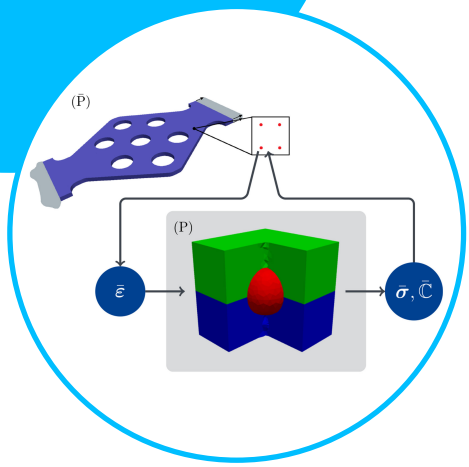
MSc./BSc. thesis
SimTech Projektarbeit/Forschungsmodul

University of Stuttgart
Institute of Applied Mechanics

FE^2 (FE Square) simulations using GPU-accelerated microscale models



Multi-level Finite Element simulations in the spirit of the FE^2 (FE Square) method can give accurate predictions for the behavior of complex materials with underlying heterogeneous microstructure. However, this goes along with an unacceptable computational burden. Replacing the microscale simulations with GPU-accelerated surrogate models can provide the sought-after efficiency.
Previous works, e.g., in [1] have shown that realistic FE^2 simulations are indeed possible, but have required a high implementation effort. Today, with PyTorch and ONNX, technologies are available that make it possible to easily define GPU-accelerated surrogate models in Python code. The goal here is to implement a minimum working example and, depending on the desired scope, to add extensions (adaptive model switching, new material models).

[1] Fritzen, F., and Hodapp, M. (2016) The finite element square reduced (FE2R) method with GPU acceleration: towards three-dimensional two-scale simulations. Int. J. Numer. Meth. Engng, 107: 853–881. doi: 10.1002/nme.5188.

Tasks

The thesis/project would include following tasks:

- Get familiar with the concept of multi-scale Finite Element simulations
- Literature study for suitable microscale models (full-order and reduced-order models)
- Implement GPU-accelerated surrogate models in Python (we will guide you)
- Calling the microscale models from an existing C++ FEM code (we will guide you)

Requirements

- Interest in simulation technology (FEM simulations and beyond)
- Intermediate programming knowledge (ideally Python or C/C++)

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