High-gain interval observer for continuous-discrete time systems : Application to a quadcopter

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Introduction

State estimation is a key challenge concerning control and fault detection of complex uncertain systems. Interval observer design is a promising way to tackle this issue in the context of bounded uncertainties [1,2]. This work focuses on continuous-discrete interval observer design for a class of partially linear systems subject to sampled data measurements. The proposed approach is an extension of [3]. The observer structure is based upon a discretization of their resulting observer. A sufficient condition on the maximum allowable sampling period is derived in order to ensure the observer stability. The aim is to deal with the implementation issue on a real system. Results will be tested on the Navigation-Guidance-Control loop of a quadcopter.

Main results

The High-Gain Interval Observer (HGIO) design presented in [3] consists in four main steps. The first two are offline computation of the associated gains and parameters. The last two are online, based on the proposed observers, to compute the estimated bounds of the output and the state. In this work, the resulting observer for state bounds estimation has been discretized at a sampling period T_d by a 3^{rd} order polynomial method. Indeed, this choice allows to work with higher sampling periods than those of the rectangular method.
As a first result, a sufficient implicit condition on the sampling period for the observer stability has been proven based on the non-divergence of the radius dynamics. It consists in checking that a Metzler matrix is Hurwitz. Later, an explicit condition will be given to derive the maximum allowable sampling period. Moreover, as the measurement sampling period has to be lower than T_d, this condition also defines the maximum measurement sampling period.
The implementation of the HGIO for a quadcopter will be initially conducted in Hardware In The Loop (HITL) simulation with a Pixhawk 4. Later it will be tested on an experimental plateform in real conditions through outdoor experiments.

References

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