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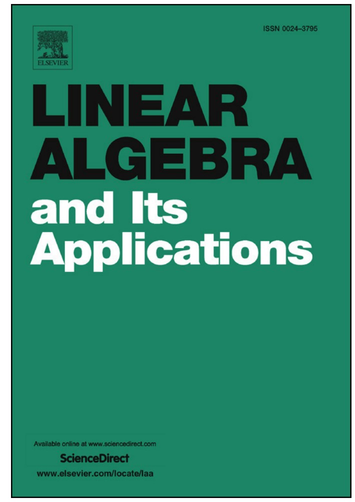

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Stability Analysis of Bilinear Iterative Rational Krylov Algorithm☆

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Abstract

Models coming from different physical applications are very large in size. Simulation with such systems is expensive so one usually obtains a reduced model (by model reduction) that replicates the input-output behaviour of the original full model. A recently proposed algorithm for model reduction of bilinear dynamical systems, Bilinear Iterative Rational Krylov Algorithm (BIRKA), does so in a locally optimal way. This algorithm requires solving very large linear systems of equations. Usually these systems are solved by direct methods (e.g., LU), which are very expensive. A better choice is iterative methods (e.g., Krylov). However, iterative methods introduce errors in linear solves because they are not exact. They solve the given linear system up to a certain tolerance. We prove that under some mild assumptions BIRKA is stable with respect to the error introduced by the inexact linear solves. We also analyze the accuracy of the reduced system obtained from using these inexact solves and support all our results by numerical experiments.

Keywords: Bilinear Dynamical Systems, Model Reduction, Iterative Solves, Krylov Subspace Methods, Petrov-Galerkin, Backward Stability.
2010 MSC: 34C20, 41A05, 65F10, 65G99

1. Introduction

A dynamical system describes a relation between two or more measurable quantities by a set of differential equations. The system may be linear or nonlinear. A bilinear dynamical system is one such weakly nonlinear system. The system can be described both in the time domain and in the frequency domain. In the time domain, a Multiple Input Multiple Output (MIMO) bilinear dynamical system with m inputs and p outputs is represented as follows [1, 2]:

$$\zeta : \begin{cases} \dot{x}(t) &= Ax(t) + \sum_{k=1}^{m} N_k x(t) u_k(t) + Bu(t), \\ y(t) &= Cx(t), \end{cases} \tag{1}$$

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