A Synchronizing Controller Using a Direct Adaptive Interval Type-2 Fuzzy Sliding Mode Strategy

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Abstract— In this paper, a direct adaptive interval type-2 fuzzy sliding mode control scheme is proposed for synchronizing two different chaotic systems. This method guarantees the global asymptotic stability synchronization of the two state trajectories using lyapunov stability criteria. This combination reduced the chattering phenomena of the control efforts by type-2 fuzzy paradigm. To elucidate the performance of this method, the simulation results to synchronize two different chaotic systems such as Lorenz and Chen are given. This method ensures the convergence of the synchronization error between two systems towards zero as time goes to infinity. Simulation results show the effectiveness of proposed method.

Keywords— Adaptive control; Chaotic systems; Interval type-2 fuzzy system; Sliding mode control; Synchronization.

I. INTRODUCTION

Chaos is a random-like and unpredictable behavior in deterministic phenomena. There are many systems with chaotic behavioral such as the Chua’s system, Duffing system, unified system, Rössler system, Lu system, and Chen’s system [1]-[7]. Fujisaka and Yamada first introduced chaos synchronization in 1983 [8]. The main idea of synchronization process is to design a controller so that the output of the slave system can follow the output of the master system asymptotically. In the recent years, chaos synchronization has become one of an important topic in the nonlinear science. Due to its powerful applications in many fields such as chemical reactions, power converters, biological engineering, information processing, secure communications, nonlinear control system, chaos synchronization has been developed. As is well known, in the state trajectories of a chaotic system, if starting from two nearby initial conditions then separate exponentially in the course of the time, so those trajectories depends on the initial conditions.

In recent years, many methods have been developed for the synchronization of chaotic systems such as adaptive control [9]-[12], variable structure or sliding mode control [13]-[16], impulsive control [17]-[19], feedback control [20],[21], fuzzy control [22]-[24], back-stepping design [25]-[27], active control [1],[28],[29], passive control [30], H infinity method [31],[32] and so on.

Several previous researches in this area include Lin et al. [33] presented an adaptive interval type-2 fuzzy sliding mode control for synchronization of uncertain fractional order chaotic systems. The survey results indicate a good use of type-2 fuzzy system has to deal with uncertainties. In another research, Lin et al. [34] presented a direct adaptive interval type-2 fuzzy system has to deal with uncertainties. In another research, Lin et al. [34] presented a direct adaptive interval type-2 fuzzy sliding mode controller for synchronization of two different uncertain chaotic systems. Lin et al. [22] presented an adaptive fuzzy sliding mode control for synchronization of uncertain fractional order chaotic systems with time delay. Yassen [29] used active control techniques to synchronize two different chaotic systems.

In addition, several previous researches using the same method include El-Bardini et al. [36] presented an adaptive interval type-2 fuzzy controller for the multivariable anesthesia system. Ougli et al. [37] presented a type-2 fuzzy adaptive controller of a class of nonlinear system.

The aim of this paper, a direct adaptive interval type-2 fuzzy sliding mod control technique is used to design suitable controllers to synchronize two different chaotic systems. This article is written by another method for improving [35].

This paper is organized as follows: In Section II describes two different chaotic systems such as Lorenz and Chen. A brief description of a direct adaptive interval type-2 fuzzy sliding mode control is presented in Section III. The simulation results are provided in section IV. Finally, the conclusion is discussed in Section V.

II. SYSTEMS DESCRIPTION

In this section describes two different chaotic systems are considered to be synchronized. The master chaotic system is as follows,

$$\dot{x} = f(x) + F(x)\alpha$$

(1)

Where $x$ is state vector and $\alpha$ is the unknown parameter vector of the system, $f(x)$ is an $n \times 1$ matrix, $F(x)$ is an $n \times m$ matrix and are known function matrices. In addition, the slave chaotic system is as follows,

$$\dot{y} = g(y) + G(y)\beta + u$$

(2)