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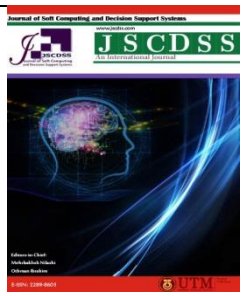

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Design a Tracking Control Law for Nonlinear Continuous Time Fuzzy Polynomial Systems

Roozbeh Salimi Taremi [a,*], Pouria Karimi Shahri [b], Arian Yousefyan Kalareh [c]

[a] Electrical and Computer Engineering Department, Islamic Azad University, Tehran, Iran
[b] Mechanical Engineering Department, UNC Charlotte, Charlotte, NC, USA, 28262
[c] Mechanical Engineering Department, Tarbiat Modares University, Tehran, Iran

*** Corresponding author email address**: pkarimis@uncc.edu

Abstract

In this paper, the method of designing a tracking control law for fuzzy polynomial systems is investigated. In the proposed method, which is a generalization of the existing methods, the nonlinearities of the system are also considered. Therefore, a wide range of systems can be controlled using this approach. The output feedback control rule is considered based on the structure of the observer and the controller. The closed-loop system stability and performance conditions will be extracted in the format of the sum of squares by guaranteeing H_∞ tracking index. The proposed method is a generalization of the tracking control law design for Sugeno fuzzy systems. The numerical simulation results show the performance of the proposed method.

Keywords: Polynomial fuzzy systems, Tracking control rule, Sum of squares observer controller, Infinite norm, Takagi-Sugeno, Nonlinear continues time.

1. Introduction

The Takagi-Sugeno (T-S) fuzzy model has received much attention in recent years after applying linear matrix inequality, and so far, much research has been done, especially on the application of linear matrix inequality in various fields like optimal control, robust control and non-linear control (Wang et al., 1995). In general, the control method based on the fuzzy model offers a straightforward and effective method as a complement to other non-linear control methods. Although linear matrix inequality control is an efficient and effective method for the T-S fuzzy model, many design problems cannot be articulated by linear matrix inequality.

In recent years, another set of fuzzy systems has been developed that are more general in modelling non-linear systems than T-S fuzzy systems. This class of systems are known as Fuzzy Polynomial Systems (FPS). The main difference between these systems and the T-S fuzzy systems is that the linear subsystems in the T-S system rules section have become polynomial subsystems dependent on the system states (Tanaka et al., 2006). Various activities have been performed to analyse the fuzzy polynomial systems. Among these are (Yu et al., 2018; Izadi and Ghasemi, 2019; Izadi et al., 2014; Yan et al., 2019; Shahri et al., 2019). In addition, this control method can also be used for non-linear systems such as heterogeneous traffic networks in order to maximize the outflow of the highway (Tanaka et al., 2012).

Stabilization and tracking are two primary aims for control problems, which the later one is more difficult to pursue than stabilization. There are various methods for designing the output tracking control rule in the literature, such as the observer-controller design. Some work has been done on the observer design to stabilize polynomial fuzzy systems (e.g., Chang and Wu, 2012). In this research, polynomial fuzzy observer for three classes of polynomial fuzzy systems is investigated. As mentioned, the results of the study in Tanaka et al. (2006) are solely dedicated to system stabilization and do not apply to the tracking problem.

Various studies have been carried out on the design of the observer for T-S fuzzy systems. Investigation of these studies will allow the development of the methods of fuzzy polynomial systems. In Shanjian et al. (2015), a fuzzy controller and observer are designed to reduce the tracking error. In this paper, H∞ scheme is used to design the observer gain. In Tseng et al. (2001), the problem model reference tracking control for discrete-time affine fuzzy systems with external disturbances is introduced, which uses H∞ scheme to reduce the disturbance effect (e.g., Chang and Wu, 2012). In this paper, based on the fuzzy