Balancing On-Sample and Intersample Behavior in Sampled-Data System Inversion

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1 Introduction

System inversion is essential in feedforward and learning control. Ideally, perfect tracking can be achieved by exact system inversion. Due to a digital controller implementation, the system inversion has to be performed in the discrete-time domain.

2 Description

Zeros discretized by zero-order-hold can be classified as two types: 1) intrinsic zeros corresponding to the system dynamics; or 2) discretization zeros due to signal sampling [1]. If the plant relative order is even, one of the discretization zero(s) is located close to $z = -1$ [2]. The system inversion for zero at $z \simeq -1$ brings high-oscillating control input [3] and results in poor inter-sample performance [4].

3 Approach

To balance the on-sample and inter-sample tracking error, a novel sampled-data system inversion shown in Figure 1 is proposed. The single-rate inversion achieves exact tracking on sample at the cost of poor inter-sample performance, whereas multi-rate inversion achieves better intersample performance compromising on-sample tracking error (at control period T_u). In the developed approach, the system is decomposed into two parts and the inversion is applied separately.

4 Results

The developed approach is applied to a positioning system shown in Figure 2 with non-equidistant sampling. As shown in Figure 3, the proposed inversion yields the better performance compared with the existing approach. It is concluded that the proposed approach exploits additional degrees of freedom for discrete-time system inversion and demonstrates better performance.

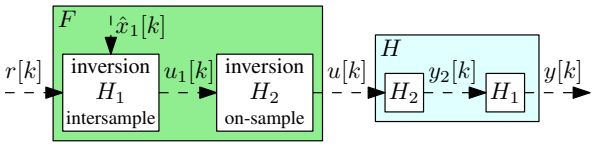

Figure 1: Block diagram of the proposed approach. The discrete-time system H is decomposed into H_1 and H_2. Multi-rate inversion is applied to H_1 for the purpose of intersample behavior. Single-rate inversion is applied to H_2 for the purpose of on-sample behavior.

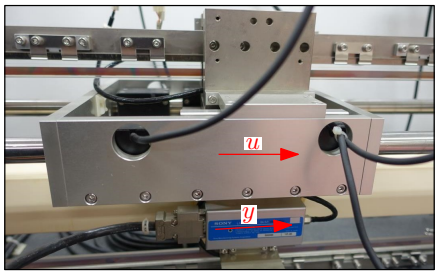

Figure 2: Motion system used in simulations and for experimental validation.

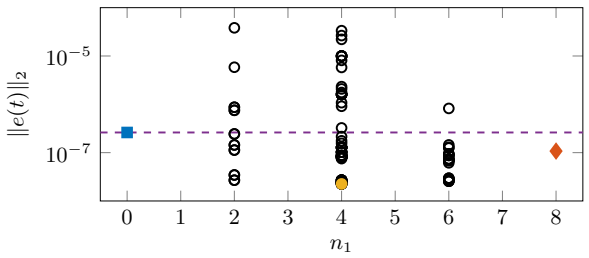

Figure 3: Continuous-time versus on-sample error in simulations. The approach balances the intersample behavior and the on-sample behavior for continuous-time performance.

References

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