Karlsruhe Institute of Technology

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Master thesis – Numerical

Prediction of flow field inside a structured laminar channel using physics-informed neural network

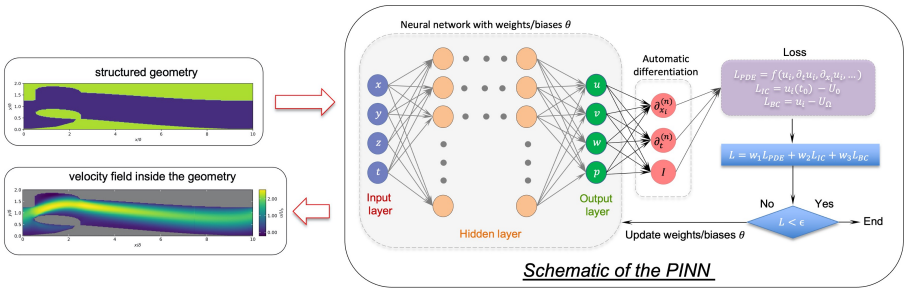
Background

Laminar flow through flat channels is a fundamental configuration studied in fluid mechanics, offering an analytical solution for velocity distribution. However, when the channel walls deviate from being flat (structured walls) the flow becomes unpredictable, lacking an analytical solution. Though numerical simulations can be used to predict the flow field, the success of these simulations depends heavily on the careful discretization of the spatial domain, $i.e.$, mesh generation. Also, numerical simulations become the bottleneck for performing any kind of optimization or for screening an extensive repository of structured geometries; for example to select the structured geometry with the least pressure loss.

Content of the Thesis

For the present study, we will use a physics-informed neural network (PINN) to predict the time-resolved flow field inside arbitrarily structured channel walls. PINNs utilize the underlying equations governing the physical phenomenon, which in the present case are the continuity and Navier-Stokes equations, while training the neural network. The important questions that need to be addressed are: a) how to efficiently parameterise the structured geometries to give it as input the NN and b) how to train the NN for a wide range of flow conditions (Reynolds number, initial and boundary conditions etc.).

Reference: Cai et al., Acta. Mech. Sin. 37(12), 1727–1738 (2021).



Schematic of the PINN

Requirements

Basic knowledge of fluid mechanics

Beneficial Skills

Knowledge of programming - Python
Machine learning

Start: immediately

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