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A Physics-Informed Machine Learning Framework for RANS-based Predictive Turbulence Modeling HENG XIAO, JINLONG WU, JIANXUN WANG, Virginia Tech, JULIA LING, Sandia National Labs — Numerical models based on the Reynolds-averaged Navier–Stokes (RANS) equations are widely used in turbulent flow simulations in support of engineering design and optimization. In these models, turbulence modeling introduces significant uncertainties in the predictions. In light of the decades-long stagnation encountered by the traditional approach of turbulence model development, data-driven methods have been proposed as a promising alternative. We will present a data-driven, physics-informed machine-learning framework for predictive turbulence modeling based on RANS models. The framework consists of three components: (1) prediction of discrepancies in RANS modeled Reynolds stresses based on machine learning algorithms, (2) propagation of improved Reynolds stresses to quantities of interests with a modified RANS solver, and (3) quantitative, a priori assessment of predictive confidence based on distance metrics in the mean flow feature space. Merits of the proposed framework are demonstrated in a class of flows featuring massive separations. Significant improvements over the baseline RANS predictions are observed. The favorable results suggest that the proposed framework is a promising path toward RANS-based predictive turbulence in the era of big data. (SAND2016-7435 A)

Jinlong Wu
Virginia Tech

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