MODEL REDUCTION OF SWITCHED SYSTEMS
BASED ON SWITCHING GENERALIZED GRAMIANS

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ABSTRACT. In this paper, a general method for model order reduction of discrete-time switched linear systems is presented. The proposed technique uses switching generalized gramians. It is shown that several classical reduction methods can be developed into the generalized gramian framework for the model reduction of linear systems and for the reduction of switched systems. Discrete-time balanced reduction within a specified frequency interval is taken as an example within this framework. To avoid numerical instability and to increase the numerical efficiency, a generalized gramian-based Petrov-Galerkin projection is constructed instead of the similarity transform approach for reduction. It is proven that the proposed reduction framework preserves the stability of the original switched system. The performance of the method is illustrated by numerical examples.

Keywords: Model reduction, Switched systems, Gramian and stability

1. Introduction. The complexity of models is increasing in response to the ever-increasing need for the accurate mathematical modeling of physical as well as artificial processes for simulation and control. To maintain tractability, efficient computational prototyping tools are required to replace such complex models by simpler models that capture their dominant characteristics. Due to this fact, model reduction methods have become increasingly popular over the last two decades [1-3,41,42]. Such methods are designed to extract a reduced order state space model that adequately describes the behavior of the system in question.

Most of the studies on model order reduction to date have been devoted to linear systems. The few methods proposed for nonlinear systems are not strong compared with linear reduction methods.

On the other hand, most of the methods that have been proposed to date for the control and analysis of hybrid systems suffer from high computational burden when dealing with large-scale dynamical systems. This has motivated the study of model reduction for hybrid systems [4-17]. The model reduction problem for Markovian switched systems was studied in [16]. In Markov jump systems, the transition probabilities of the jumping process are important, and to date, almost all of the issues with Markov jump systems have been investigated assuming the knowledge of transition probabilities. However, the likelihood of obtaining complete knowledge on the transition probabilities is questionable, and the cost of doing so is likely high [17]. The method presented in [4] deals with the