A Feasible Approach for Enriching a Projection-Based Reduced-Order Model With an Artificial Neural-Network to Mitigate the Kolmogorov Barrier to Reducibility

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ABSTRACT

Inspired by our previous work on mitigating the Kolmogorov barrier using a quadratic approximation manifold [1], we propose a computationally tractable approach for combining a projection-based reduced-order model (PROM) and an artificial neural network (ANN) to mitigate the Kolmogorov barrier to the reducibility of convection-dominated flow problems [2]. Specifically, we present a PROM-ANN concept whose main objective is to reduce the dimensionality of the online approximation of the solution beyond what is possible using affine and quadratic approximation manifolds.

In contrast to previous approaches for constructing arbitrarily nonlinear manifold approximations for nonlinear model reduction that exploited one form or another of an ANN, the training of the PROM-ANN we propose does not involve data whose dimension scales with that of the high-dimensional model; and this PROM-ANN is hyperreducible using any well-established hyperreduction method. Hence, unlike many other ANN-based approaches, the PROM-ANN concept we present here is practical for large-scale and industry-relevant CFD problems. We demonstrate its potential for parametric, shock- and convection-dominated, turbulent flow problems.

REFERENCES

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