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Model Reduction of Distributed Nonstationary LPV Systems

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Abstract

This paper is on the structure-preserving model reduction of distributed systems formed by heterogeneous, discrete-time, nonstationary linear parameter-varying subsystems interconnected over arbitrary directed graphs. The subsystems are formulated in a linear fractional transformation (LFT) framework, and a communication latency of one sampling period is considered. The balanced truncation method is extended to the class of systems of interest, and upper bounds on the ℓ_2-induced norm of the resulting error system are derived. Balanced truncation suffers from conservatism since it only applies to stable systems which possess structured solutions to the generalized Lyapunov inequalities. The coprime factors reduction method is then provided as a partial remedy to this conservatism. An illustrative example is given to demonstrate the efficacy of the proposed approaches.

Keywords: structure-preserving model reduction, balanced truncation, coprime factors reduction, linear parameter-varying systems, linear time-varying systems, interconnected systems.

1. Introduction

This work is on the model reduction of distributed systems formed by heterogeneous, discrete-time, nonstationary linear parameter-varying (NSLPV) subsystems interconnected over arbitrary directed graphs. The subsystems are formulated in a linear fractional transformation (LFT) framework. It is assumed that the information sent by a subsystem at the current time-step is received by the target subsystem at the next time-step. We refer to such systems as distributed NSLPV systems.

NSLPV models [1, 2] extend standard/stationary linear parameter-varying (LPV) models in the sense that the state-space matrix-valued functions can have an explicit dependence on a priori known time-varying terms, in addition to their dependence on time-varying scheduling parameters that are not known a priori, but are available for measurement at each time-step. The dependence of the state-space matrices on these parameters is assumed to be rational so as to allow for formulating the subsystems in an LFT framework. This assumption, however, is not generally restrictive as nonlinear functions that are not rational can frequently be approximated by rational ones. An NSLPV model formulated in an LFT framework is basically an interconnection of a nominal linear time-varying (LTV) model and a Δ-operator which consists of all the

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