Karlsruher Institut für Technologie

Institut of Biomedical Engineering

IBT

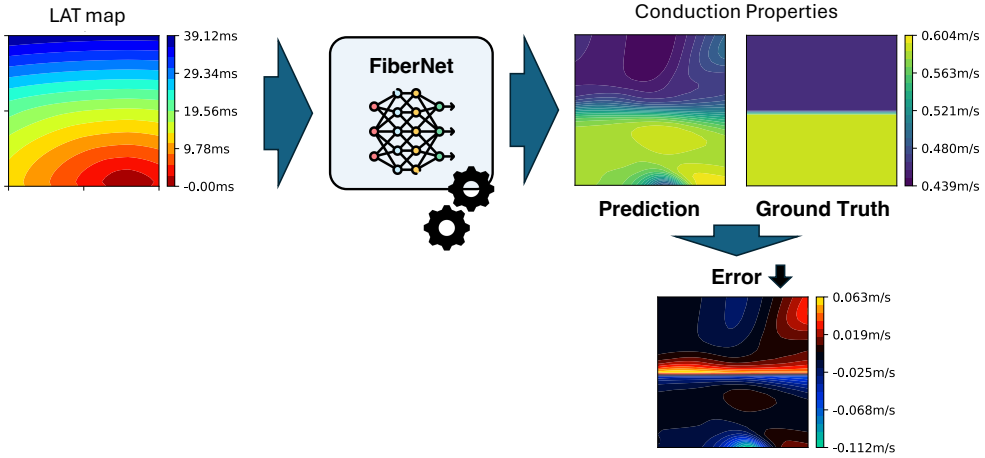
Master's Thesis or Student Project and Bachelor's Thesis

Optimizing Physics-Informed Neural Networks for Cardiac Conduction Property Estimation

Motivation

Atrial fibrillation (AF) is a widespread cardiac arrhythmia, and a major clinical concern due to its link to stroke. A critical mechanism underlying AF is the slowing and heterogeneity of electrical conduction velocity (CV) in the heart. Therefore, accurately estimating the direction-dependent CV in a patient's atria is key to understanding the disease and guiding personalized treatment strategies.

However, the clinical data used for this estimation (Local Activation Time (LAT) maps) is often sparse and noisy, making the accurate reconstruction of tissue properties challenging. To address this, FiberNet presents a promising method. It is a physics-informed neural network-based approach that incorporates the governing physical law of wave propagation into the learning process, offering an approach to tackle the challenge of low-quality clinical data.



Project description

FiberNet has demonstrated success in estimating tissue properties from simulated data. However, its performance often declines significantly when faced with noisy data or in tissue regions with gradual structural transitions. This project aims to maximize FiberNet's robustness and accuracy. This will be measured by comparing prediction accuracy against a benchmark dataset and accomplished by investigating two core optimization strategies:

A) Hyperparameter Optimization: Systematically tune the neural network architectures and balance the components of the total loss function.

B) Exploring Alternative Regularization Schemes: Investigate and implement alternative regularization schemes to better capture complex, heterogeneous tissue properties and mitigate noise sensitivity.

Notes

- The thesis can be written in German or English
- Programming skills in Python are beneficial
- Basic knowledge about the physiology of the human heart is welcome

Research area
Computational cardiac modeling

Project
Optimizing physics-informed neural networks for conduction property estimation

Orientation
Parameter optimization, software programming, simulation

Course of studies
Engineering, natural science or mathematical study course

Starting date
Beginning of 2026

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