Available online at www.sciencedirect.com

ScienceDirect

Journal of the Franklin Institute 353 (2016) 426–447

Journal of The Franklin Institute

www.elsevier.com/locate/jfranklin

Delay-dependent robust fault detection for Markovian jump systems with partly unknown transition rates

Furong Chen, Yanyan Yin, Fei Liu*

Key Laboratory of Advanced Process Control for Light Industry, Ministry of Education, Institute of Automation, Jiangnan University, Wuxi 214122, China

Received 1 September 2014; received in revised form 11 October 2015; accepted 1 December 2015
Available online 12 December 2015

Abstract

This paper focuses on delay-dependent robust fault detection (RFD) problem for continuous-time Markovian jump systems (MJSs) with partly unknown transition rates and time-varying delay. Free-connection weighting matrices are firstly addressed to robust fault detection filter design, which reduce the conservatism caused by fixed-connection weighting matrices. By considering Lyapunov stability theory, new delay-dependent stochastic stability criteria are eatablished in terms of linear matrix inequalities (LMIs). Based on this, sufficient conditions are given and proved to guarantee the existence of the robust fault detection filter system. Furthermore, an optimization design approach is derived with an improved cone complementarity linearization algorithm. Finally, a simulation example is given to show that the designed robust fault detection filter can detect the faults sensitively, and also respond robustly to unknown disturbances.

Keywords: Robust fault detection; Markovian jump systems; Partly unknown transition rates; Delay-dependent; Improved cone complementarity linearization algorithm

1. Introduction

Fault detection and isolation (FDI) in dynamic systems has attracted much attention due to an increasing demand for higher safety and reliability requirements in the last two decades, among

*Corresponding author.
E-mail address: fliu@jiangnan.edu.cn (F. Liu).

http://dx.doi.org/10.1016/j.jfranklin.2015.12.001

which model-based FDI is investigated particularly [1]. The main idea of model-based FDI is to construct a residual generator and then obtain the residual evaluation function the threshold [2,3], once the value of the residual evaluation function is larger than the threshold, fault is generated. However, it is hard to avoid modeling errors and unknown disturbance inputs which may affect the performance of many practical systems seriously. They may leave faults undetectable, or even lead to false detection. As a result, increasing the robustness of fault detection system is of great importance in designing a model-based FDI system. Distinguished from the conventional concept of robustness of control systems, robust FDI under consideration is determined to increase the robustness of residual to modeling errors and unknown disturbance inputs, and meanwhile enhance the sensitivity to faults [4–6]. So far, there are numerous systematic studies devoted to model-based robust FDI in industrial systems and great progress has been made. In a model-based robust fault detection (RFD) scheme, the main challenge is to strike a balance between robustness and sensitivity in the presence of model uncertainties, which is considered as the robust fault detection problem [7].

On another research front line, Markovian jump systems (MJSs) have been widely investigated because such systems match many practical systems whose structures are subject to random abrupt parameter changes due to, for instance, component failures, system noises, sudden environment changes, etc. The existing results cover various control problems such as stability and stabilization, robust control and H_∞ filtering [8–11], etc. Furthermore, time delays are the inherent features of many practical systems such as communication, electronics, manufacturing and chemical systems and they are often the main cause of instability, oscillation and poor performance of systems [12–13]. Therefore, it is of great significance to study MJSs with time delay. At present, there exist various approaches to deal with time-varying delay systems. For example, the delay partion technique has been applied to deal with the delay-dependent systems [14]. This method is to divide time delay into several components evenly, and is one of the very effective techniques to study time-delay system. The input–output technique is also an effective method which has been demonstrate in [15]. Hoverwer, both methods cannot deal well with time-varying delay systems in the case that time delay enlarges. The reciprocally convex approach [16] as another method to delay with time delay systems, which has been proved to be more effective and less conservative than the delay partion technique and the input–output technique. In order to reduce the results' conservativeness, Hien et al. [17] and Shao et al. [18] try to construct a new parameter-dependent Lyapunov function. In spite of such many improvements, some bounding inequalities are applied in all of these methods, which cause conservative results inevitably. Considering all these conditions, Wu et al. [19] have proposed the free connecting weight method, by which the relevant conclusions become much less conservative.

In recent years, much effort has been devoted to time-delay Markovian jump systems [20–22]. Despite these developments, many results on MJSs are on the assumption that the transition rates are all accessible. However, in many practical systems, transition rates of the Markovian jump systems are hard to measure exactly or may be only partly transition rates are available. Therefore, it is more important to study MJSs with partly unknown transition rates and time-delay. The works in [23–28] have made some attempts in the area with respect to stability, stabilization, tracking control and H_∞ filtering of such stochastic jump systems. In [25,26], the fixed connection weighting matrices were introduced by making use of the relationship of the transition rates among each subsystem, and some inequalities were addressed to bound the cross terms in the weak infinitesimal operator of the selected Lyapunov function, in which the fixed connection weighting matrices and inequalities were proved to be an effecient way to solve