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RESEARCH ARTICLE

Dynamical Analysis of a 3D Fractional-Order Chaotic System for High-Security Communication and its Electronic Circuit Implementation

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Abstract
This article, a 3D fractional-order chaotic system (FOCS) is designed; system holds Equilibria can take on various shapes and forms by introducing a nonlinear function and the value of its parameters. To comprehend the system's behavior under diverse conditions and parameter values, a dynamical analysis is conducted through analytical and numerical means. This analysis employs techniques like phase portraits, Lyapunov exponents (LEs), bifurcation analysis, and Lyapunov spectra. The system demonstrates attractors that are more intricate compared to a regular chaotic system with an integer value, specifically if we set the fractional order q to 0.97. This characteristic makes it highly appropriate for developing secure communication systems. Moreover, a practical implementation has been developed using an electronic circuit to showcase its feasibility of the system. A secure communication system was built using two levels of encryption techniques. The propose sound encryption algorithm is verified through tests like histogram, correlation, and spectrogram investigation. The encryption correlation coefficient between the original signal and the encrypted one is 0.0010, this result shows a strong defences against pirate attacks.

Keywords Fractional-order chaotic system · Equilibria · Dynamical analysis · Communication system · Encryption techniques · Security analysis · Mathematical operators

1 Introduction

Chaos is a highly intriguing and complex nonlinear phenomenon that has been extensively researched over the past 40 years by the scientific, Mathematical, and Engineering Communities. As a result, generating chaos has become a significant area of research. Many chaotic systems have been developed by taking inspiration from the famous Lorenz system [1–5]. There has been significant interest in

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