

PARAMETRIC NON-INTRUSIVE REDUCED-ORDER MODELS VIA OPERATOR INFERENCE FOR LARGE-SCALE ROTATING DETONATION ENGINE SIMULATIONS

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ABSTRACT

In this presentation, we will investigate the construction of unsteady parametric non-intrusive reduced-order models (ROMs) for large-scale, realistic rotating detonation rocket engine (RDRE) combustion chambers, with the end goal of employing these reduced models to accelerate the design optimization of RDREs. The large computational cost of the corresponding high-fidelity simulations restricts the number of parametric instances that can realistically be simulated to generate training data. Moreover, the resulting training data sets are often sparse and comprise down-sampled time instants from the high-fidelity simulation. These problems are therefore representative benchmarks for large-scale, realistic simulations for which the available simulation data sets are usually (extremely) scarce. Our goal is to assess the potential of constructing accurate and predictive data-driven parametric ROMs for these challenging unsteady problems. To this end, we employ the operator inference (OpInf) procedure [1], which learns structure-preserving ROMs for systems with polynomial structure, without needing access to the high-fidelity simulator source code. To mitigate the challenge associated with training parametric ROMs using data from only a low number of parameter instances, we approximate the parametric dependence of the ROM operators via a Taylor expansion. We consider RDRE simulations for two injector designs, for which the corresponding high-fidelity simulations require more than 10,000 cores and 5-10 million CPU-hours to simulate 1-2 ms of physical time. We consider parametric variations in the mass flow-rate and equivalence ratio. Our results [2] are promising and show that OpInf can be used to construct accurate parametric ROMs from sparse training sets for parametric predictions outside of the training set and for predictions beyond the temporal training horizon.

Distribution Statement A: Approved for Public Release; Distribution is Unlimited. PA# AFRL-2022-5626

REFERENCES

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- [2] I.-G. Farcas, R. P. Gundevia, R. Munipalli, and K. E. Willcox, Parametric non-intrusive reduced-order models via operator inference for large-scale rotating detonation engine simulations, *AIAA Scitech 2023 Forum*, 2023