

Deep neural networks for accelerating fluid-dynamics simulations

Prof. Dr. Thomas Richter

University of Magdeburg Institute of Analysis and Numerics

University Square 2 39106 Magdeburg

In this talk we discuss the use of deep neural networks for augmenting classical finite element simulations in fluid-dynamics. The talk is split into two distinct parts.

First, we present the deep neural network multigrid method (DNN-MG) [1,2] that can be considered as a multiscale scheme based on classical finite elements for the coarse scale and a deep neural network for predicting the fine scales. Embedded in a Newton-multigrid framework, the neural network is only acting locally. This allows for very small and efficient networks that require only a small amount of high fidelity data for training. At the same time it shows very promising generalization capabilities, since the network does not need any information about the problem geometry. We present first numerical results and discuss the approximation and stability properties of the augmented finite element / neural network framework.

In the second part we present an approach for the efficient simulation of particulate flows with non-spherical particles [3,4]. We have in mind configurations with many and small particles, which cannot be resolved in detail in a classical simulation. On the other hand, for general non-spherical particles, like blood cells or polygonal objects, there exist no analytical laws for predicting hydrodynamical coefficients like drag, lift or torque. Based on resolved simulations we train a neural network for establishing exactly such a mapping from the particle- and flow-configuration to the resulting forces. We discuss different use cases and demonstrate the accuracy and generalizability of this approach.