Fault-tolerant control of networked LPV systems with time-delays

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1. Introduction

Linear Parameter Varying (LPV) models have proven to represent in a better way nonlinear systems with the additional benefit to develop formal stability proofs that guarantee robustness over a wide set of operating conditions Alwi and Edwards (2014); López-Estrada et al. (2019). LPV systems can be viewed as polytopic systems composed by a set of linear models blended by scheduling functions. Their main advantage is to extend powerful linear design tools to complex nonlinear models Shamma (2012). Some applications of LPV models can be consulted in the recent papers Theilliol and Aberkane (2011); Montes de Oca et al. (2011); Chadli et al. (2013); Sename et al. (2013); Rotondo et al. (2014); Rodrigues et al. (2015), the books Lendek et al. (2011); Briat (2014) and the references therein. In particular, the state estimation and its application to fault diagnosis and fault-tolerant control have gained interest from the theoretical and practical points of view. For example, in Hamdi et al. (2012) a fault detection observer has been developed for LPV descriptor systems. In Shi and Patton (2014) the authors propose an observer-based active fault-tolerant controller, which can simultaneously estimate the system states, sensor faults, and actuator faults. Robust fault detection observers that can deal with unknown inputs can be consulted in Astorga-Zaragoza et al. (2011); López-Estrada et al. (2015); López-Estrada et al. (2017). Recently, extensive investigation has been done for control applications, as can be consulted in the papers Lopez-Estrada et al. (2014); Rotondo et al. (2014); **?**, the books Lendek et al. (2011); Briat (2014) and the references therein.

Most of the works consider that the real applications respond immediately and that there is not a limitation on the magnitude of the signal generated by the control inputsDang et al. (2017). However, this consideration is not realistic; for example, in level control, the magnitude of the flow depends on the limitation of the aperture of the valve. In other words, in real systems, the input delay and actuator saturation often occur due to the physical boundary of the system to be controlled. Although these problems have been studied extensively for linear systems Zhou et al. (2017), few works are reported for multimodel systems. For instance, in Jia et al. (2015) was proposed a fault reconstruction and fault-tolerant control via learning observers for TS systems. The authors in Xu et al. (2017) suggest a robust dissipative control is investigated for uncertain flexible spacecraft based on TakagiSugeno, which considers a LyapunovKrasovskii method and convex optimization technique to design an altitude controller on the aircraft. Also, time-delay in the parameter varying scheduling functions was considered in Hu et al. (2017), which also finds a LyapunovKrasovskii approach to guarantee the controller performance. Nevertheless, to the best of my knowledge, fault-tolerant control systems, which consider time-delay and actuator saturation, have not been reported.

This work proposes a fault-tolerant control for under-actuated systems modeled as an LPV system with time-delays and actuators saturation. The idea is to consider a H_∞ and H_-/H_∞ approaches to design a suboptimal robust, reliable controller such that the closed-loop system can maintain stability and

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performances for the actuator fault case. The main contribution of the work is focused on the mathematical development of the algorithms. However, some case studies could be considered to exemplify the applicability of the proposed algorithms, for example, a 3D crane system, unmanned aerial vehicles, inverted pendulum, among others.

2. Objectives

General

Develop fault tolerant control algorithms for underactuated networked linear parameter varying systems with time-delays.

Specifics

- Design an active fault diagnosis scheme for networked LPV systems.
- Considered time-delays among the agents comunications of the networked LPV systems
- Propose an FTC approach for networked LPV systems with time-delay by considering a robust approach to guarantee robustness against the external disturbances, model mismatches, and sensor noise.
- Consider some case of study to test the control algorithms in simulations, for example mobile robots or unmanned aerial vehicles.

3. Goals

- Two papers JCR submitted or accepted in prestigious journals as the Fuzzy Sets and Systems, the International Journal of Control, or Transaction in Automatic Control.
- Three international conference papers as SYSTOL, Safesprocess, World IFAC, CCD, among others.
- one master thesis related to the implementation of a real 3D crane system.
- 1 Collaboration agreement with the Centre for Research on Automatic Control of Nancy, France.

Financing

The main goal of this work is to develop theoretical algorithms. Therefore, it is not necessary extra financing for the strengthening of the project. However, there exist collaboration with the "Instituto Tecnológico de Sonora," which has many underactuated systems for testing the algorithms developed during the tests.

Link

The work will be done in collaboration with the Research Centre for Automatic Control of Nancy, France. As a result of this collaboration, it is expected a "cotutelle" agreement and student mobility.

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