Master’s thesis:  
Can machine learning outperform a human expert in scalar flux modeling?

The accurate prediction of the convective heat transfer in turbulent flows is still a challenge. The Reynolds averaging of the energy conservation equation leads to the so-called scalar fluxes, which describe the energy transport due to the turbulent fluctuations. Even though plenty of models for these scalar fluxes were proposed in the past, they all share structural limitations because they were calibrated using only very sparse data. The recent ascent of data-driven modeling and machine learning allows to extract potentially more sophisticated models from a much larger database.

This project is concerned with the development of such data-driven scalar flux models by inferring the spatial distributions of formerly constant model coefficients and approximate them with functions. The objective of this thesis is twofold: First, the impact of these functions’ complexity on the model performance shall be quantified by testing a number of models built by using different regression approaches, e.g. neural networks or symbolic regression, on a set of academic and real world test cases. Second, these results should allow for an assessment whether these augmented models indeed outperform those models carefully designed by human experts.

Tasks
- Literature review
- Familiarization with the existing tool chain (Python, OpenFOAM)
- Implementation of nonlinear and deep symbolic regression
- Development of data-driven models of varying complexity by using different regression approaches (neural networks, symbolic regression, nonlinear regression etc.)
- Testing of the proposed models on a set of academic and real-world test cases
- Documentation

Place of work:  
As this thesis is conducted in cooperation with Prof. Bassam Younis, there is the possibility to stay at University of California, Davis (US) over the course of the project. However, it is also possible to conduct all research at ITLR.

Begin and duration:  
April 2023 (negotiable), 6 months

For more information, please get in touch with:  
Hannes Mandler, M.Sc.  
hannes.mandler@itlr.uni-stuttgart.de
+49 (0)711 685-62636

Prof. Bassam Younis  
bayounis@ucdavis.edu

Fig. 1: Spatial distributions of optimal ($g_1^{opt}$) and traditional ($2c_\mu$) coefficient value