IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Data-Driven Turbulence Modeling and Simulation

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Abstract

Turbulent fluid flows are characterized by a wide spectrum of spatial and temporal scales. Unfortunately, the cost of resolving these scales with Direct Numerical Simulation (DNS) grows quickly with Reynolds number, so engineers will be unable to apply DNS to aerodynamic flows of industrial interest for many decades to come. Alternatively, one can model all scales using Reynolds Averaged Navier-Stokes (RANS) or just the smallest scales using Large Eddy Simulation (LES). RANS remains the turbulence modeling and simulation paradigm of choice in industry while LES continues to grow in popularity. However, state-of-the-art RANS and LES approaches are inaccurate for many aerodynamic flows of industrial interest, especially those exhibiting flow separation or transition to turbulence.

In this talk, I will discuss our work toward arriving at improved RANS and LES approaches by leveraging advances in machine learning and the availability of high-fidelity simulation data for model training. The key to our approach is constructing model forms with embedded invariance properties. This enables us to train remarkably accurate, efficient, and generalizable RANS and LES models using sparse training data. Specifically, I will provide a high-level overview of our approach as well as illustrative numerical results. I will also highlight ongoing and future research directions including Hybrid RANS/LES modeling of separating turbulent boundary layers and in situ learning of turbulence closures from streaming simulation data.

Dr. John Evans is an Associate Professor, the Associate Chair for Undergraduate Curriculum, and the Jack Rominger Faculty Fellow in the Ann and H.J. Smead Department of Aerospace Engineering Sciences at the University of Colorado Boulder. His research interests lie at the intersection of computational mechanics, geometry, and approximation theory, with current thrusts in isogeometric analysis, immersogeometric analysis, interactive simulation, and data-driven modeling. He has won a number of awards for his research and teaching including the 2021 Gallagher Young Investigator Award from the United States Association for Computational Mechanics and the 2021 AIAA Rocky Mountain Educator of the Year (College/University), and he is currently Editor of the journal Engineering with Computers.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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