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Fuzzy dissipative control for nonlinear Markovian jump systems via retarded feedback ☆

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Abstract

This paper deals with the problem of the dissipative control for a class of nonlinear Markovian jump systems through Takagi–Sugeno fuzzy model approach. The transition rates of Markovian process under consideration are assumed to be partly known. We aim to design retarded feedback controllers such that the resulting closed-loop system is stochastically stable and strictly $(Q, S, R)-\theta-$dissipative. By introducing a novel augmented Lyapunov functional and some free Markovian switching matrices, some sufficient conditions for the solvability of the above problem are given in terms of linear matrix inequalities. Finally, two numerical examples are given to demonstrate the effectiveness of our proposed approach.

1. Introduction

The Takagi–Sugeno (T–S) fuzzy model approach is an efficient and widely accepted technique to cope with the analysis and design of nonlinear systems [1–5]. The idea is to represent or

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approximate the nonlinear systems by T–S fuzzy model, which is described by smoothly blending a set of simple linear subsystems together through the membership functions [6–9]. As a result, based on this fuzzy model, some simple control designs have been developed to achieve control performance of many complex nonlinear systems, such as the Henon system, chaotic Lorenz system, and truck trailer system [10–13]. For this reason, there have been lots of results on the stability analysis and control synthesis for T–S fuzzy systems. To mention a few, by solving some convex optimization problems with linear matrix inequality (LMI) constraints, some effective H_∞ controller design approaches were presented for continuous-time T–S fuzzy systems [14–16] and discrete-time T–S fuzzy systems [17–20], respectively. In [21,22], several H_∞ filters were designed, which guarantee that the corresponding filtering error systems are stable with $\gamma-$disturbance rejection. More recently, the problems of passivity analysis and passive control for T–S fuzzy delayed systems were studied in [23], where some delay-dependent conditions for the solvability of the problems were presented by using LMI relaxation technique. It should be pointed out, however, that all these problems come down to the dissipativity analysis and dissipative control problems.

As noted in [24–27], in the dissipativity theory, a useful framework for the study of nonlinear control systems is provided by using an input–output description regarding the system energy. However, it is not easy to construct an efficient controller to deal with the dissipative design problem of nonlinear control systems [28]. In this case, the T–S fuzzy model may be used, and a fuzzy controller is developed to achieve the dissipative design goal of the original nonlinear systems. Therefore, the fuzzy dissipative control is a problem worthy of study.

On the other hand, in many practical systems, the abrupt phenomena cannot be ignored and lead to the changes of system parameters. The study of Markovian jump systems, therefore, has been the subject of extensive research activity [29–33]. A large portion of the literature has focused on the analysis and synthesis of linear Markovian jump systems. In context of nonlinear Markovian jump systems, by using the T–S fuzzy model approach, some results have been derived and widely applied in many practical systems such as circuit systems [34,35], a single-link robot arm [36], electrical power systems [37], and backing up control of a computer simulated truck–trailer [38,39]. In these papers, the transition rates are assumed to be completely known. This assumption may limit the scope of the applications of these results because it may be prohibitively expensive, and indeed sometimes impossible, to measure all transition rates [40–45]. Taking partly known transition rates into account, some sufficient conditions for the solvability of the fuzzy stabilization problem for Markovian jump nonlinear systems were presented in [46], which were further improved in [47]. In addition, time delay is often encountered in control signal transmission channel [48,49,51]. When information on the size of the time delay is available, retarded controllers can achieve better performance than traditional controllers since not only the current but also the past control signals are used [52]. Moreover, on the basis of the T–S fuzzy model approach, the dissipative control problem for nonlinear Markovian jump systems has not been fully investigated so far. These motivate the present study.

This paper is concerned with the dissipative control problem for a class of nonlinear Markovian jump systems via the T–S fuzzy model approach. We aim to design retarded controller such that the resulting closed-loop system is stochastically mean-square stable and strictly $(Q,R,S)-\theta-$dissipative. For this purpose, some sufficient conditions are established for the solvability of the problem based on LMI formulations combined with the Lyapunov–Krasovskii method. A retarded controller is constructed and two numerical examples are given to illustrate the effectiveness of the proposed method. It is worth pointing out that the dissipative control problem considered here includes the H_∞ control problem or passivity based control

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