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Deterministic Random Dynamics Generated by Non-linear Non-invertible Transformations of Oscillating Functions

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Abstract: We investigate the generation of highly complex dynamics within non-invertible transformations of specific sets of continuous-time variables. We show that the time series complexity indices depend on the previous values emerging from the initial variables, through analytical complexity models for Fourier spectra, Lyapunov exponents and correlation functions. In some cases, these systems can produce completely unpredictable dynamics in a deterministic way. A comparison of the theory with standard numerical complexity estimators is presented.

Keywords: *strange attractors, chaotic dynamics; complex behavior, chaotic systems; random number generation.*

Mathematics Subject Classification (2010): 37D45, 34C28, 65C10.

1 Introduction

Polynomial functions used as non-linear, non-invertible transformations can be found in a large number of systems that exhibit chaos and hyperchaos, among which we can highlight a modified version of Chua's circuit [1], and the Ikeda system implemented in an electro-optical feedback oscillator with time delay [2–4], whose nonlinear transfer characteristic is a sine function. In discrete-time one-dimensional systems, the non-invertibility is essential for the existence of chaos [5], for example, the Logistic, Tent and Bernoulli maps use this kind of nonlinearity. These maps have been used for the development of the *deterministic*

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