VILNIUS UNIVERSITY
FACULTY OF MATHEMATICS AND INFORMATICS
MATHEMATICS AND APPLIED MATHEMATICS

Flow Field Reconstruction from Sparse Data using Physics-Informed Neural Networks

1st Report of the Practical Task

Author: Ugnius Alekna

Vilnius
2023

1. **What task do you plan to solve?**

The main task of this project is to employ Physics-Informed Neural Networks (PINNs) to reconstruct flow field of blood and boundary shape of blood vessels from limited, noisy data. This is particularly valuable in situations where obtaining high-quality blood flow measurements is challenging due to low Signal-to-Noise Ratio (SNR). The project‘s goal is to combine readily available noisy data with the governing physical laws, enabling the reconstruction of both the flow field and the boundary shape using PINNs.

2. **What data/images do you plan to analyze?**

This project will utilize synthetic data, obtained by numerical simulations using Finite Element Method (FEM), then corrupted by Gaussian noise and sampled accordingly. It will include velocity vector measurements capturing flow characteristics within the spatio-temporal domain of interest (imitating data, acquired with Magnetic Resonance Velocimetry (MRV) technique).

3. **What computing resources do you plan to use?**

For this project, I intend to use Google Colaboratory, a cloud-based computing environment. The platform offers access to a T4 Graphics Processing Unit (GPU) with 16 GB of GDDR6 RAM.

4. **What programming language (frameworks, libraries) do you plan to use?**

I will primarily work with Python with the use of deep learning framework PyTorch, along with NumPy library for numerical operations and MatPlotLib library for data visualization.

5. **If the program code has already been presented, whether you plan to improve it or to create a new one.**

The program code will be developed as part of this research project. My focus will be on customizing and refracturing the existing PINN implementations in order to address the specific challenges of this practical task.

6. **Other aspects you think are important.**

In addition to the primary objectives, integration of Convolutional Neural Network (CNN) architecture could hold promise for enhancing the flow field reconstruction task. CNNs are well-suited for capturing local patterns and features while maintaining translational invariance, potentially benefiting the overall success of the project.

Another aspect under consideration is the potential use of DeepXDE framework, which offers customization for spatio-temporal problem domains and boundary conditions. Depending on the project's needs, it could enhance the approach.