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Discrete-time H_-/H_∞ sensor fault detection observer design for nonlinear systems with parameter uncertainty

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SUMMARY

This work concerns robust sensor fault detection observer (SFDO) design for uncertain and disturbed discrete-time Takagi–Sugeno (T–S) systems using H_-/H_∞criterion. The principle of the proposed approach is based on simultaneously minimizing the perturbation effect and maximizing the fault effect on the residual vector. Furthermore, by introducing slack decision matrices and taking advantage of the descriptor formulation, less conservative sufficient conditions are proposed leading to easier linear matrix inequalities (LMIs). Moreover, the proposed (SFDO) design conditions allow dealing with unmeasurable premise variables. Finally, a numerical example and a truck–trailer system model are proposed to illustrate the efficiency of the SFDO design methodology. Copyright © 2013 John Wiley & Sons, Ltd.

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KEY WORDS: discrete-time nonlinear systems; T–S models; descriptor approach; SFDO; unmeasurable premise variables; H_-; H_∞; LMI

1. INTRODUCTION

Recently, tremendous research effort has been invested in the field of fault detection and isolation (FDI) for different types of systems. The FDI devise is key in several applications and, in particular, in those looking for safety and efficient solutions of industrial control schemes (see [1–7] and references therein). An FDI system must be able to bear with different types of faults in sensors and/or actuators, which can occur instantaneously (abrupt faults) or slowly in time (incipient faults). Traditionally, the strategies for fault detection are divided in approaches on the basis of quantitative models, where the knowledge of mathematical models of the plant is required [2, 8–10] and on qualitative models using some pattern analysis of the historic process data [11–13]. Generally, most of the previous references illustrate approaches for dealing with abrupt faults, which may be easier to be detected than incipient faults. In the context of incipient faults, the reader can see the following references that present a novel approach based on two-step fuzzy/bayesian formulation for change point detection in time series [14, 15]. So far, observer-based FDI is one of the most effective methods and has obtained much more attention. Observers designed to implement fault detectors have historically been quantitative, utilizing numerical equations to model the system and characterize inputs and disturbances. This is the case of the presented paper and other various works [2,5,8,16,17]. Generally, the proposed observer design approaches are dealt with robustness against disturbances and/or sensitivity to faults. Hence, in these studies, optimization problem is formulated

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