6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 15 June 2018, Glasgow, UK

MODEL REDUCTION BASED ON THE MAPPING FROM BOUNDARY VALUES TO QUANTITIES OF INTEREST

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Key words: *Goal-Oriented, Model Reduction, Cross-Covariance, Multi-Scale, Gas Networks*

In various simulation settings the focus of attention is not on the inner workings of a process, but the effect of a boundary value on some quantities of interest (QoI). Hence, an accurate approximation of the entirety of a model's degrees of freedom (DoF) is not necessary. Model reduction can exploit this prerequisite by constructing reduced order models that primarily approximate the mapping from boundary values to quantities of interest.

The cross-covariance operator of the boundary-to-DoF and DoF-to-QoI mappings encodes information on a coordinate transformation in which the degrees of freedom are sorted by importance with respect to the target boundary-to-QoI mapping [1]. A reduced order model is then assembled by low-rank projections obtained from a truncated singular value decomposition of the cross-covariance operator. This approach is justified for linear systems by results from systems theory but it extends also to nonlinear systems.

An application is provided by scenario analysis for gas transportation networks [2]. The associated underlying model is a system of nonlinear partial differential-algebraic equations, which, after an index reduction and a spatial discretization, becomes a large-scale system of nonlinear ordinary differential equations with multi-scale behavior. A data-driven variant of the cross-covariance-based model order reduction approach is evaluated for this gas network model.

Acknowledgement

Supported by the German Federal Ministry for Economic Affairs and Energy (BMWi), in the joint project: "MathEnergy – Mathematical Key Technologies for Evolving Energy Grids", subproject: Model Order Reduction (Grant number: 0324019**B**).

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