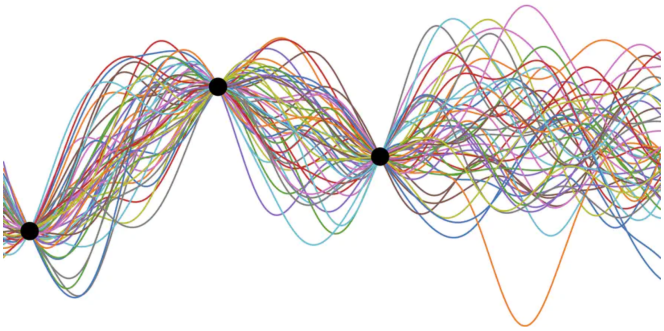
Uncertainty Quantification

Karlsruhe Institute of Technology

Master Thesis:
Multilevel Gaussian Process Regression

Course of Study: Mathematics, Computer Science, Computational Engineering



Topic

This thesis explores the intersection of Gaussian process (GP) regression and multilevel Monte Carlo methods (MLMC). As a flexible method in scientific machine learning, GP regression allows for a probabilistic framework for modeling and making predictions about complex systems with quantified uncertainty. The goal is to develop and implement a scalable and data-efficient framework that leverages the strengths of both techniques: the probabilistic, non-parametric modeling capabilities of GPs and the variance reduction and computational efficiency of MLMC. This approach is particularly relevant for multi-fidelity modeling, where data or simulations are available at varying levels of accuracy or cost.

Tasks

- Review the foundations of Gaussian Processes and Multilevel Monte Carlo methods
- Develop a theoretical and computational framework for Multilevel Gaussian Processes
- Test the method on example problems, such as material simulations in mechanical engineering (e.g., fiber-reinforced composites), or option pricing (e.g., Black–Scholes model)
- Evaluate and compare performance with existing GP or surrogate modeling approaches

Requirements

- Background in numerical methods, probability, and statistics
- Programming experience in Python
- Interest in uncertainty quantification

What we offer

We offer a research-oriented project at the interface of applied mathematics, statistics, and scientific machine learning. Additionally, this research project provides an opportunity to contribute to ongoing research with potential for academic publication.

Contact: Sebastian Krumscheid, Stjepan Salatovic

E-mail: sebastian.krumscheid@kit.edu, stjepan.salatovic@kit.edu