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DEVELOPMENT OF A DATA-DRIVEN WALL-MODEL FOR SEPARATED FLOWS

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Large Eddy Simulations (LES) are of increasing interest for turbomachinery design since they provide a more reliable prediction of flow physics and component behavior. However, they remain prohibitively expensive at high Reynolds numbers or actual complex geometries. Most of the cost is associated with the resolution of the boundary layer, and therefore, to save computational resources, wall-modeled LES (wmLES) has become a valued tool. However, wall models are not yet reliable in predicting the complex flow configurations occurring in turbomachinery passages. Most existing analytical wall models assume the flow to be fully turbulent, attached, flow aligned, and near-equilibrium. These assumptions no longer hold when different flow regimes and complex flow features coexist. Although significant progress has been made in recent years (e.g., non-equilibrium models using pressure gradients), they have not always brought a clear benefit for such realistic flows. This paper proposes an innovative data-driven wall model to treat separated flows.

Among the many possibilities to solve this complex regression problem, deep neural networks have been selected for their universal approximation capabilities [1]. In the present framework, the two-dimensional periodic hill problem is selected as a reference test case featuring the separation of a fully turbulent boundary layer. Gaussian Mixture Neural networks (GMN) and Convolutional Neural Networks (CNN) combined with a self-attention layer [2] are trained to predict the wall-parallel components of the wall shear stress using instantaneous flow quantities and geometric parameters. The *a priori* and *a posteriori* validation of such data-driven wall models on the periodic hill problem will be presented.

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