Spatio-Temporal Modeling for Next-Generation Motion Control

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1 Background

Flexible dynamics in next-generation motion systems lead to inherent spatio-temporal system dynamics. Inevitably, next-generation control techniques increasingly rely on accurate modeling techniques that capture the spatio-temporal nature of the flexible dynamic behavior [1]. Two case studies are being investigated: adaptive optics and mechanical stage control.

2 Problem Formulation

A key challenge for next-generation motion systems is the modeling of the spatio-temporal flexible dynamics. Traditional parametric and nonparametric identification approaches aim to identify the temporal behavior of the flexible dynamics. As a result, the flexible dynamic behavior is estimated at a limited spatial grid which limits the understanding of the position-dependency of the flexible dynamic behavior[2]. The aim of this paper is to identify and reconstruct the spatio-temporal behavior for spatio-temporal control of next-generation motion systems with a large number of spatially distributed actuators.

3 Approach

Given a motion system $G_m : [u_1 \dots u_{n_a}]^\top \mapsto [y_1 \dots y_{n_s}]^\top$ with a large amount n_a of spatially distributed actuators and a limited amount of n_s sensors, i.e. $n_s \ll n_a$. The aim is to model the spatio-temporal nature of the flexible dynamic behavior. The approach includes the identification of modal models [2]. The modal system description is exploited by including mechanical systems knowledge [3]. The proposed approach allows enhancing the estimation of the spatial system behavior [4].

4 Results

The proposed approach is illustrated on an experimental beam setup, see Figure 1. The approach proposed in this paper allows identifying the full response G_m while only having access to the first sensor by exploiting the proposed approach. In particular, the approach allows analyzing the spatio-temporal behavior with limited sensing capabilities, see Figure 2. In particular, the full system G_m is identified while only having access to the first sensor.

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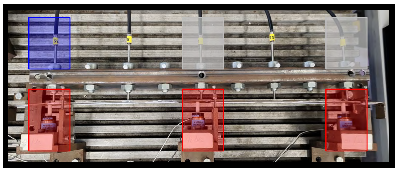

Figure 1: Experimental overactuated beam setup. The three voice-coil actuators are indicated in red. The flexible beam system G_m is actuated by three voice coil actuators (red) and the displacement is measured by three sensors (blue and grey). The proposed method only considers the first sensor (blue) to estimate the full system G_m.

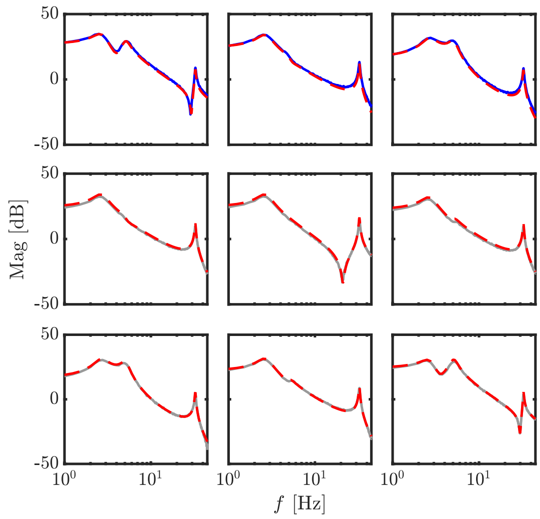

Figure 2: Element-wise Bode magnitude plot of the non-parametric estimate of the full system G_m (grey), the non-parametric estimate of subsystem G_o (blue), and extended plant G_m (dashed red).

References

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