Advanced Fractional Mathematics, Algorithms and Artificial Intelligence with Applications in Complex Chaotic Systems

Chaos, a long-term aperiodic and random-like behavior manifested by many nonlinear complex dynamic systems, evokes that the system per se is inherently unstable and disordered, which requires the unveiling of representative and accessible paths into richness of complexity and the plethora of experimental processes to generate novelty, diversity and robustness. Characterized by a large number of similar entities which interact among one another with unexpected outcomes arising at higher spatiotemporal scales, complex systems point a broad range of distinct systems from biological to physical and social, often related to collective behavior [1]. While chaos can be attained by the iteration of simple rule and processes of nonperiodic and random behaviors, complexity encompasses a collection of dynamic behaviors derived from the interconnection of various subunits. Since there exist numerous attribute properties and patterns which cannot be described only by theory, the internal complexity of systems involves chaos theory, chaos of fractional nonlinear dynamics and artificial phenomena [2]. Correspondingly, fractional mathematics and application of fractional calculus techniques to problems are capable of describing the existence characteristics of complex natural, physical, medical, scientific and engineering-related systems more accurately, reflecting the actual state properties, co-evolving entities observations and patterns of such systems in a truer manner regarding nonlinear dynamic systems and modeling complexity evolution and order of fractional chaotic as well as complex systems [3].

Fractional calculus (FC), with its differentiation and integration of non-integer order, represents the generalization of classical differential and integral calculus. Therefore, fractional integral and derivatives, in contrast with classical integer-order calculus allow adoption in a broader range of cases [4,5,6,7]. FC brings together the combination of computational methods within an extensive array of distinct complex systems along with fractional derivatives, fractional differential equations, fractional wavelet, fractional entropy, fractional neural networks, fractional fuzzy, among many others to pave the way for systematic optimized solutions, addressing the systemic properties in a holistic way through revealing the spontaneous processes. Such essential fractional mathematical modes help the handling of entropies, a measure of uncertainty, diversity and randomness frequently employed to characterize complex dynamical systems. Fractional entropies are often associated with fractals and fractal dimension, with its measures being related to patterns and processes of time, space and information [8]. Fractional wavelets, as generalized extensions of wavelet multi-resolution analyses in time-fractional frequency domain, are capable of characterizing the signal features, overcoming limitations related to time-frequency plane and obtaining hidden local structures of the signals [9]. It is worth stating that computational (algorithmic) complexity, which refers to the measure of the amount related to the computing resources of time and space, has precarious value as it generates an approximate sense of the volume of computing resources that are necessary for the algorithm in order to prove the input data have different values and sizes [10]. By providing an explicit physical interpretation, efficiency for practical applications and more manageable computational complexity, fractional mathematics and Artificial Intelligence (AI) can capture the history of dynamical effects existent in different natural and artificial phenomena, proving to be essential modes with their conceptions supporting a productive interplay in the exploration of the structure and functions with respect to complex system dynamics [2]. This can be achieved by powerful computational capabilities of neural networks, from single cell activities to large random neural networks at macroscopic scales, in presence of chaos and randomness.

Based on this sophisticated and computer-assisted proof approach, complexities, chaotic conditions and nonlinear elements, gaining a more prominent position through dynamical, causalities distribution, chaotic and neural intelligent systems, it is possible to attain feasible solutions, designed simulations, optimization processes, along with technical analyses and related computing processes and some interesting areas of applications such as mathematics, physics, chemistry, biology, medicine, modern neuroscience, physiology, engineering, robotics and control, geology, meteorology, astronomy, electrical and telecom engineering, genetics, information science, data science, computer science, applied soft computing, evolutionary computing, information and communication technologies, statistical mechanics, economics and social sciences to name some. Consequently, our special issue aims to provide a novel direction towards innovative and thought-provoking inter-,multi-and transdisciplinary and model-based and data-driven research based on advanced mathematical modeling and computational foundations in conjunction with chaos-inspired model training and optimization methods, so we expect to receive studies concerned with the theoretical and applied dimensions of nonlinear dynamics and complex systems, merging mathematical analysis, advanced methods and computational technologies to be presented in order to exhibit the implications of applicable approaches in real systems and other related domains.

The potential topics of our special issue include but are not limited to:

- Many and multi-objective optimization of evolutionary computation
- Fractional-order chaotic signals with machine learning
- Data-driven forecasting of high-dimensional chaotic processes
- Fractional entropy for digital imaging processes
- Fractional entropy-based image enhancement for deep segmentation for medical image / signal analyses
- Fractional wavelet transform in image enhancement
- Image encryption algorithms
- Neuroimaging and whole-brain modeling
- Evolutionary computation with fractional methods
- Soft computing-based applications for modeling dynamic nonlinear systems
- Complexity analysis and visualization of fractional information
- Chaos in physical, chemical and biologically inspired fractional-order systems

- Fractal structure and hidden attractors in modeling multistability phenomena
- Chaos and nonlinear dynamics in fractional-order neural networks
- Fuzzy modeling and chaos control of partial differential systems
- Fuzzy fractional wave equations
- Fractional refined composite multiscale fuzzy entropy
- Neuro-fuzzy hybrid systems and genetic algorithms
- Mathematical analysis and modeling in complex systems
- Fractional differentiation and applications
- Higher-order nonlinear partial differential equations
- Fractional calculus and fixed-point theory with applications
- Modeling and control of partial differential equations
- Fractional calculus operators and their applications to analytic functions
- Uncertainty-driven multi-scale structures for image or signal classification with AI
- Self-similar time series with noise
- Disease dynamics and clinical applications: diagnosis, prediction and control
- Bifurcations in a class of complex differential equations
- Nonlinear Artificial Intelligence and applications with big data in complex systems
- Computational (algorithmic) complexity
- Differential equations in medicine and technology
- Long-short-term-memory network for classification and prediction of dynamical changes in fractional-order chaotic systems
- Convolutional neural networks with fractional order gradient method
- Fractional-order deep neural networks by constrained optimization
- General fractional vector classification
- Stochastic synchronization, identification, control and communication of chaotic neurons

Important deadlines for submission:
Closing date for initial submission: August 1, 2023
Deadline for final decision notification: October 1, 2023 (Part I)
Publication Date: December 2023
Subsequent continuing parts are being planned as Part II and more parts.

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