Data-driven LPV synthesis: the FIR controller case

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1 Introduction

Current state-of-the-art control design techniques in the Linear Parameter-Varying (LPV) framework are dependent on the availability of a parametric model of the to be controlled system. Such models are often obtained through first-principle modeling. In practical situations, this often results in complex models for which LPV control design can be difficult. Alternatively, system identification methods can be used. On the other hand, control synthesis techniques based on Frequency-Response-Function (FRF) measurements for linear time-invariant systems are available, avoiding the intermediate procedure of first-principle modeling (see, e.g., [1, 2, 3]). The aim of this work is to present a data-driven LPV control synthesis method for Finite Impulse Response (FIR) filters.

2 Problem formulation

Many control systems are operating condition dependent, for example a nonlinear system that operates along a trajectory. This dependency is here represented by a scheduling variable $p \in \mathcal{P}$. The goal here is to synthesize a data-driven fixed n_b-order LPV FIR controller, depicted in Figure 1, for which the signal relations are as follows:

$$u[k] = \sum_{\ell=0}^{n_b} b_\ell(p[k]) e[k-\ell], \qquad (1)$$

where the FIR coefficients $b_\ell(p[k]) = b_{\ell,0} + \sum_{j=1}^{n_p} b_{\ell,j} p_j[k]$ are scheduled along the operating regime of the system.

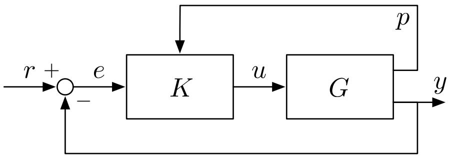

Figure 1: LPV representation of the closed-loop interconnection. K is the LPV FIR controller and G is a nonlinear system.

3 Results

The results obtained on a 2nd-order mass-spring-damper system with nonlinear spring coefficient are shown in Figure 2. A 3rd order LTI FIR controller is synthesized for the nominal operating point. This results in sufficient performance when the system is in the neighborhood of the operating point, however a deviation can lead to degradation in performance or even unstable behavior. By utilizing the LPV framework, a LPV FIR controller is synthesized. The LPV FIR controller is able to adapt the controller coefficients to the operating conditions of the system, therefore significantly increasing the performance.

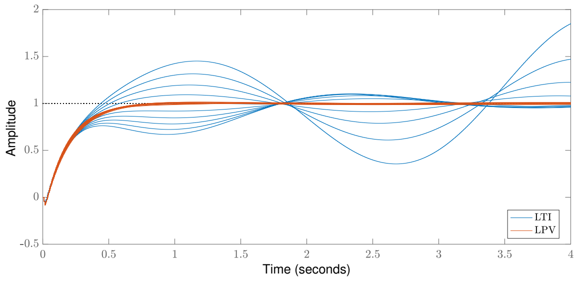

Figure 2: Step responses of the closed-loop system at the grid-points, using 3rd order LTI and LPV FIR controllers. Sampled on a grid $\mathcal{P}$ consisting of 10 grid-points.

Currently, the LPV FIR synthesis guarantees performance and stability locally. In the future, we are aiming to develop global performance and stability guarantees.

References

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