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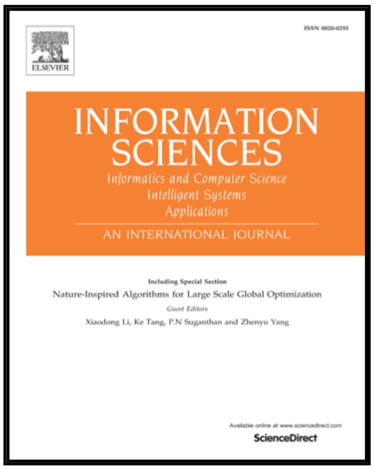

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Descriptor Sliding Mode Approach for Fault/Noise Reconstruction and Fault-tolerant Control of Nonlinear Uncertain Systems☆

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Abstract

The problem of fault/noise reconstruction and fault-tolerant control of Lipschitz nonlinear uncertain systems is investigated in this paper. A descriptor sliding mode approach is presented, where an auxiliary descriptor state vector consisting of system state vector, actuator fault vector, and virtual sensor fault vector is introduced to construct a new augmented descriptor system, based on which a novel descriptor sliding mode observer is designed for system state estimation and fault/noise reconstruction. Through LMI optimization the stability conditions of estimation error dynamics are established to facilitate the determination of the design parameters. In light of estimation information, a fault tolerant controller is designed to maintain system stability. It is shown that by utilizing the descriptor sliding mode approach, satisfactory fault reconstruction performance can be obtained, and the reachablity of the sliding mode surfaces can be achieved in both descriptor error space and estimation state space. A numerical simulation example is presented to validate the effectiveness and benefits of the proposed approach.

Keywords: Fault/noise reconstruction, Uncertain nonlinear systems, Descriptor sliding mode observer, LMI, Fault tolerant control

1. Introduction

Many important practical engineering systems have strict requirement for their safety and reliability. This makes fault detection and fault-tolerant control a theoretically interesting and practically important area of research that has attracted much attention during the past decades. Although various FDI (fault detection and isolation) methods have been proposed recently, the issue of restoring the accurate fault profile by FDI alone has not been well addressed. Part of the technical difficult stems from the fact that during the diagnosis and identification process unexpected disturbances, model uncertainties and noises may occur, causing unexpected impacts on system performance. In this work we explore an effective method for fault reconstruction and estimation to capture the location, magnitude and dynamic behavior of the faults for dynamical systems. The key challenge is to restore the shape of the fault.

Borrowing the observer design technique for Lipschitz nonlinear systems and singular systems (see, for example, [13-14,20-21,34-37]), various fault reconstruction approaches based on observer have been proposed in literature. For instance, Gao and several other researchers have made remarkable progress on descriptor based approaches for fault estimation and reconstruction [6-11]. More specifically, in [6] and [7], based on linear system, descriptor observer

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