Balanced Truncation for Linear and Nonlinear Systems on Industrial Scale

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Balanced truncation has been one of the most successful model reduction techniques during the past four decades. Its use in systems and control theory is ubiquitous, and it also has been adopted by many neighboring disciplines that utilize state-space modeling and transfer function concepts. Originally designed for linear (stochastic) systems, it has seen adaptations to deal with structured linear (e.g., delay, network, mechanical) systems, as well as extensions to general and structured nonlinear systems. Often, balanced truncation is perceived with the misconception that it can only be used for model order reduction of systems with a few hundred state space variables due to the high computational cost involved in computing system Gramians. In this talk, we will summarize our efforts on enabling balanced truncation to deal with truly large-scale engineering problems on industrial scale problems. We will see that using enhanced numerical linear and multilinear algebra techniques, we are able to reduce linear systems with tens of millions of states, and nonlinear systems with a couple of thousands of states on desktop computers, enabling its use as building block in digital twinning and other engineering areas. The presentation will also highlight the software developments in the CSC department at MPI Magdeburg towards industrial use of balanced truncation as a model reduction paradigm.