Semester Thesis: Machine Learning algorithms for multiphase flows – Evaluating the potential and the limits

The aim of this thesis is to investigate the potential of machine learning tools to analyse and predict the dynamic behavior of cavitating flows and cavitation erosion. In cavitating flows, vapor filled cavities are formed, which later implode emitting intense shockwaves and potentially damaging surfaces in the vicinity. Our team, which is part of the gas dynamics research group, performs three dimensional fluid simulations of cavitating flows. To predict possible material damage induced by cavitation, we record pressure maxima at surfaces and afterwards cluster data of material points together to physical pits. Currently the clustering is done using a simple flood fill algorithm and spatial and temporal criteria. As part of the thesis, clustering algorithms from machine learning frameworks should be applied to the point based pressure data and the results compared to those of flood fill algorithm. Additionally, it should be assessed whether the machine learning clustering algorithms provide a deeper insight into data correlation. One can start with machine learning frameworks available in matlab and later switch to e.g. Spark or Tensorflow.

A second, more complex task is to perform a feasibility study of predicting cavitation dynamics and occurrence of material damage based on a simulation dataset of a short time-span. Since formation and subsequent collapse of the vapor structures is a periodic process, there is a big potential therefore. One of the main ideas is to train an appropriate machine learning algorithm with data and then try to predict the behavior for a different operating point.

Requirements:
- Interest in machine learning, basic knowledge of machine learning and the most common frameworks is advantageous but not essential.
- Interest in multiphase flows.
- Ability to work independently.

Task:
- Familiarization with cavitation and cavitation erosion.
- Evaluation of the state of the art of machine learning in CFD and multiphase flows.
- Evaluation of suitable programs for the clustering of the data and comparison with the current algorithm.
- Feasibility study of predicting cavitation dynamics and occurrence of material damage.

Depending on the type of thesis and the interests of the student, the task can be adapted and modified. Interested students from other faculties (e.g. computational science engineers, computer scientists, mathematicians and physicists) are also very welcome.

Please send your application to theresa.trummler@tum.de.

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Figures from left to right: Experimental pits of cavitation induced damage (Franc et al. 2012); example of point data and clustered data with color-coded time; exemplary temporal evolution of vapor and intensity of recorded pressure peaks