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Observer-based control for singular nonhomogeneous Markov jump systems with packet losses☆

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Abstract

This paper is concerned with the observer-based H_∞ control for a class of singular Markov jump systems over a finite-time interval, where the transition probability (TP) is time-varying and is limited to a convex hull. Due to the limited capacity of network medium, packet losses are presented in the underlying systems. Firstly, using a stochastic Lyapunov functional, a sufficient condition on singular stochastic H_∞ finite-time boundedness for the corresponding closed-loop error systems is provided. Subsequently, a linear matrix inequality (LMI) condition on the existence of the H_∞ observer-based controller is developed from a new perspective. Finally, three numerical examples are provided to illustrate the effectiveness of the proposed controller design method, wherein it is shown that the proposed method yields less conservative results than those in the literature.

1. Introduction

The past several decades have witnessed a great deal of interest in Markov jump systems (MJSs). This increased interest is due to their strong ability to describe systems subject

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to abrupt variation in their structures or parameters [1]. As a result, MJSs can be utilized to characterize and model many types of systems in applications, such as communication systems, networked control systems, economics systems, and others. It is a fact that TPs play an important role in the performance of such systems. Based on the assumption that the TPs are time invariant, the stability analysis and synthesis for MJSs have been studied in [2–8]. For example, the problem of adaptive sliding-mode stabilization for MJSs with actuator faults was discussed in [7]; the energy-to-peak state estimation for Markov jump recurrent neural networks with time-varying delays was studied in [8]. However, in practical applications involving economic systems, flight control systems and networked control systems, the TPs are not time invariant. As it is well known that packet dropout and stochastic delays in the networked control systems can be expressed by a Markov process or Markov chain. In practice, delay or packet dropouts are changing in different periods, which results in the time-varying transition probabilities, so the investigation of the control problem on MJSs with nonhomogeneous Markov process or Markov chain becomes important. Recently, the issue of state estimation for Markov jump neural networks with piecewise homogeneous Markov chain was concerned in [9,10]. For nonhomogeneous MJSs (NMJSs), the stability analysis and controller design have been investigated in [11–15]. Especially, when the time-varying TPs are assumed to be in a polytopic sense, the design of controller for NMJSs was investigated in [12–15]; the filtering problem for Markov jump neural networks was investigated in [16].

Singular systems, also referred to as descriptor systems, differential-algebraic systems, generalized state-space systems or semi-state systems, have attracted a large number of researchers' attention. The reason is that they have widespread applications in biological systems, networked control systems, economic systems, power systems, and so on [17,18]. Recently, the observer-based controller for descriptor system with Brownian motions was investigated in [19]. Singular MJSs, as a special class of MJSs, have been widely studied due to their perfect application in the real system [20–32]. Many interesting results for singular MJSs are produced, for example stabilization [20,21,23–26], sliding mode control [22,27], finite-time control [28–32]. In particular, the observer-based finite-time control problem for discrete-time singular MJSs has been studied in [28]. However, in order to use the existing LMIs method, there is mandatory restriction on the Lyapunov variables in [28], which will lead to conservative results. By invoking equality constraints $P_{ia}B_i = B_i\theta_i$, the reliable sliding mode finite-time control for discrete-time singular MJSs with sensor fault and randomly occurring nonlinearities has been discussed in [31]. In this case, checking the conditions may involve numerical difficulties. Thus, developing a method to give a less conservative condition on the existence of an observer-based controller for singular MJSs in terms of strict LMIs motivates our current study.

Networked control systems have many advantages such as lower cost, higher reliability and easier maintenance. The network-induced problems has been attracted lots of researchers in the past decades, such as network-induced time delays [33,34], event-triggered control [35,36]. It is worth mentioning that in networked control systems, the data may be damaged in the network due to limited bandwidth, sensor failure and noisy measurements. This can degrade the system performance or even cause system-level faults. Consequently, many useful results on designing networked control systems against the packet losses have been developed [37–43]. The H_∞ control problem for nonlinear systems with missing measurements between the sensor, controller and actuator was studied in [38]. Authors in [41] considered the H_∞ filtering problem for discrete-time singular systems with lossy measurements. For singular MJSs with missing measurements, the design of filter was given in [42,43]. But up to now,

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