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Neural network prediction of the flow field in a periodic domain with hyper-neural network parametrization

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Computational fluid dynamics (CFD) is a powerful tool for numerical simulations of various processes in the industry. Unfortunately, there is still a very challenging task in terms of computational demands. Some numerical simulations are unrealizable by traditional CFD methods with today's computational resources. The use of neural networks to solve CFD problems can overcome this problem because neural networks can predict the flow field very fast, [1, 2]. This contribution aims to describe a developed neural network architecture, which can quickly predict a steady flow field in a blade cascade. The presented neural network consists of an autoencoder, which transforms the coordinates of the inter-blade area grid points onto flow field variables. The internal convolution layers were modified to include a periodic boundary condition. Furthermore, an approach for parametrization of the autoencoder for various Reynolds numbers was proposed. This approach uses another dense neural network, called hypernet, which maps a given Reynolds number onto autoencoder weights. Within this study, the autoencoder was trained for three different Reynolds numbers Re = 100, 500, 1000 on the train set of 200 randomly generated blade profiles. The resulting autoencoder weights were used for the training of the hypernet. The key part of this work is the study of the behavior of the autoencoder on unseen profiles for weights generated by hypernet for Reynolds numbers Re = 250, 750, which were not included in the training set.

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