MoRePaS 2015

Stability Preserving, Adaptive Model Reduction of DAEs by Krylov Subspace Methods

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Model order reduction based on *Krylov subspace methods* stands out due to its generality and low computational cost, making it a predestined candidate for the reduction of *truly-large-scale* systems. Even so, the inherent flexibility of the method can lead to quite unsatisfactory results as well. In particular, the preservation of stability is not guaranteed per se, attaching even more importance to the careful selection of free design parameters. Whenever a given system is modeled by a set of linear *ordinary differential equations* (ODE), some remedies for stability preservation are available, such as the one presented in [4] for *strictly dissipative* realizations or the $\mathcal{H}_2$-*pseudooptimal* reduction strategy introduced in [3, 5].

Oftentimes the object oriented, computerized modelling of dynamical systems yields a system of *differential algebraic equations* (DAE), which present characteristics not covered by standard ODE theory. In particular, the transfer behavior might be improper and in general, model reduction involves the approximaton of the dynamical and preservation of the algebraic part [1]. Even though in recent years many publications addressed *DAE-aware* reduction strategies for different indices and structures, the problem of stability preservation is hardly covered.

In this contribution, we consider index-1 DAEs in *semiexplicit form* and propose two reduction strategies that guarantee the stability of the reduced model. In this context, we will take special care in effectively reducing the underlying ODE while operating on the DAE. We will show in theory and through numerical examples that this is not always granted when extending the DAE-aware procedure described in [1] to the case of one-sided reduction. Moreover, we will show that also in the DAE case $\mathcal{H}_2$-pseudooptimal reduction has a series of advantages. The resulting stategy, adapted from [2], will preserve stability and select adaptively both the expansion points and the order of the Krylov subspace. The case of *improper* DAEs retaining an *implicit feedthrough* will be considered both in theory and examples.

References

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