The rational-extended Krylov subspace method for model reductions

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Abstract

Consider the multi-input multi-output (MIMO) linear time-invariant (LTI) system described by the state-space equations

$$\left\{ \begin{array}{lcl} \dot{x}(t) & = & A\,x(t) + B\,u(t) \\ y(t) & = & C\,x(t), \end{array} \right. \tag{1}$$

where $x(t) \in \mathbb{R}^n$ denotes the state vector and $u(t),\ y(t) \in \mathbb{R}^p$ are the input and output vectors respectively of the (LTI) system (1). When working with high order models, it is reasonable to look for an approximate model:

$$\left\{ \begin{array}{lcl} \dot{x}_m(t) & = & A_m\,x_m(t) + B_m\,u(t) \\ y_m(t) & = & C_m\,x_m(t), \end{array} \right.$$

such as $A_m \in \mathbb{R}^{m\times m}$, $B_m,\ C_m^T \in \mathbb{R}^{m\times p}$, $x_m(t),\ y_m(t) \in \mathbb{R}^m$, and $m \ll n$, while maintaining the most relevant properties of the original system (1).

Several approaches in this area have been used. Among these approaches are the Krylov subspace methods. These are projection methods that have played a major role in large scale model reductions. Projection-type methods determine an approximation of the approximate solution by projecting a given problem onto a much smaller approximation space. Projection-type methods determine an approximation of the approximate solution by projecting a given problem onto a much smaller approximation space. The approximation spaces that have been widely studied in the past for a variety of problems are the standard Krylov space, the inverse Krylov space, and the rational Krylov space. Each of the aforementioned spaces mentioned has advantages and disadvantages. Thereby, we introduce a new method that will be used for reducing the transfer function and can be extended to approach the solutions of Sylvester and Riccati equations.

The general idea of this method is to provide a new Krylov subspace that is richer than the rational Krylov subspace as well as the extended Krylov subspac. This idea comes from the lack of information on the matrix A when using rational Krylov subspace. That is why, we introduce a new method that we name the extended-rational Krylov method. The objective of this work is to exploit this new space to approach the dynamical system and the transfer function.

References

[1] O. Abidi, M. Heyouni et K. Jbilou: The extended block and global Arnoldi methods for model reduction. Numerical Algorithms 75 (2017) 285-304.