Hyperelastic Laminates, Composite Voxels and FFT-based Homogenization at Finite Strains

Felix Ospald[1] Matthias Kabel[2] Matti Schneider[3]

Today, many industrial applications involve complex materials with a heterogeneity on the microscopic scale. For the prediction of the effective behavior of these materials, homogenization methods are readily applied. However, especially for nonlinear material laws these methods are heavily demanding from the computational perspective, often pushing commercial FEM software on workstations to its limits.

In contrast to boundary conforming FEM, FFT-based homogenization methods operate on regular voxel grids and cannot resolve interfaces exactly in general, therefore requiring excessively high resolutions for accurate results. In this talk, we study hyperelastic laminates and associate their effective properties to voxels containing interfaces, extending previous ideas successfully applied in the framework of linear elasticity [1].

We demonstrate that furnishing interface voxels with appropriately rotated effective hyperelastic properties of a two-phase laminate significantly enhances both the local solution quality and the accuracy of the computed effective elastic properties, with only a small computational overhead compared to using classical FFT-based homogenization.

The results are also readily applicable for non-boundary conforming FEM, like micro finite element analysis [2].

References:

[1] Matthias Kabel, Dennis Merkert, Matti Schneider *Use of composite voxels in FFT-based homogenization.* Comp. Meth. Appl. Mech. Engng., 294 (2015) 168-188.
[2] Peter Arbenz, Cyril Flaig, Daniel Kellenberger *Bone structure analysis on multiple GPGPUs* J. Parallel Distrib. Comput., 74 (2014) 2941-2950.

[1] TU Chemnitz, Numerical Mathematics (Partial Differential Equations), Chemnitz, Germany,
felix.ospald@mathematik.tu-chemnitz.de

[2] Fraunhofer ITWM,
matthias.kabel@itwm.fraunhofer.de

[3] Fraunhofer ITWM,
matti.schneider@itwm.fraunhofer.de