REDUCED-ORDER MODELING FOR UNCERTAINTY QUANTIFICATIONS IN FLUID-STRUCTURE INTERACTION PROBLEMS

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ABSTRACT

We propose a reduced-order model (ROM) based on tensor train decomposition (TTD) [1] and polynomial chaos expansion (PCE) to reduce the computational complexity. Initially, TTD is used to extract the spatial, temporal, and parameterized modes into TT-cores. Subsequently, PCE is used to approximate the parameter-dependent TT-cores. The combination of TTD and PCE constructs the complete representation of the parameterized space-time-dependent problems. The uncertainty quantification (UQ) framework based on the proposed ROM is performed on several problems. It is validated by a 1D Burgers' equation and 1D diffusion-reaction problems. Subsequently, it is used to analyze FSI problems, including the flow over a circular cylinder and a flexible fin, where the full-order solutions are obtained using the immersed boundary method [2]. This comprehensive UQ analysis demonstrates the proposed ROM as not only a calibration tool but also a framework for addressing uncertainties, correlations, and parameter identifications in FSI studies.

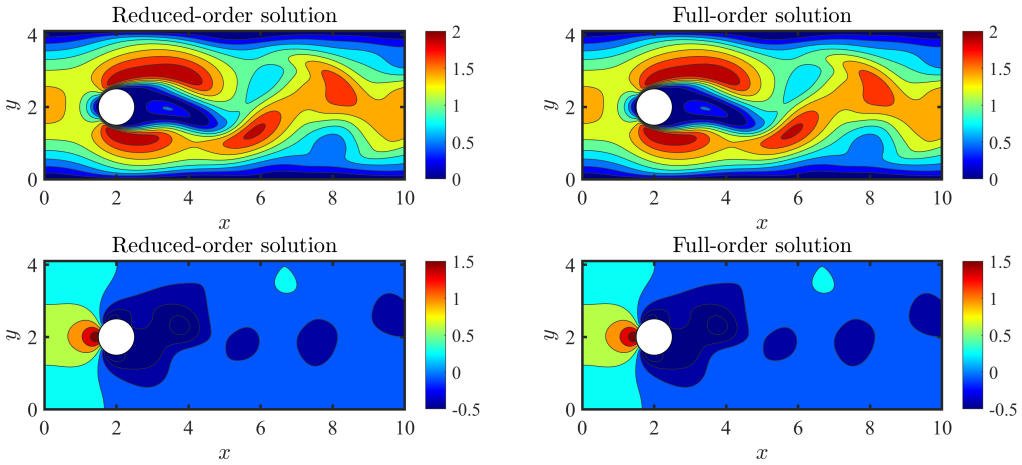

Figure 1. Comparison of reduced-order and full-order solutions of the velocity magnitude and pressure at $t = 100$ and $Re = 80.25$ for flow over a circular cylinder.

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