Dynamics of Continuous, Discrete and Impulsive Systems
Series **B:** *Applications & Algorithms* **13 (2006)** 291-304

ROBUST PEAK-TO-PEAK MODEL REDUCTION FOR UNCERTAIN LINEAR SYSTEMS: CONTINUOUS- AND DISCRETE-TIME CASES

Yanhui Li[1], Huijun Gao[2], J. Lam[3] and Changhong Wang[2]

[1]Electrical and Information Engineering College, Daqing Petroleum Institute
Daqing, Heilongjiang Province, 163318, P. R. China

[2]Inertial Navigation Center, Harbin Institute of Technology
Harbin, Heilongjiang Province, 150001, P. R. China

[3]Department of Mechanical Engineering, The University of Hong Kong
Hong Kong, P. R. China

Abstract. This paper investigates the problem of robust peak-to-peak model reduction for continuous- and discrete-time uncertain linear systems. For a given stable system, our purpose is to construct reduced-order systems, such that the error system between these two models is asymptotically stable and has a guaranteed peak-to-peak performance. This problem is solved by using the projection lemma and sufficient conditions are obtained for the existence of admissible reduced-order models in terms of linear matrix inequalities (LMIs) plus matrix inverse constraints. Since these obtained conditions are not expressed as strict LMIs, the cone complementarity linearization (CCL) method is exploited to cast them into nonlinear minimization problems subject to LMI constraints, which can be readily solved by standard numerical software. In addition, the development of zeroth-order model is also presented. Both continuous- and discrete-time cases are considered. The efficiency of the proposed methods is demonstrated via numerical examples.

Keywords. Model reduction, peak-to-peak performance, linear systems, LMI, Cone complementarity linearization.

1 Introduction

The problem of model reduction is very important in many areas of engineering, especially in control system analysis and synthesis. It is often desirable to find a reduced-order model to approximate the original high-order model without significant error introduced. Many important results on model reduction have been reported, which involve various efficient approaches such as the aggregation method [1], the balanced truncation method [2, 3], and the optimal Hankel norm approximation method [4]. Very recently, the linear matrix inequality (LMI) technique has also been introduced to solve the model reduction problem for different classes of systems (see, for instance, [5, 6, 7] and the references therein).

In solving the model reduction problem, some performance indices are usually introduced to evaluate the error between the original system and the reduced-order system. Some widely used performances are H_∞, $L_2 - L_\infty$ and H_2. These performances assume the input signal to be energy bounded, and therefore the model reduction methods upon these performances are most suitable for systems with inputs that belong to L_2 space. If the input signal is assumed to be bounded on magnitude only, the minimization of peak-to-peak gain, which computes the worst-case peak value of the error with persistent bounded input, becomes more appropriate as a performance criterion in the construction of reduced-order models. The model reduction problem based on such a performance is usually called peak-to-peak model reduction, or L_1 model reduction in the continuous case