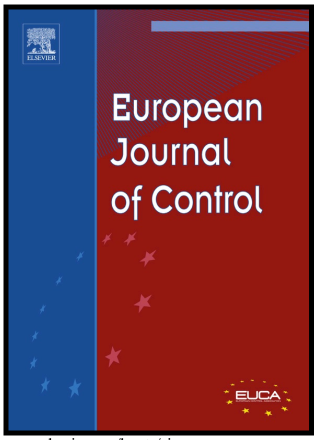
Author's Accepted Manuscript



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PII: S0947-3580(16)30251-5
DOI: http://dx.doi.org/10.1016/j.ejcon.2016.12.001
Reference: EJCON187

To appear in: *European Journal of Control*

Received date: 21 October 2015
Revised date: 5 August 2016
Accepted date: 4 December 2016

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European Journal of Control ... (2016) 1–12

European Journal of Control

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Abstract

This paper presents a sliding mode fault detection scheme for linear parameter varying (LPV) systems with uncertain or imperfectly measured scheduling parameters. In the majority of LPV systems, it is assumed that the scheduling parameters are exactly known. In reality due to noise or possibly faulty sensors, it is sometimes impossible to have accurate knowledge of the scheduling parameters and a design based on the assumption of perfect knowledge of the scheduling parameters cannot be guaranteed to work well in this situation. This paper proposes a sliding mode observer scheme to reconstruct actuator and sensor faults in a situation where the scheduling parameters are imperfectly known. The efficacy of the approach is demonstrated on simulation data taken from the nonlinear RECONFIGURE benchmark model.

1. Introduction

Fault detection and isolation (FDI) plays an important role in many engineering applications – especially in the aerospace, electrical machinery and process control industries. An effective fault detection scheme, when used with appropriate controllers can maintain the integrity of the closed-loop system in the presence of faults. One popular approach for designing FDI schemes is based on observer concepts, usually based on linear theory or slightly extended versions. A wide range of observer paradigms have been considered in the literature: for example Kalman filters and their extensions (see for example [1, 2, 3]), $\mathcal{H}_\infty$ filters (see for example [4, 5, 6]), unknown input observers (see for example [7, 8, 9]), and sliding mode observers (SMOs) (see for example [10, 11, 12]). One approach to extending linear methods to make them work effectively across the whole plant operating range is to design (linear) observers at select operating points, and then schedule the gains with respect to certain parameters [4]. One of the main difficulties with gain scheduling is the selection of the operating points and how to choose the gains at intermediate points. Furthermore, formally, between the operating points the stability of the observer cannot be guaranteed.

A more rigorous alternative approach is based on so-called linear parameter varying (LPV) system designs. In the LPV approach the gains are automatically scheduled with respect to the plant varying parameters. Another advantage is many nonlinear systems can be naturally approximated by LPV systems [13, 14]. Recent results on LPV based fault detection schemes appears in [15, 16, 17] from work in the EU-funded ADDSAFE project. Recently several sliding mode observer structures have been proposed for LPV systems (see for example [18, 19, 20]). However in all these papers the scheduling parameters are assumed to be perfectly known. However in reality this may not be the case: for example inaccurate sensors and/or faults can lead to imperfect knowledge of the parameters. The use of this corrupted information will affect the performance of the observer. The design of Luenberger-like observers in scenarios involving uncertain scheduling parameters has been investigated. In [21], using a Linear matrix inequality (LMI) framework an LPV observer was proposed. Later, a controller and a combined controller-observer scheme for inexact continuous LPV polytopic systems was presented in [22, 23]. In [24, 25] $\mathcal{H}_\infty$ filters were employed to deal with uncertainty in the scheduling parameters; exploiting parameter dependent LMI methods. More recently, an $\mathcal{H}_\infty$ filter has been proposed to deal with both additive and multiplicative uncertainties in the LPV parameters in [26]. Recent applications of these ideas to aerospace systems have been explored in [27, 28]. A fault reconstruction scheme for LPV systems with perfect scheduling parameter knowledge, using $\mathcal{H}_\infty$ methods has been investigated in [29]. Very few papers have addressed specifically the fault