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Synchronization of a new fractional order chaotic system

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Abstract
In this paper we have introduced a new fractional order chaotic system and investigated chaos synchronization between the new fractional order chaotic system and the Lü fractional order chaotic system using active control technique. Numerical simulations are carried out using Matlab to show the effectiveness of the method.

Keywords Synchronization · Chaotic system · Fractional order · Lü system

Mathematics Subject Classification 34A08 · 34D06 · 34H10

1 Introduction

Chaotic systems are those dynamical systems that defy synchronization. Two identical autonomous systems starting at nearly the same initial points in phase space have uncorrelated trajectories, even though each of them maps out the same attractor in phase space. Since the seminal paper by Pecora and Carroll [1], chaos synchronization has acheived a great deal of interest among the researchers due to its potential applications in many fieids.

Fractional calculus is a classical mathematical concept that has a history as long as calculus itself. It is a generalization of ordinary differentiation and integration to arbitrary order. It has many applications in physics and engineering such as dielectric polarization [2], viscoelastic systems [3,4], electrode–electrolyte polarization [5] and so on.

In recent years, studies of chaos, hyperchaos and synchronization have achieved considerable attention due to their potential applications in secure communication and control processing [6,7], economics [8], biology [9] etc. Some of the approaches which have been presented to achieve chaos synchronization in fractional order chaotic systems are adaptive control method [10,11], sliding mode control method [12,13], linear and non-linear feedback control method [14,15], active control method [16,17], backstepping control method [18,19], etc.

Recently, Ahmad et al. [20] have studied Global chaos synchronization of new chaotic system using linear active control, Vincent et al. [21] have extended the concept of multi-switching synchronization to combination synchronization, Wu et al. [22] studied the synchronization of new fractional order hyperchaotic system in their paper. Yu and Li [23] used Laplace transformation theory and variational iteration method to study Rössler system. Ibrahim in his paper [24] studied the stability and stabilization of complex fractional order Lorenz systems. Ibrahim and Jalab [25] studied the time delay of a complex fractional order Liu system.

In our paper, we have constructed a new system and by using Wolf algorithm [26] we have shown that chaos exist in that system by calculating the Lyapunov exponents of the system. We have used the active control technique to synchronize the new fractional order chaotic system with the Lü fractional order chaotic system.

This paper is organized as: in Sect. 2, the fractional order derivative and its approximation are given. In Sect. 3, we described the new three-dimensional system in both integer and fractional order, Sect. 4 is devoted to the study of the synchronization between the two non-identical fractional-order chaotic systems using active control method. In Sect. 5, we present the numerical results to verify the effectiveness of the method. Finally, the conclusion is given in Sect. 6.

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