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Editorial: Advances in nonlinear systems and networks, volume III

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Editorial on the Research Topic
Advances in nonlinear systems and networks, volume III

1 Introduction

Nonlinear systems and networks theory is a branch of automatic control theory. It takes systems and networks described by nonlinear differential equations or difference equations as its research objects, focusing on their motion laws and analysis methods, and belongs to the field of physics [1–5]. Its core feature is the failure of the superposition principle, and it mainly studies complex phenomena such as self-excited oscillation, frequency-dependent amplitude, multi-valued response, bifurcation and chaos [6–10].

In recent years, with the development and application of emerging technologies such as big data [11, 12], cloud computing [13, 14], Internet of Things [15–17], and datacentral networks [18–20], nonlinear technologies have gradually shifted from system modeling to intelligent computing [21–24]. At present, nonlinear systems and networks have been deeply studied and applied in the following fields, such as chaotic systems [25–27], neural networks [28–32], memristors [33–35], neural circuits [36–38], system synchronization [39, 40], and related application fields [41–47].

Due to the success of the first and second Research Topic of "Advances in Nonlinear Systems and Networks", we have decided to continue to focus on the ongoing progress of nonlinear systems and networks in the third volume. This Research Topic has published a total of 10 research papers, covering the latest research progress in areas such as adaptive iterative learning control, chaotic system modeling, memristor mathematical model, nonlinear circuit, and their applications.

2 Summary of papers presented in This Research Topic

Zhang et al. in the paper "FSE-RBFNN-based LPF-AILC of finite time complete tracking for a class of time-varying NPNL systems with initial state errors", proposed a low-pass filter adaptive iterative learning control (LPF-AILC) strategy is proposed. The authors combined the Radial basis function neural network (RBFNN) with the Fourier Series expansion (FSE) and proposed a new function approximator (FSE-RBFNN) to model various time-varying nonlinear parametric functions. To mitigate the influence of the initial state error, the article introduces a dynamically changing boundary layer and a series of methods for dealing with the upper bound of unknown errors. Finally, the correctness of the proposed control method was verified through two simulation examples.

Yu et al. in the paper "New discrete memristive hyperchaotic map: modeling, dynamic analysis, and application in image encryption", by coupling the upgraded cosine discrete memristor with the Cubic mapping, a new type of discrete memristor hyperchaotic mapping is constructed. Then, the dynamic characteristics of the system are deeply analyzed. Subsequently, based on the proposed hyperchaotic mapping, the paper presents a new image encryption scheme, effectively scrambling and diffusing the image data. During the diffusion process, a new forward and reverse diffusion strategy is introduced, which improves the encryption efficiency. Finally, through relevant security analysis, it is found that this scheme has high security and practicability.

Wang et al. in the paper "Monophasic and biphasic neurodynamics of bi-S-type locally active memristor", proposed an artificial memristive neuron was proposed to reproduce the function of biological neurons. By using the Chua expansion theorem, the authors established a mathematical model of a double S-type local active memristor with negative differential resistance (NDR). Subsequently, the paper constructed a second-order neural circuit to simulate periodic spikes and excitability. In addition, the constructed neuron circuits generate biphasic action potentials through voltage-symmetric modulation, replicating the bidirectional signal transmission similar to that of biological systems. Finally, hardware simulation verified the neural dynamics under different stimuli.

Gao et al. in the paper "Analysis and Application for the Source-free R M LC Circuits", studied the passive circuit topologies of four types of integrated memristors and energy storage components. Firstly, through mathematical modeling, the authors discovered that all four circuits are controlled by transcendental equations. Secondly, two types of four-component passive circuits were configured and analyzed. It was concluded that the capacitor and inductor provide energy for the system, while the memristor exhibits hysteresis behavior. Finally, the paper configured and discussed the application circuit. Research shows that even within the same circuit, different placement positions of memristors can lead to different topological structures and different nonlinear output behaviors.

Wang et al. in the paper "An echo state network based on enhanced intersecting cortical model for discrete chaotic system prediction", proposed an echo state network framework based on the Enhanced Intersecting Cortical Model (ESN-EICM). This model introduces a neuron model with internal dynamics (including adaptive thresholds and interneuron feedback) into the reservoir structure. The paper compares the performance of the ESN-EICM network with that of the standard ESN and long short-term memory (LSTM) networks. The experimental results show that in the test system, compared with the standard ESN and LSTM models, the ESN-EICM model generates lower error metrics (MSE, RMSE, MAE), and the performance difference is more obvious in multi-step prediction scenarios.

Tu et al. in the paper "Child information protection scheme based on hyperchaotic mapping", proposed an encryption scheme based on hyperchaotic mapping. Firstly, the authors plotted the phase diagrams of the hyperchaotic mapping under different parameter combinations. The changes in the phase trajectories confirmed the sensitivity of the hyperchaotic mapping to the control parameters. Then, the paper iterates on the hyperchaotic mapping to obtain a chaotic sequence and quantizes the chaotic sequence to obtain a pseudo-random sequence. Finally, on this basis, scrambling algorithms and diffusion algorithms were designed to encrypt and protect the images, which are used to protect the information of missing children and can effectively protect the information security of children.

Chen et al. in the paper "A novel image encryption method based on improved two-dimensional logistic mapping and DNA computing", proposed an innovative image encryption method, eliminating the security limitations of traditional one-dimensional logical mapping. Firstly, the article utilizes the improved two-dimensional Logistic-fractional mixed chaotic map (2D-LFHCM) to effectively shuffle the images by merging chaotic sequences. Then, two new algebraic deoxyribonucleic acid (DNA) calculation rules were introduced to enhance diffusion encryption. The experimental results show that this method provides superior security performance.

Zhang et al. in the paper "Grid Image Encryption Based on 4D Memristive Sprott K Chaotic Sequence", proposed an image encryption algorithm for smart grids based on chaotic systems. Firstly, the authors adopted the 4D memristive Sprott K system to generate chaotic sequences as the encryption key stream; Secondly, the article uses a dual encryption mechanism of scrambling and diffusion to scramble the positions of image pixels and replace their values, thereby enhancing the algorithm's anti-attack capability. The simulation results show that this algorithm can effectively protect the security and privacy of smart grid images.

Huang et al. in the paper "HiImp-SMI: an implicit transformer framework with high-frequency adapter for medical image segmentation", studied an implicit transformer framework for medical image segmentation with a high-frequency adapter (HIPP-SMI). The authors have designed a new dual-branch structure that simultaneously processes spatial and frequency information. Experimental evaluations show that on the Kvasir-Sessile and BCV datasets, HiImp-SMI consistently outperforms mainstream models. The framework proposed in the paper can serve as a flexible baseline for future work involving implicit modeling and multimodal representation learning in medical image analysis.

Dmitriev et al. in the paper "Self-organization of the stock exchange to the edge of a phase transition: empirical and theoretical studies", found segments in the hourly stock trading volume sequence of 3,000 listed company stocks, corresponding to the time when the stock exchange remained at the edge of the phase transition. The authors conducted theoretical arguments for this hypothesis and presented phenomenological models of the self-organization of stock exchanges at the first-order phase transition edge and the second-order phase transition edge. The practical significance of this study lies in the possibility of self-organization of stock exchanges to phase transition edge early warning, and it can be expanded in future research using high-frequency data.

3 Concluding remarks

The continuous release of this Research Topic marks that the application and development research of nonlinear systems and networks has entered a brand-new research space. As this field continues to develop, contributions from a broader range of research and applications will play a crucial role in shaping its future direction.

Finally, we would like to express our gratitude to all the authors of the 10 articles in this Research Topic for their outstanding contributions. Their research papers are all highly suitable for the scope of this Research Topic. In addition, we would also like to express our sincere gratitude to all the reviewers, editors and editorial staff of the journal Frontiers in Physics for their support.

Author contributions

FY: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. H-CI: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. HL: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. V-TP: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing.

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