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Reynolds stress correction by machine learning methods with physical constraints

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Nowaday, with the increase in computationnal power, artificial intelligence play a major role in various fields such as facial recognition, creating art and a broad range of non-linear physical system. In the field of turbulence modeling, data-driven methods represent a promising research area since they have the potential to improve classical closure models for Reynolds Averaged Navier-Stockes (RANS) equations.

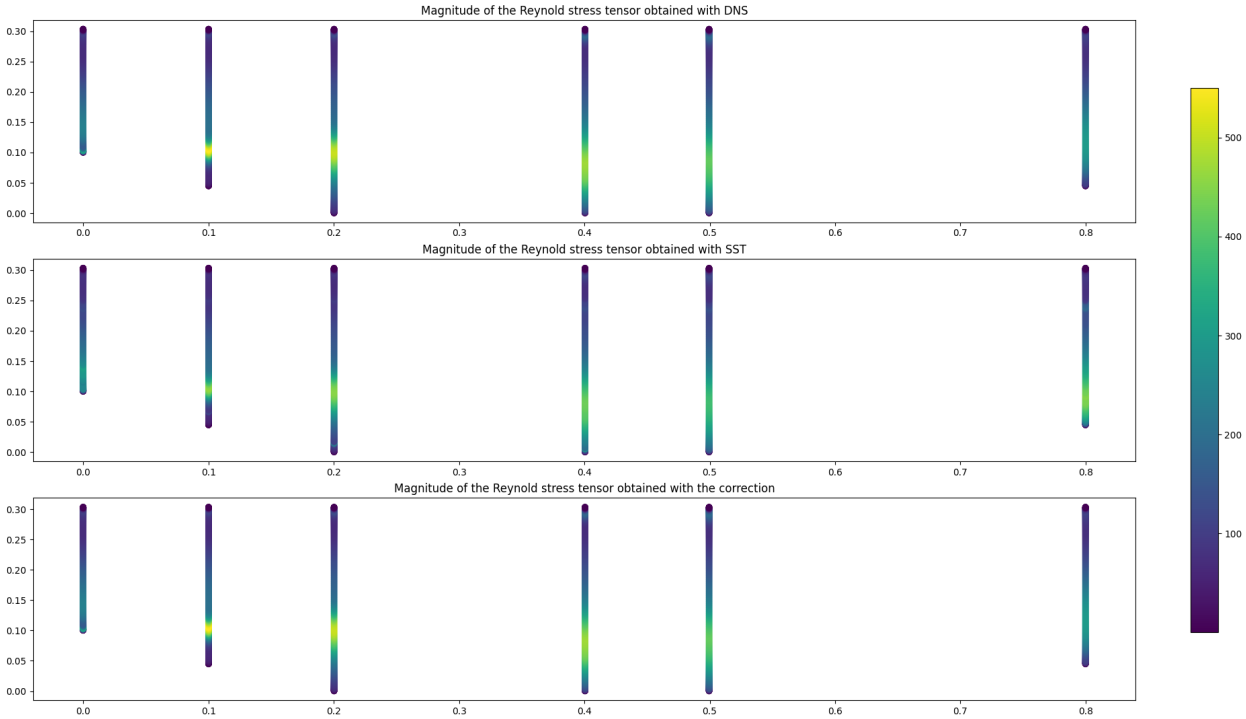
Furthermore, the available computational power allows to perform scale-resolving simulations on industrial problems characterised by significantly high values of the Reynolds number. The high-fidelity data obtained by these expensive simulations can be exploited not just to predict the performances of a system but to extract modelling knowledge on the physical phenomena which govern the flow field and develop new RANS models.

Every imporvement in RANS modelling capability has a significant impact on the industry since RANS models are still widely used for design, analysis and optimization of many aerodynamic components. In particular, Rans models can fail in the presence of separation, transition or high streamline curvature : several machine learning strategies can be exploited to compute coorections for existing RANS models in order to overcome their limitations.

In the present work, a non-linear correction to the Boussinesq assumption is evaluated by means of artificial neural networks. The goal is to express the correction as a function of local flow features and to impose some physical constraints on the obtained correction.

A database obtained by a high-fidelity DNS simulation available in the literature [3] is analyzed in order to investigate the potential of the proposed strategy. In particular, the flow on a periodic hill is considered and the Reynolds stress is evaluated in some control sections : the results obtained by the DNS, the SST RANS model and the SST RANS [4] model corrected by the DNS data are compared in figure 1

Figure 1: Comparison of Reynolds stresses evaluated in six control sections in the the periodic hill test case.



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