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Editorial: Advances in chaotification and chaos-based applications

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Editorial on the Research Topic
Advances in chaotification and chaos-based applications

With the findings of the notable Lorenz attractor in 1963, chaos research has received increasing concerns over the past few decades. The breaking of the traditional view that chaos is harmful and uncontrollable makes the chaotification (or chaos anti-control) which refers to the generation or enhancement of chaos in dynamic systems become the mainstream of chaos research. It has been widely accepted that chaos can be applied to secure communication, image encryption, fault diagnosis, path planning, and other engineering fields. A growing number of scholars have been invested in chaos-based applications. Chaotification and chaos-based applications are inseparable. Chaotification provides reliable chaotic systems and signals for chaos-based applications, and the performance of chaotic systems and signals determines their application effects. The excavation of new chaos-based application areas and the application performance requirements promote the generation of more new chaotic systems and signals. Although considerable progress has been made in chaotification, the design of new special chaotic systems and signals and the exploration of their potential application values is always an important and challenging work. The emergence of some new behaviors (such as hidden attractors, coexisting attractors, hyperchaos, multi-scroll attractors, etc) in chaotic systems brings new requirements for the design method and control technology of chaotification. Also currently the chaotification and chaos-based applications have encountered some bottlenecks with many critical issues that remain to be resolved. So we organize this topic issue to discuss new situations and new challenges in chaotification and chaos-based applications in the hope of showing some interesting research results.

This Research Topic collects seven valuable papers which cover discrete and continuous chaotic systems, low-dimensional and high-dimensional chaotic systems, memristive chaotic systems, fractional-order chaotic systems, chaotic image encryption, and secure communication. The contents involve the modeling, dynamic analysis, control, and application of chaotic systems, which are considered to be four important directions of chaos research. The main works of these papers are as follows. Bucolo et al. introduced the method for generating multi-dimensional chaotic maps and gave some examples of multi-dimensional chaotic maps based on Logistic, Ikeda, and Henon maps. Wu et al. constructed a Chua circuit with an absolute term and sufficiently investigated its dynamic properties and successfully realized it by using an FPGA circuit. Especially the hidden chaos and coexisting attractors in the system were revealed. Wang et al. established a new model of gear system by considering some nonlinear factors including tooth side clearance, transmission errors, and time-varying meshing stiffness by applying the concentrated mass method. The chaotic and periodic behaviors of the gear system were discovered by bifurcation analysis. It was shown that the dynamics of the system partially relied on the load states and the chaotic region can be avoided by increasing the mesh damping ratio. Qiu et al. studied the tracking control problem for fractional-order chaotic systems with uncertainties and input quantization by applying the backstepping control method. Based on fractional-order Lyapunov stability theory, some theoretical results were strictly obtained and numerically illustrated with the example of the fractional-order Chua–Hartley chaotic system. Yao et al. constructed a six-dimensional chaotic system by introducing flux-controlled and charge-controlled memristors to a Chua circuit. The synchronization of the system was achieved by designing an adaptive sliding-mode controller and sufficient results for synchronization were established. The synchronization was used to chaos-based image encryption and nice encryption effects strong anti-disturbance ability was obtained. Yu et al. put forward a fractional-order memristive cyclic Hopfield neural network with a new memristor model. The equilibria and their stabilities, local bifurcations, chaos, and coexisting attractors were investigated. It was shown that the network easily yields coexisting symmetric chaos . Based on the chaotic random numbers generated by the network, a new image encryption algorithm was designed and its corresponding security performance was analyzed. Zhang et al. proposed a high-dimensional chaotic system with hyperbolic sine nonlinearity and applied it to secure communication design for brain-computer interface systems. The proposed chaotic system was considered a random number generator. The physical features of output sequences used in differential chaos shift keying were eliminated via a de-correlation operation. Studies showed that the secure communication method had high efficiency and security, and its decryption process did not use channel data. The collected papers focused on the important hotspot issues in chaos theory and application reflecting the advanced nature of research work. It is worth mentioning that a new fractional-order memristive cyclic neural network model with multistability and a Chua circuit model with hidden attractors were constructed in this Research Topic. New methods from generating high-dimensional chaotic maps and chaos-based secure communication for brain-computer interface systems were established.

Chaotification and chaos-based applications are two important aspects of chaos research that remain many key issues to be solved and attract many scholars to study. Based on this Research Topic, some future research directions are inspired and can be further investigated. For chaotification, chaotic systems with hidden hyperchaos, coexisting hyperchaos, and other unique dynamic behaviors which benefit specific chaos-based applications will be more popular. New control technologies and analysis methods for high-dimensional chaotic systems or networks with complex topology will be of great significance. Since the existing chaos-based applications are still at the level of theory and algorithm designs, the practice of chaos-based applications that can produce actual economic and technical benefits will be widely discussed. The problems and challenges currently present in chaotification and chaos-based applications will promote the rapid development of chaos research and cause ongoing discussion.

Author contributions

All authors listed have made a substantial and intellectual contribution to the work and approved it for publication.

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