Accelerating and Automating Magnet Design and Simulation with Image Recognition

TECHNISCHE UNIVERSITÄT DARMSTADT

Proposal for a Bachelor's Thesis | Project Seminar
Study field: Computational Engineering | Electrical Engineering | Numerical Mathematics | Computer Science
March 10, 2025

Contact:
Dr.-Ing. Laura D'Angelo
dangelo@temf.tu-darmstadt.de
Office: S2|17 142

Description

Computational engineering and numerical simulations are essential in designing and analyzing accelerator magnets, especially as magnet geometries become more complex. During the early design phase, engineers often need to explore multiple magnet designs quickly for rough quality estimates. However, modeling each design in a sophisticated CAD software can be time-consuming and inefficient, as many ideas will not make it past the initial phase.

This proposal aims to accelerate the process by leveraging image recognition. You will develop a Python package that can interpret hand-drawn, 2D magnet geometries – recognizing the iron yoke shape and coil wire positions – and convert them into a format compatible with our in-house Biot-Savart-based solver [1] for magnetic field simulations.

Work plan

1. Set up the image recognition: Hand-drawn picture $\mapsto$ set of data points
2. Process the image data: Data points $\mapsto$ geometrical and physical data
3. Couple with the numerical field solver: Data $\mapsto$ simulation results
4. Automate the process from the picture input to the simulation output
5. Depending on the progress, expansions can be added

Prerequisites

- Proficiency in Python (or Matlab, since it is very similar)
- Basic knowledge of geometrical methods of CAD (Bézier curves and B-splines should be not unknown words to you)
- Joy in programming and numerical mathematics
- Good understanding of electrodynamics is a plus

T E M F

References

[1] L. A. M. D'Angelo et al.: "Efficient Reduced Vector Potential Formulation for the Magnetic Field Simulation of Superconducting Magnets". In: *IEEE Trans. Mag.*, vol. 60, 2024.