1 Algebraic Gramians and Model Reduction for Different System Classes

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Model order reduction by balanced truncation is one of the best-known methods for linear systems. It is motivated by the use of energy functionals, preserves stability and provides strict bounds for the approximation error. The computational bottleneck of this method lies in the solution of a pair of dual Lyapunov equations to obtain the controllability and the observability Gramian, but nowadays there are efficient methods which work for large-scale systems as well. These advantages motivate the attempt to apply balanced truncation also to other classes of systems. For example, there is an immediate way to generalize the idea to stochastic linear systems, where one has to consider generalized versions of Lyapunov equations. Similarly, one can define energy functionals and Gramians for nonlinear systems and try to use them for order reduction. In general, however, these Gramians are very complicated and practically not available. As an approximation, one may use algebraic Gramians, which again are solutions of certain generalized Lyapunov equations and which give bounds for the energy functionals. This approach has been taken e.g. for bilinear systems of the form

$$\begin{aligned} \dot{x} &= Ax + \sum_{j=1}^{k} N_j x u_j + Bu \;, \\ y &= Cx \;, \end{aligned}$$

which arise e.g. from the discretization of diffusion equations with Robin-type boundary control. In the talk we review these generalizations for different classes of systems and discuss computational aspects.