frontiers | Frontiers in Applied Mathematics and Statistics

TYPE Editorial
PUBLISHED 03 August 2023
DOI 10.3389/fams.2023.1260383

OPEN ACCESS

EDITED AND REVIEWED BY
Axel Hutt,
Inria Nancy - Grand-Est Research Centre, France

*CORRESPONDENCE
Víctor F. Breña-Medina
✉ victor.brena@itam.mx

RECEIVED 17 July 2023
ACCEPTED 25 July 2023
PUBLISHED 03 August 2023

CITATION
Breña-Medina VF and Aguirre P (2023) Editorial: Recent advances in bifurcation analysis: theory, methods, applications and beyond - volume II. *Front. Appl. Math. Stat.* 9:1260383. doi: 10.3389/fams.2023.1260383

Editorial: Recent advances in bifurcation analysis: theory, methods, applications and beyond - volume II

Víctor F. Breña-Medina[1]* and Pablo Aguirre[2]

[1]Departamento de Matemáticas, Instituto Tecnológico Autónomo de México, Álvaro Obregón, Mexico, [2]Departamento de Matemática, Universidad Técnica Federico Santa María, Valparaíso, Chile

KEYWORDS

bifurcation, chaos, mathematical modeling, biomathematics, spatiotemporal dynamics

Editorial on the Research Topic
Recent advances in bifurcation analysis: theory, methods, applications and beyond - volume II

The study of dynamical systems has long been a focal point for mathematicians and scientists across various disciplines. Understanding the behavior of non-linear events and capturing the essential features of interactions occurring in nature is crucial for modeling phenomena in fields such as Engineering, Biology, Chemistry, and Physics. These interactions often exhibit complexity and play important roles across different spatiotemporal scales. Therefore, gaining a deep understanding of the phase space structure in these models has become essential from various perspectives, particularly within the realm of applied dynamical systems.

Dynamical models can take on various forms, including finite and infinite-dimensional systems described by vector field flows, iterations of maps, hybrid discrete-continuous settings, as well as delay and partial differential equations. In all these approaches, the topological changes that arise from slowly varying parameters are of particular interest. These changes shape different scenarios that are often expensive or not feasible to explore experimentally. Understanding the reconfiguration of invariant objects during bifurcations is crucial for comprehending the dynamics of the system. Bifurcations can trigger significant transitions from one type of dynamics to completely new responses, including the emergence of chaotic regimes or families of solutions with distinct spatiotemporal features. These features are particularly relevant for describing the complete phase space of a dynamical system and classifying the parameter regimes where natural phenomena may occur.

In this second Research Topic, a collection of diverse works is gathered, exploring both the applied aspects of bifurcations and the reorganization of families of solutions. These works shed light on both longstanding and emerging challenges associated with these dynamical phenomena.

The topics covered in this Research Topic include novel fundamental findings on bifurcation phenomena in various systems, such as systems of partial and ordinary differential equations and maps.

For instance, Pelz and Ward focus their work on the study of symmetry-breaking pitchfork bifurcations in a setting where two bulk diffusing species are coupled to two-component non-linear intracellular reactions. These reactions occur only within a disjoint collection of small circular compartments. The authors employ a hybrid analysis approach that combines path continuation techniques with a singular perturbation approach, leading to the identification of linearly stable asymmetric patterns.

In another direction, Blyuss et al. investigate a predator-prey model with ratio dependence and Holling type III functional response. Their study places particular emphasis on the dynamics close to extinction, exploring the intricate behavior near the threshold of population survival. They examine the existence and stability of equilibria using an Omega function and analyse the effects of predation rate, predator fecundity, and functional response parameter on the stability of extinction and coexistence steady states.

Additionally, Hittmeyer et al. construct a three-dimensional horseshoe for a family of Hénon-like diffeomorphisms, which is the only explicitly given example of a system known to have a hyperbolic invariant set called a blender. The analysis involves constructing a three-dimensional box that acts as an outer cover of the hyperbolic set. The successive forward or backward images of this box form a nested sequence of sub-boxes containing the hyperbolic set and its local invariant manifolds. This construction provides additional geometric insight into the behavior of the hyperbolic set and its classification as a blender.

Finally, Berres and Castañeda thoroughly study a hyperbolic system describing bidisperse suspensions, where two types of small particles scatter in a viscous fluid. The authors provide analytical solutions to relevant Riemann problems connecting the origin with any point in the phase space. They also provide semi-analytical solutions connecting any state with the maximum packing concentration line. The behavior of the solutions in relation to the contact manifolds is discussed, shedding light on the existence of quasi-umbilic points within the system. These points can potentially lead to new types of bifurcations as crucial elements of the elliptic/hyperbolic boundary in the system of partial differential equations.

These contributions, along with those in the first installment[1] of this Research Topic, offer valuable insights into the behavior of dynamical systems near bifurcation points and their implications in different domains. Upon examining diverse models and employing advanced analytical and numerical techniques, these works advance our understanding of bifurcations and their role in shaping the dynamics of complex systems.

1 https://www.frontiersin.org/research-topics/16966/recent-advances-in-bifurcation-analysis-theory-methods-applications-and-beyond

Author contributions

VB-M and PA: conceptualization, writing – original draft, and writing – review and editing.

Funding

VB-M thanks the financial support by Asociación Mexicana de Cultura A.C. PA thanks Proyecto Basal CMM-Universidad de Chile.

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