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Studienarbeit

Numerical multiscale and multiphysics modeling

Computational modeling of the material behavior of composite materials requires the accurate resolution of the microstructure. Additonally, in many engineering applications, mechanical effects are coupled with, for example, thermal, electric or chemical effects. Typical applications are energy storage devices, biomechanics and water flow in concrete cracks (Fig. 1-3). To solve the resulting partial differential equations, numerical methods are employed. Popular choices are the Finite Element Method (FEM) and methods based on the Fast Fourier Transform (FFT).

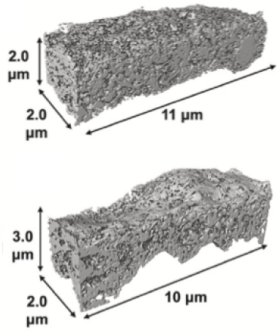

Fig. 1) Catalyst layer in electrolysis cell before and after assembly [1]

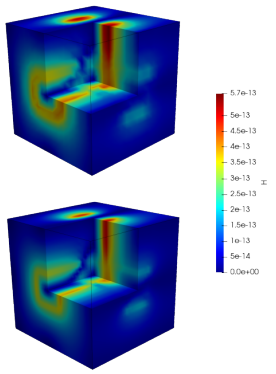

Fig. 2) Magnetic field strength in bone modeled for early detection of osteoporosis

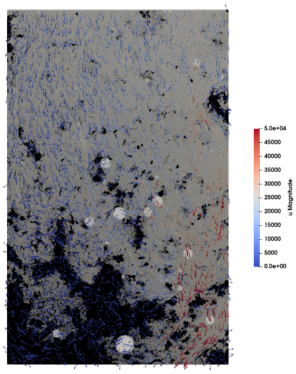

Fig. 3) Fluid flow in a concrete crack recovered from CT image

In this project, we want to implement a specific material model using the open source programming language Julia [2]. Furthermore, we want to investigate the behavior of the model. Computational homogenization allows to model the material behavior across different length scales.

Prerequisites: basic knowledge of coding, good understanding of fundamentals in math and mechanics

Tasks

- Acquisition of basic knowledge regarding material modeling and numerical methods
- Implementation of the model in the programming language Julia
- Investigation of the material model behavior and visualization of results using the software ParaView

References

[1] K. J. Ferner, et al. Morphological analysis of iridium oxide anode catalyst layers for proton exchange membrane water electrolysis using high-resolution imaging. International Journal of Hydrogen Energy, 59:176–186 (2024).
[2] J. Bezanson et al. The Julia programming language, https://julialang.org// (2025).