Dominant Subspaces of High-Fidelity Nonlinear Structured Parametric Dynamical Systems and Model Reduction

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In this work, we investigate a model order reduction scheme for high-fidelity nonlinear structured parametric dynamical systems. More specifically, we consider a class of nonlinear dynamical systems whose nonlinear terms are polynomial functions, and the linear part corresponds to a linear structured model, such as second-order, time-delay, or fractional-order systems. Our approach relies on the Volterra series representation of these dynamical systems. Using this representation, we identify the kernels and, thus, the generalized multivariate transfer functions associated with these systems. Based on this, we aim at constructing reduced-order systems interpolating the generalized transfer functions from the original model at a given set of interpolation points. We show that if enough interpolation points are taken, the projection matrices of interpolation-based model reduction encode the reachability and observability subspaces of the system. Moreover, we propose an algorithm that enables the extraction of dominant subspaces from the prescribed interpolation conditions. This allows the construction of reduced-order models that preserve the structure. We demonstrate the efficiency of the proposed method by means of various numerical benchmarks.

References

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