Technische Universität München

Fachgebiet Kontinuumsmechanik

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Master‘s Thesis / Bachelor‘s Thesis

Machine Learning Techniques in the context of Reduced Basis Methods for Stochastic Partial Differential Equations

The role of numerical simulation in engineering and science has become increasingly important over the past decades. System or component behavior is often modeled by (a set of) partial differential equations and associated boundary conditions. In general, the analytical solution is unavailable, so that in practice, a discretization procedure such as the finite element method (FEM) is used. As the physical problems become more complex and the mathematical models more involved, current computational methods prove increasingly inadequate, especially in contexts requiring numerous solutions of parametrized partial differential equations for many different values of the parameter. Even for modest-complexity models, the computational cost to solve these problems is prohibitive. Over the past decade numerous tools in the field of Reduced Basis Methods (RBM) have been developed. These numerical methods permit the efficient and reliable evaluation of this PDE-induced input-output relationship in real-time or in the limit of many queries — that is, in the design, optimization, control, and characterization contexts.

At the Fachgebiet Kontinuumsmechanik we are investigating on new strategies for finding the reduced bases. We incorporate Bayesian machnie learning tools which try to find the reduced dimension and parameters in a probabilistic fashion. A first conceptual study of combining a classifyer with a mixture of Principal Component Analysers seems promising and will be investigated further.

The scope of this thesis is to:

- get familiar with the reduced-basis approximations
- get familiar with Bayesian machine learning techniques
- get familiar with existing MATLAB / C++ code
- analyse problem examples

Requirements:

- Basic programming skills (MATLAB / C++)
- Basic knowledge on FEM & strong interest in FE modeling
- Advanced mathematics (probability theory / functional analysis / algebra)

Literature / websites:

- *A. T. Patera, G. Rozza:* Reduced Basis Approximation and A Posteriori Error Estimation for Parametrized Partial Differential Equations, MIT Pappalardo Graduate Monographs in Mechanical Engineering, V1.0, 2007.
- Christopher M. Bishop: Pattern Recognition and Machine Learning

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