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Improving Turbulence Models and Wall Functions by Using Machine Learning

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Machine Learning (ML) is used for developing wall functions for Large Eddy Simulations (LES). I use Improved Delayed Detached Eddy Simulations (IDDES) in fully-developed channel flow at a frictional Reynolds number of 5 200 to create the database. This database is used as a training set for the ML method. I use Support Vector Regression and Nearest Neighbor(s), both available in Python. The input (i.e. the influence parameters) is y +. The ML method is trained to predict U +. The trained ML model (SVR) is saved to disk and it is subsequently uploaded into the Python CFD code pyCALC-LES 1 . SVR finds a time-averaged regression line. As an alternative I also investigate Nearest neighbor (uploading the database to pyCALC-LES) using Python's scipy.spatial.KDTree. This method capture the unsteadiness of U +, see Fig. 22 in this report2 . IDDES is then carried out on coarse – and semi-course – near-wall meshes and the wall-shear stress (using the local y + and u¯) is predicted using the developed ML models. The test cases are channel flow at Reτ = 16 000 and flat-plate boundary layer. I'm currently extending the method to adverse-pressure gradient flows. I have created a number of databases using well-resolved LES in diffuser flows with opening angles 6 o ≤ α ≤ 18o . The influence parameters are local u¯ and y + as well as the non-dimensionalized pressure gradient, p +. I use Neural Network (pytorch in Python). Finally, I will present some preliminary work on how to use Neural Network (pytorch) in Python to improve the prediction of the Reynolds stresses in non-linear eddy-viscosity and algebraic Reynolds stress turbulence models.

[1]pyCALC-LES: a Python code for DNS, LES and Hybrid LES-RANS. M2 Fluid Dynamics[R.1], Chalmers, Gothenburg, 2021. [2]L. Davidson, "Using Machine Learning for formulating new wall functions for Large Eddy Simulation: A Second Attempt",M2 Fluid Dynamics, Chalmers, Gothenburg, 2022.