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The Hong Kong University of Science and Technology

Scientific Computation Concentration Seminar

A closure model for computational fluid dynamics accurate across multiple flow regimes

By

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Abstract

Flow predictions from state-of-the-art flow solvers are still unable to predict the full flight envelope and comply with the stringent accuracy requirements and computational efficiency demanded by Certification by Analysis. Here, we address the question of how to devise closure models for large-eddy simulation (LES) capable of accounting for a rich collection of flow physics in a single unified approach. The model envisions the flow as a collection of building blocks whose information enables the prediction of the small scales. The core assumption of the model is that simple canonical flows contain the essential physics to provide accurate predictions in more complex flows. The approach brings together for the first time six modeling advances that are lacking in previous works: 1) the model is directly applicable to arbitrary complex geometries, 2) it is constructed to predict different flow regimes (zero/favorable/adverse mean-pressure-gradient effects, separation, mean-flow three-dimensionality, laminar flow,...), 3) it can be scaled-up to capture additional flow physics if needed (e.g., shock waves), 4) it unifies into one entity the subgrid-scale model and the wall model, 5) it guarantees consistency with the numerical discretization and the gridding strategy of the flow solver, and 6) the output of the model is accompanied by a confidence score in the prediction for uncertainty quantification and grid refinement. The approach is implemented using two interconnected artificial neural networks: a classifier, which identifies the contribution of each building block in the flow; and a predictor, which estimates the effect of missing scales via a combination of the building-block units. The model is validated in a realistic aircraft configuration: the NASA Common Research Model High-lift.

Short Bio:

Adrian Lozano-Duran is the Draper Assistant Professor at MIT AeroAstro. He is also a faculty member of the MIT Center for Computational Science and Engineering. He received his Ph.D. in Aerospace Engineering from the Technical University of Madrid in 2015 under the supervision of Javier Jimenez. From 2016 to 2020, he was a Postdoctoral Research Fellow at the Center for Turbulence Research at Stanford University. His research is focused on computational fluid mechanics and physics of wall-bounded turbulence. His work includes turbulence theory using new tools (graph theory, information theory,...) and reduced-order models by artificial intelligence.

Date: ***Friday, 5 May 2023***

Time: ***10:00a.m. – 11:00a.m.***

Online via Zoom: ***https://hkust.zoom.us/j/97130328824 (passcode: 606219)***

All are welcome!