Nonlinear Dynamics

**Special Issue of Nonlinear Dynamics**
**"Chaos theory and applications:**
**A retrospective on lessons learned and missed or new opportunities"**

Chaos, from the Greek *khaos*, "abyss, that which gapes wide open, that which is vast and empty", is a relatively young scientific discipline, which however has old and important roots, dating back (at least) to James Clerk Maxwell in 1860 and Henry Poincaré in 1890. The birth of the modern age of Chaos is commonly referred to the work of Edward Lorenz in 1963. After this triggering point, it became a flourishing and fascinating research field, that attracted the interest of top scientists as well as many valuable researchers, still active to date. Looking for the word "Chaos" in modern research tools an almost uncountable number of papers appear.
After 60 years of huge developments, after books (J. Gleick, Chaos; R. Abraham and Y. Ueda, The Chaos Avant-Garde: Memories of the Early Days of Chaos Theory; etc.) and Symposia (IUTAM Symposium on 50 Years of Chaos: Applied and Theoretical, Kyoto, 2011, etc.), we felt it was the right time for a pitstop, aimed at looking:

(i) *backward*, of course, to "summarize" the major developments and their applications, successes and failures;
(ii) *forward*, to see the new ongoing developments of this fascinating discipline and future perspectives, in particular unexplored ones; and
(iii) *laterally*, i.e. to works that, while strictly not classifiable as belonging to the chaos family, are close and relevant indeed, having common features.
We have also tried to give an answer, that is necessarily partial and incomplete, to the questions "Who were we?", "Who are we?", "Who will we be?" in Chaos.

According to this vision, we selected and invited a limited number of top Scientists to contribute to this Special Issue, asking them to bring their ideas, reflections, viewpoints, developments, regrets, etc. Thus, the Special Issue was open to review papers, to position papers as well as, of course, to technical papers, even those not specifically referring to Chaos. The enthusiastic responses of the invited scholars have been encouraging.

Chaos is intrinsically multidisciplinary, and it is of interest and find applications in mathematics, science, engineering, physics, economics, chemistry, biology, medicine, etc. Without exaggeration, we can say that almost any system that evolves in time (dynamical system) is susceptible to be chaotic, whatever its meaning, its evolution equations, its dimension, etc. The Guest-Editor composition reflects, as much as possible, this fundamental aspect: Gardini, from mathematics and economy, Grebogi, from physics, and Lenci, from engineering. Also, the invited authors have been selected with the aim of representing and typifying the interdisciplinarity of Chaos.

One of the most famous property of Chaos is the sensitivity to the initial conditions, also popularly known as “Butterfly effect” after Lorenz in 1972 (but although known to Maxwell and Poincaré) and after movies like “Sliding doors”. It entails, even if the system is totally deterministic and known, that small changes in initial conditions lead, sooner or later, to large differences. In other words, this means that, in the chaotic realm, we are not able to make long term predictions, unless we are able to know exactly the starting point, which is of course not the case in the real world. According to this distinct property, we cannot predict whether this Special Issue will be relevant or not. We can only hope that it will be of interest for both senior scholars, aimed at knowing a little bit more about Chaos, and younger researchers, aimed at finding new ways, new results and new applications.

We wish to thank all the authors for their hard work, and for supporting our idea. Last but not least, we wish to thank the Editor-in-Chief of Nonlinear Dynamics, Prof. Walter Lacarbonara, that not only hosts this Special Issue, but triggered it and helped during its development.

Guest Editors of the Special Issue

Laura Gardini, Urbino
Celso Grebogi, Aberdeen
Stefano Lenci, Ancona

List of papers

Crinkled changes of variables
Suddhasattwa Das (Jim Yorke)

Global and local performance metric with inertia effects
Peng Ji (Jurgen Kurths)

Multilayer brain network combined with deep convolutional neural network for detecting major depressive disorder
Zhong-Ke Gao (Celso Grebogi)

Particle filtering for chaotic dynamical systems using future right-singular vectors
Ryne Beeson (Sri Namachchivaya)

The high forecasting complexity of noisy periodic orbits limits the ability to distinguish them from chaos
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The Lorenz system: hidden boundary of practical stability and the Lyapunov dimension
Nikolay V. Kuznetsov

Stability of synchronous states in sparse neuronal networks
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Is it really chaos? The complexity of transient dynamics of double pendula
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Nonlinear dynamics in the flexible shaft rotating-lifting system of silicon crystal puller using Czochralski method
Hai-Peng Ren (Celso Grebogi)

Chaos in Onedimensional Structural Mechanics
Valeria Settimi (Giuseppe Rega)

Chaos in Impact Oscillators not in Vain: Dynamics of New Mass Excited Oscillator
Ekaterina Pavlovskaia (Marian Wiercigroch)

Noise-Induced Chaotic-Attractor Escape Route
Balakumar Balachandran

Intra-well and cross-well chaos in membranes and shells liable to buckling
Paulo Batista Gonçalves

Synchronization and chimera state in a mechanical system
Marcelo A Savi

Chaos and Bifurcation Analysis of Stochastically Excited Discontinuous Nonlinear Oscillators
Narayanan S

Impulsive torque control of biped gait with power packets
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Theoretical Analysis of Dynamic Behaviors of Cable-stayed Bridges Excited by Two Harmonic Forces
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Chaos, Border Collisions and Stylized Empirical Facts in an Asset Pricing Model with Heterogeneous Agents
Mikhail Anufriev

Property and evolution of the running-in attractor in an actual dynamic system
Cong Ding

A dynamic Parrondo's paradox for continuous seasonal systems
Armengol Gasull

Nonlinear asset-price dynamics and stabilization policies
Frank Westerhoff

Codimension-two border collision bifurcation in a two-class growth model with optimal saving and switch in behaviour
Ingrid Kubin

On the Influence of Memory on Complex Dynamics of Evolutionary Oligopoly Models
Fabio Lamantia

Global dynamic scenarios in a discrete-time model of renewable resource exploitation: a mathematical study
Anastasiia Panchuk

Dynamics and bifurcations of a map of homographic Ricker type
J. Leonel Linhares Rocha

Complex Dynamics of Multi-regional Economic Interactions
Marcelo A Savi