PhD Dissertation Defense Announcement

Mechanical and Aerospace Engineering Department

University of Texas at Arlington

Non-Intrusive Reduced Order Model Formulation for Inverse Shape Design including Deforming Meshes and Multiphysics Problems

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2PM, Friday, October 13, 2023

Location: Woolf Hall 413

Abstract

Despite significant advancements in computer capabilities for numerical simulations, engineers still struggle with computer resource requirements, including time and memory requirements, when dealing with large-scale full-order model (FOM) simulations. Applications that require real-time calculations or numerous repeated calculations necessitate innovative approaches to enhance computational efficiency. This work introduces a Reduced Order Modeling (ROM) approach that integrates Proper Orthogonal Decomposition (POD) with machine learning and provides a solution field that approximates the FOM solution with a mere fraction of the computational resources required by the FOM. The ROM is then used as a surrogate to the FOM in design optimization problems that require many objective function evaluations. This significantly reduces the number of FOM calculations required for optimization problems that involve multiple parameters. The method has been shown to be effective with parameters that govern shape. Demonstrated applications include inverse shape detection in 3-D heat conduction and 2-D inverse airfoil shape design in viscous flow. Both applications demonstrated the ability to handle deforming meshes and showed a computation time reduction of 72% compared to the case where FOM was used exclusively. The real-time inverse detection of a flow velocity and temperature field from simulated wall temperature measurements was also demonstrated, both with and without simulated measurement errors. The approach is non-intrusive and can make use of analysis software, including commercial software, without modification. This study also included the effect of sample sizes, sampling techniques, and machine learning algorithms on the accuracy of the ROM.