Chair for Computational Analysis of Technical Systems

RWTH AACHEN UNIVERSITY

Master thesis

for students of Mechanical Engineering, CES, SiSc, etc.

Adaptive Loss Scaling in Physics-Informed Neural Networks for Flow Modeling in Stirred Tank Reactors

Physics-Informed Neural Networks (PINNs) have gained considerable traction in recent years due to their potential as reduced-order models, effectively integrating experimental data with the physical constraints of a problem. However, when applied to complex problems involving intricate geometries, PINNs often face training difficulties. A key challenge is balancing multi-scale losses to prevent the model from becoming biased towards minimizing specific terms during training. This thesis aims to investigate and compare the effectiveness of various strategies for addressing this issue in the context of modeling flow in stirred tanks, with the potential to enhance these strategies further.

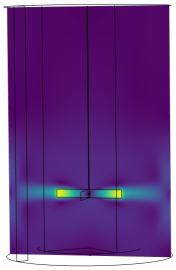

Fig.1: Velocity field inside a STR.

Individual Steps

- Familiarize yourself with the topic of Physics-Informed Neural Networks and existing STR models.
- Conduct a literature review on adaptive scaling of loss components in PINNs.
- Implement selected adaptive scaling strategies in an in-house PyTorch codebase.
- Test the implemented strategies on a STR test case.

Prerequisites

- Interest in applying Physics-Informed Machine Learning to fluid dynamics modeling.
- Familiarity with programming, preferably in Python.
- Prior knowledge of neural networks and Python machine learning libraries is beneficial, but not required.

Literature

- Raissi, M., et al. "Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations." (2019)
- Wang, S., et al. "An Expert's Guide to Training Physics-informed Neural Networks." (2023)

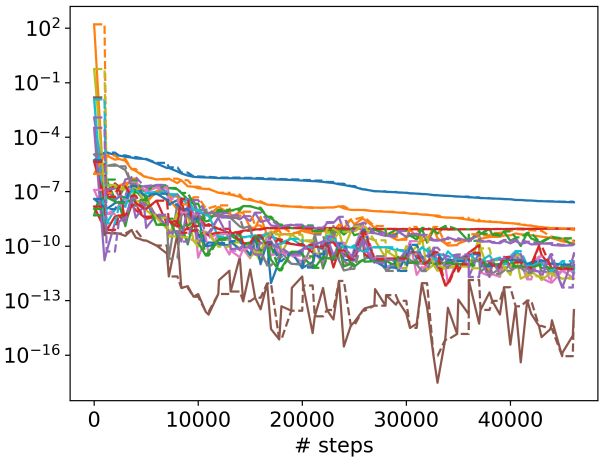

Fig.2: Convergence of loss components for a STR model.

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