Universität Stuttgart

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NRG

Implementation of a Fully-Differentiable 1D Discontinuous Galerkin Flow Solver

Master Thesis (m/w/d)

Background

CFD has become an important tool in the design process of technical systems. Traditionally, design optimizations were suggested by experts based on their experience and CFD was used in forward mode in order to confirm that the proposed changes are indeed effective. In recent years, this geometry optimization process underwent a significant paradigm shift. Rather than relying on educated guesses of a few experts, one tries to use more compute ressources to exhaustively explore the landscape of all possible designs for the global optimum. Due to the typically high geometric complexity and the therefore huge design space, a brute-force search is unaffordable. Thus, it was begun to use CFD in inverse mode that is to compute the sensitivity of the CFD solution with respect to the geometry. Mathematically speaking, this requires to differentiate the flow solver with respect to its inputs. Using automatic differentiation as in modern AI workflows seems to be a promising route towards developing differentiable flow solvers eventually enabling the efficient solution of inverse problems.

Project Description

In this thesis, such a fully-differentiable Discontinuous Galerkin solver is supposed to be developed for turbulent plane channel flows. To this end, the work is structured as follows:

- Literature review on differentiable flow solvers
- Development of a differentiable 1D flow solver
- Verification of the implementation on a turbulent plane channel flow
- Benchmarking of different frameworks like PyTorch or Jax
- Documentation of the results

Your Profile

- Solid understanding of computational fluid dynamics
- Solid understanding of the Discontinuous Galerkin method
- Basic Fortran programming skills

Application

If you are interested, even if you don't fulfill all the listed requirements, please send your application (incl. CV and latest transcript) via e-mail.

Start: as soon as possible

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