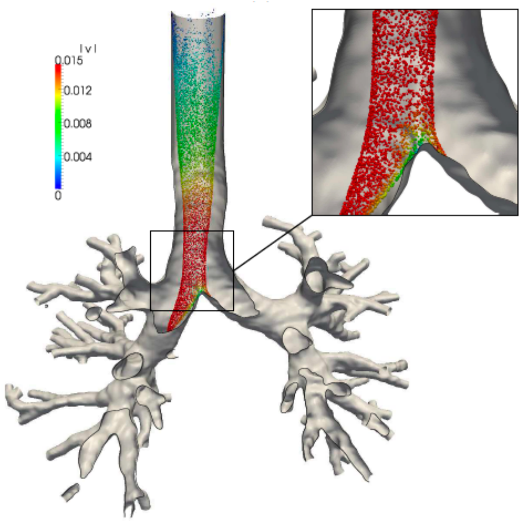
Aerodynamisches Institut und Lehrstuhl für Strömungslehre
RWTH AACHEN UNIVERSITY

Bachelor/Master Thesis

Machine learning-based prediction of forces in Lagrangian point-particle approaches

Particle laden turbulent flows play an important role in many technical fields such as drug deposition in human airways, or the combustion of solid biofuels. To simulate these problems, two different approaches are available: The fully resolved direct numerical simulation (DNS), where all features of the flow field including the surface of the particles are resolved, and the Lagrangian point-particle approach, where empirical models are used to determine the forces acting on each particle. Due to the high computational costs of the DNS approach, reduced order point-particle models are indispensable for the simulation of large scale technical applications. These models produce good results for very small particles but lead to significant errors for larger ones.

In this thesis, data from a DNS will be used to train an artificial neural network (ANN) which predicts the forces acting on a particle in a reduced order point-particle model. In a first step, fully resolved simulations with many particles have to be performed to extract the local flow field and force data for each particle, resulting in a large database for the determination of new point-particle models. In the second stage, the ANN is trained based on this database, where velocity data from a particle's surrounding flow field function as input, the acting force as output, and the acting forces from the DNS as ground truth. In a final step, it is investigated how transfer learning improves the predictive capabilities of the ANN. That is, the ANN is pre-trained with ground truth data from empirical drag laws, and the highly resolved data from the DNS are employed solely in the final training iterations.



Particle distribution for respiratory flow in a lung [1]. The particles are colored by the velocity magnitude and their diameter has been scaled by a factor of 50 for visualization purpose. The outer surface has partially been removed to show the internal particle distribution.

You ...

- ... are interested in fluid dynamics and machine learning
- ... had exposure to programming and machine learning frameworks
- ... are eager to learn new skills and are able to work in an independent manner

If you are interested, please contact:

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[1] A. Lintermann and W. Schröder: Simulation of aerosol particle deposition in the upper human tracheobronchial tract, European Journal of Mechanics B/Fluids, Volume 63, pp. 73-89, 2017.