Krylov subspace model reduction for bilinear and MIMO quadratic-bilinear systems

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Abstract

The detailed mathematical modeling of complex dynamical systems often leads to a large number of ordinary differential equations, whose large dimension makes them hard to simulate and handle. This motivates the need of reduced-order models that capture the most dominant dynamics and preserve the relevant properties of the original model, thus keeping the computational expense and the storage requirements low.

Most dynamical systems are inherently *nonlinear*. Although in some cases the behaviour can locally be well described by linear or linearized time-invariant (LTI) models, nonlinear systems generally exhibit complex behaviours that linear models are unfortunately not able to capture. For the reduction of LTI models, several well-established techniques are available, all having their advantages and disadvantages. For the reduction of nonlinear models, well-known simulation-based methods like POD and TPWL are widely used. In recent years, popular linear reduction techniques like balanced truncation, Krylov subspace methods and $\mathcal{H}_2$ optimal approaches have been extended and successfully applied to bilinear [1, 3] and quadratic-bilinear systems [2]. The main advantage of these techniques – as opposed to POD or TPWL – is that they aim at approximating the input-output behaviour of the underlying nonlinear system without expensive simulations for different training input signals.

In this talk we deal with model order reduction for nonlinear systems using transfer function concepts and Krylov subspace methods. First, new conditions for $\mathcal{H}_2$ pseudo-optimality [4] for bilinear systems will be presented and discussed, whereby particular attention will be paid to the underlying bilinear Sylvester equations. Current advances and findings in this framework will be also reported. Then, the talk will focus on the (tangential) interpolation-based reduction of MIMO quadratic-bilinear systems, partly based on the work [2].

Keywords: nonlinear systems, model order reduction, Krylov subspace methods

References

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