Accepted Manuscript

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PII: S0947-3580(17)30165-6
DOI: 10.1016/j.ejcon.2018.01.001
Reference: EJCON 246

To appear in: *European Journal of Control*

Received date: 6 May 2017
Revised date: 4 November 2017
Accepted date: 5 January 2018

Stabilization of Linear Impulsive Systems under Dwell-Time Constraints: Interval Observer-Based Framework

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Abstract

The problem of interval observer design is studied for a class of linear impulsive systems. Ranged and minimum dwell-time constraints are considered under detectability assumption. The first contribution of this paper lies in designing interval observers for linear impulsive systems under ranged and minimum dwell-time constraints, and investigating positivity of the estimation error dynamics in addition to stability. Several observers are designed oriented on different conditions of positivity and stability for estimation error dynamics. The boundedness of the estimation error (input-to-state stability property) and the observer stability conditions are stated as infinite-dimensional linear programming problems. Next, an output stabilizing feedback design problem is discussed, where the stability is checked using linear matrix inequalities (LMIs). Efficiency of the proposed approach is demonstrated by computer simulations for a commercial electric vehicle equipped with a low power range extender fuel cell, a bouncing ball, an academic linear impulsive system and for Fault Detection and Isolation (FDI) and Fault-Tolerant Control (FTC) of a power split device with clutch for heavy-duty military vehicles.

I. Introduction

There are many approaches dealing with the design techniques for state observers [1], [43], [27]. Frequently, these methods are based on (partial) linearity of the observed system, since analysis and design of stability and performance for linear systems are more developed. When it comes to take into account the presence of a disturbance or uncertain parameters, the synthesis of a conventional estimator (whose estimates are converging to the true values of the state) may be complicated [16], [1], [10], [11]. In such a case the problem of pointwise estimation can be substituted by the interval one, then using input-output measurements an observer has to estimate the set of admissible values (interval) for the state at each instant of time [30]. An advantage of interval observer is that it allows many types of uncertainties to be taken into account in the system. The interval observer design techniques have been developed for many types of models: continuous-time [38], [48], [9], discrete-time [16], [39], [21], [40], time-delay [41], [17], [18] and algebraic-differential [19] ones.

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This work was supported in part by the Government of Russian Federation (Grant 074-U01); the Ministry of Education and Science of Russian Federation (Project 14.Z50.31.0031) and by the Fonds de recherche du Québec - Nature et technologies (FRQNT) international internships fellowship (Energy/Digital/Aerospace).