Trajectory Tracking of Cart-Pendulum Dynamics Using Multiple Time Delayed Feedback

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Abstract

A trajectory tracking problem is investigated for a linear time invariant (LTI) underactuated dynamics using a fixed control law. Differently from the traditional treatment, we also consider a possible occurrence of *multiple time delays* in the feedback control. It's known that such time-delayed LTI systems may exhibit multiple stable operating zones (pockets) in the space of the delays. The tasks that are undertaken here are the determination of these pockets analytically, the utilization of them for stabilization and relevant experimental validation. The practical objective of the study is to accomplish a successful trajectory tracking for an underactuated mechanical system, cart-and-pendulum dynamics, under the presence of multiple and independent time delays. First, we model the system as accurately as we can, and select a desirable fixed control law for the non-delayed feedback structure. We then investigate the stability map corresponding to this fixed control strategy when unpreventable delays occur in the feedback. This is done using a recent methodology, which is called the *cluster treatment of characteristic roots* (CTCR). We also experimentally verify the analytical findings of CTCR and deploy a counterintuitive control strategy called the "*delay scheduling*" based on the knowledge obtained from CTCR. If there is an unavoidable delay composition which renders unstable behavior, the