BALANCING-RELATED MODEL REDUCTION FOR DATA-SPARSE SYSTEMS

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Abstract

Model reduction is an ubiquitous tool to facilitate or even enable the simulation, optimization and control of large-scale dynamical systems. Application areas range from microelectronics (device and circuit simulation) over computational biology, control of mechanical and electrical systems to flow control and PDE-constrained optimization. In this talk, we will focus on problems from the latter application areas. In particular, we will discuss model reduction techniques based on system balancing for (optimal) control of parabolic partial differential equations. After discretization of the elliptic (spatial) differential operator by FEM or BEM methods, large-scale, sparse (in case of FEM) or data-sparse (in case of BEM) linear control systems are obtained. Due to the cubic complexity of standard implementations of balanced truncation and relatives, it is not possible to apply these methods directly to such systems.

Here, we will discuss how the use of hierarchical matrices and the corresponding formatted arithmetic enables us to implement balanced truncation and related algorithms for model reduction in almost linear complexity. Our approach is based on the sign function method for solving Lyapunov equations, where matrix inversions, additions, and multiplications are replaced by the corresponding operations for hierarchical matrices [1]. Numerical experiments will demonstrate the applicability of this approach to control problems for several types of parabolic PDEs.

References

[1] U. Baur and P. Benner, *Factorized solution of Lyapunov equations based on hierarchical matrix arithmetic*, Computing, 2006 (electronic). DOI: 10.1007/s00607-006-0178-y.

[2] U. Baur and P. Benner, *Gramian-based model reduction for data-sparse systems*, Chemnitz Scientific Computing Preprints, January 2007.