Topic aims to highlight the latest advancements in research across the field of Applied Mathematics and Statistics with a focus on new insights, novel developments, current challenges, latest discoveries, recent advances, and future perspectives in the field of Dynamical Systems.

The Research Topic solicits brief, forward-looking contributions that describe the state of the art, outlining recent developments and major accomplishments that have been achieved and that need to occur to move the field forward. The authors have identified the greatest challenges in the sub-disciplines and how to address those challenges. The aim of this special edition Research Topic is to shed light on the progress made in the past decade in the field of Dynamical Systems and on its future challenges to provide a thorough overview of the field. Hopefully, this topic collection will inspire, inform, and provide direction and guidance to researchers in the field.

Complex systems in nature exhibit a hierarchy of scales, and these scales may interact with each other in a non-linear way [1]. To understand and even control their behavior, it is essential to describe the system's non-linear dynamics by mathematical models and, where necessary, take into account the interactions at different scales. Babilio et al. review the mathematical study of deformations of solid circular rings at a certain spatial scale under forcing control. This fundamental scientific problem shows diverse applications, such as buckling-driven transformations of thin-film materials for applications in electronic microsystems, self-excited oscillations in collapsible tubes, and pliable fluid-carrying shells or pulse wave propagation in arteries.

Fluids may exhibit non-linear spatio-temporal pattern formation, and corresponding modern theories involve dynamical system models on a single spatial and temporal scale. Such models consider underlying processes on smaller scales. Abarzhi assesses the properties and characteristics of two such models: canonical Kolmogorov turbulence and interfacial Rayleigh–Taylor mixing. In her Perspective article, she demonstrates the relationship between scaling laws and spectral shapes in both models.

Traversing hierarchical scales in neuronal systems in detail, Coombes reviews neuronal mass models evolving on a mesoscopic scale and provides insights into how corresponding novel models employ microscopic non-linear dynamics of single neurons in a network on the mesoscopic scale. The Perspective article discusses the neural mass model for synchrony and neuron activity average, as well as how the spatial average of single-neuron activity and the neurons' synchrony interact.

Typical complex natural systems exhibit intrinsic noise. Employing microscopic non-linear dynamics in a mesoscopic mean-field model in the presence of noise provides an additional challenge. The Perspective article by Hutt reviews how additive stochastic forces in microscopic neuronal models translate to mesoscopic neural models. It is shown how computer science techniques can be used to augment microscopic sub-grid scale modeling, thereby extending mesoscopic mean-field models.

The combination of mathematical and computer science techniques has been shown to improve multi-scale models [2]. In his Perspective article, Bocquet points out promising perspectives of artificial intelligence methods in climate research, which combine spatio-temporal dynamical models on multiple spatial and temporal scales and data assimilation. He discusses the technical obstacles and future challenges of machine learning techniques in this context.

Understanding complex systems is a challenging task that demands a combination of diverse techniques and approaches. Besides the mathematical analysis approach shown in the articles mentioned above, the analysis of observed time series provides important insights into the systems' dynamical properties. For instance, time series of extreme events, such as heartbeats, extreme rainfalls, or even landslides, reflect the complex systems underlying non-linear dynamics. Marwan reviews the literature on methods for analyzing such events, with a focus on recurrence time series analysis. This analysis type is pertinent for experimental data that are not observed under controlled laboratory conditions, thus addressing an important challenge in future experimental research.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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