Fast $\mathcal{H}_2$-optimal model order reduction

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Abstract

The computer-based modeling of dynamical systems often results in a large number of ordinary differential equations. The behavior of such systems can be described—at least locally—through linear state-space models. Numerical simulations, optimizations and control design based on such models usually represent major challenges on the storage and computational power, motivating the need or reduced order models that represent a good approximation of the dynamic behavior while preserving fundamental properties.

For linear time-invariant systems, several model reduction approaches have been effectively developed since the 60’s. Amongst these, *Krylov subspace methods* (also known as *interpolatory*) stand out due to their flexibility and low computational cost, making them a predestined candidate in the reduction of *truly large-scale* systems [1, 2]. However, the inherent flexibility of the method can lead to very bad results as well, attaching an even higher importance to the appropriate choice of free design parameters.

Recent advances demonstrate ways to find reduction parameters that locally minimize the $\mathcal{H}_2$-norm of the error system [3, 4, 5]. Unfortunately, the search for optimal parameters often requires several iterations, leading to computational expenses that can exceed those of classical methods such as *balanced truncation*.

In this contribution, we address this issue by first analyzing the computational complexity of the methods [6] and then propose a new reduction framework that uses *model functions*—i.e. local approximations of the original model—to speed-up the search for $\mathcal{H}_2$-optimal parameters. We will prove that optimality of the results is retained and will discuss under which conditions this strategy effectively reduces the overall computational complexity of the reduction.

*Keywords:* Model order reduction; $\mathcal{H}_2$-optimality; Computational complexity

References


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