Chair of Computing in Civil and Building Engineering
TUM School of Engineering and Design
Technical University of Munich

Modeling:
Mathematics:
Programming:
Science:

Software Lab:

Unit cell generator for multiscale analysis

Description

For the analysis of multiscale materials such as additively manufactured structures or materials with inclusions, it is preferred to define a representative unit cell (UC) of the material. This unit cell may then be used in a homogenization approach to obtain effective material parameters or be evaluated "online" in a nested FE-approach (FE^2) [1].
In the scope of optimization, the fast and reliable generation of unit cell geometries with a high-quality mesh is paramount. Furthermore, the generated mesh has additional requirements, such as compatibility on the boundaries of the unit cell.
This software lab project aims to develop a Python library that generates the geometry and mesh for different parametrized unit cell structures [3].

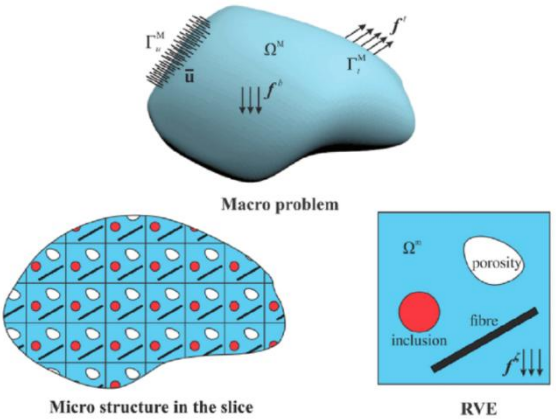

Fig. 1: Homogenization approach [2]

Task

- **Unit Cell Selection:** Investigate and select different UC types.
- **Unit Cell Parametrization:** Define a low-dimensional geometric parametrization of the selected UCs.
- **Geometry Creation:** Ensure a reliable UC geometry generation.
- **Meshing:** Generate FE meshes with different element types and a predefined mesh quality. The mesh must be suitable for multiscale analysis.

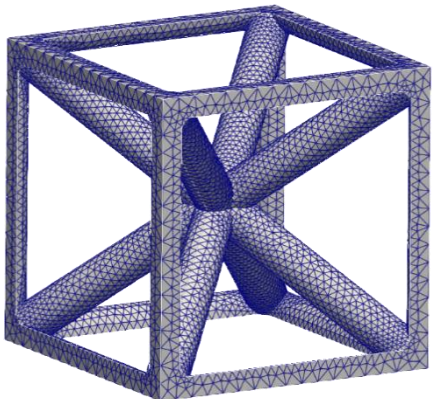

Fig. 2: FE-mesh of a strut-based unit cell

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References

[1]: F. Feyel and J.-L. Chaboche, 'FE2 multiscale approach for modelling the elastoviscoplastic behaviour of long fibre SiC/Ti composite materials', *Computer Methods in Applied Mechanics and Engineering*, vol. 183, no. 3–4, pp. 309–330, Mar. 2000, doi: 10.1016/S0045-7825(99)00224-8.

[2]: S. Mohammadi, *Multiscale biomechanics: theory and applications*. Hoboken, NJ: John Wiley & Sons Inc, 2023. doi: 10.1002/9781119033714.

[3]: Nazir, A., Abate, K.M., Kumar, A. *et al.* A state-of-the-art review on types, design, optimization, and additive manufacturing of cellular structures. *Int J Adv Manuf Technol* **104**, 3489–3510 (2019). doi: 10.1007/s00170-019-04085-3