Parametric Model Order Reduction Based on Multi-Moment-Matching and an Acceleration Strategy

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Abstract: In this talk, a model order reduction technique based on multi-moment-matching for reduced order modeling of parameterized systems is discussed. This technique is motivated by matching the multi-moments of the transfer function for the large-scale parameterized system of differential algebra equations (DAEs) in the first order form,

$$E(\mathbf{p})\dot{x}(t) + A(\mathbf{p})x(t) = Bu(t), \quad y(t) = Cx(t), \tag{1}$$

or in the second order form

$$M(\mathbf{p})\ddot{x}(t) + D(\mathbf{p})\dot{x}(t) + T(\mathbf{p})x(t) = Bu(t), \quad y(t) = Cx(t). \tag{2}$$

The system matrices $E(\mathbf{p}), A(\mathbf{p}), M(\mathbf{p}), D(\mathbf{p}), T(\mathbf{p}) \in \mathbb{R}^{n\times n}$ depend on the vector of parameters $\mathbf{p} = (p_1, p_2, \ldots, p_m)^T$. The matrix $B \in \mathbb{R}^{n\times q_1}$ is the input matrix associated with the input signal $u(t)$ and $C \in \mathbb{R}^{q_2\times n}$ is the output matrix. In the applications of circuit simulation and microelectromechanical systems (MEMS) simulation, the parameters usually represent geometric or physical variables which need to be optimally designed. In order to get an optimal design, the systems above need to be simulated repeatedly according to different values of the parameters, either during an optimization loop or when exploring the parameter space. However, due to the complexity of the designed devices, the models which describe the devices are very complex, which lead to very large-scale DAEs in (1) or (2).

The model order reduction technique based on multi-moment-matching aims at deriving a reduced small parameterized model, which preserves all the parameters, such that the original large system in (1) or (2) can be replaced with the reduced model during simulation and design. In this talk, a numerical algorithm for computing the multi-moment vectors which are used to get the reduced model is discussed. Furthermore, a Krylov subspace recycling strategy which can be used to further accelerate the model reduction process is introduced.

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