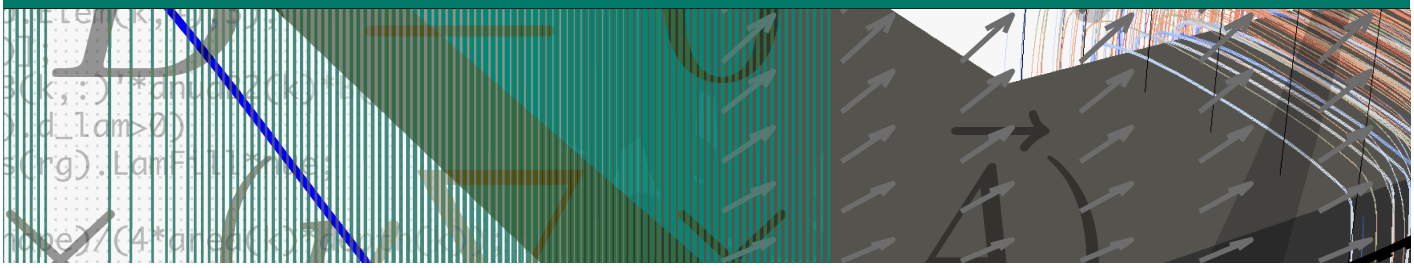
Machine Learning with Polynomial Chaos Expansion for Electromagnetic Simulations

TECHNISCHE UNIVERSITÄT DARMSTADT

Proposal for a bachelor's or master's thesis
Study field: Computational Engineering | Computer Science | Electrical Engineering | Mathematics
March 16, 2026



Description

In computational electromagnetics, simulations often need to be evaluated repeatedly for different parameters. Performing full numerical simulations for each parameter configuration can be computationally expensive.

Recent works have explored the use of machine learning techniques, such as deep neural networks (DNNs), Gaussian processes (GPs) and Polynomial Chaos Expansion (PCE), to learn parametric solutions of electromagnetic problems. These approaches enable fast predictions once a model has been trained. In particular they learn the solution in terms of coefficients with respect to a (possibly reduced) finite element or isogeometric basis. For example, the case where GPs with additional gradient information are trained is discussed in [1].

In this thesis, regression-based PCE will be explored as an alternative approach for gradient-enhanced learning. This framework represents the parametric dependence of the solution in terms of a series expansion in orthogonal polynomials.

The thesis will involve a literature review on PCE and the implementation of a PCE-based surrogate model for parametric electromagnetic problems. If time permits, residual-based error estimators or predictive uncertainty intervals for the surrogate model can also be explored.

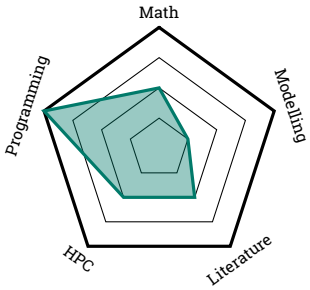
Prerequisites

- Programming experience in Python and MATLAB.
- Interest in machine learning methods.
- Basic understanding of numerical methods for partial differential equations.

Supervisors:
Merle Backmeyer, M.Sc.
Dr.-Ing. Dimitrios Loukrezis
Prof. Dr. Sebastian Schöps

Contact:
merle.backmeyer@tu-darmstadt.de

Weighted Core Areas:



The project will be conducted in collaboration with the Centrum Wiskunde & Informatica in Amsterdam.

[1] M. Zorzetto, M. Backmeyer, M. Wiesheu, R. Torchio, F. Dughiero, and S. Schöps, "Gradient-informed machine learning in electromagnetics," Cornell University, Preprint arxiv:2601.18300, 2026.

CEM