Chair for Computational Analysis of Technical Systems

RWTH AACHEN UNIVERSITY

Master thesis

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

Prediction of Complex Flow Fields in Stirred Tank Reactors with Physics-Informed Machine Learning

Cell cultivations in bioreactors are essential tools in biotechnological research and production. To find optimal process parameters, so-called multi-query scenarios need to be modelled. For such scenarios, Computational Fluid Dynamics simulations can prove time-consuming and computationally expensive. This motivates the attempts to employ physics-informed machine learning to construct reduced bioreactor models.

Physics-informed machine learning aims to reduce the amount of data needed to learn a solution of a problem by incorporating its underlying physics into the training process. Therefore methods from this field are especially suited for solving problems with typically sparse data and known governing equations.

This thesis aims to further explore the applicability of Physics-Informed Neural Networks (PINNs) in bioreactor modelling and transferability of the performance-enhancing strategies applied in 2D to a 3D model.

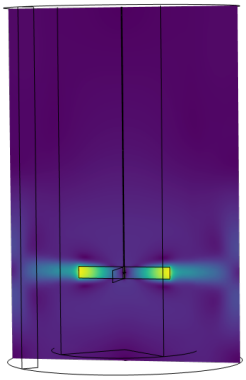

Fig.1: Velocity field inside a simplified bioreactor.

Individual Steps

- Familiarization with the topic of Physics-Informed Neural Networks and existing 2D models
- Development of a 3D stirred tank reactor model

Prerequisites

- Interest in the application of Physics-Informed Machine Learning in the context of biotechnology
- Familiarity with programming languages, preferably Python
- Previous knowledge of neural networks and Python machine learning libraries highly 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)
- Kuschel, M., "Resolving heterogeneities in single and multiphase bioreactor systems - Predictive modelling tools towards successful scale-up." (2020)

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