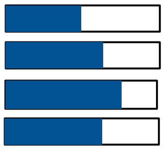
Chair of Computational Modeling and Simulation
TUM School of Engineering and Design
Technical University of Munich

Software Lab: 3D Discontinuous Finite Cell Method

Modeling:
Mathematics:
Programming:
Science:



Background

The Finite Cell Method (FCM) is an advanced computational approach rooted in high-order Finite Element Methods (FEM). Unlike traditional FEM, where conforming elements must align with the boundaries of the physical domain, FCM employs structured cells that do not necessarily conform to these boundaries. Initially developed at TUM in 2005, the method has since been extensively refined and applied to a variety of complex problems. Currently, our focus is on developing a discontinuous version of FCM for solid mechanics problems. In this version, the connectivity between cells is established through fluxes, which are expressed in terms of displacements and/or their gradients to accurately represent the physical interconnection of cells. This novel approach is expected to offer greater flexibility and efficiency, particularly in solving multi-material problems, handling domains with moving boundaries, and simulating processes such as additive (3D printing) and subtractive manufacturing. By leveraging structured non-conforming cells, the discontinuous FCM aims to significantly expand the applicability of the method to new and challenging domains.

Extending the Code from 2D to 3D

- **Objective**: Transition the current 2D implementation of the Discontinuous Finite Cell Method (DFCM) to 3D, enabling simulations of more complex physical problems and geometries.
- **Expected Outcome**: A fully functional 3D DFCM solver capable of handling arbitrary geometries and physical domains.

Task

- Extend the existing 2D mesh generator to 3D.
- Update shape function implementations to support high-order 3D cells
- Modify the integration schemes to handle 3D domains, including adapting Gauss quadrature to higher-dimensional spaces.
- Redefine data structures to store 3D geometry, nodes, connectivity, and boundary information.
- Update visualization tools for 3D domains and results.

Supervisor

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References:

- Parvizian, J., Düster, A. & Rank, E. Finite cell method. Comput Mech 41, 121–133 (2007).
- A. Düster, J. Parvizian, Z. Yang, E. Rank, The finite cell method for three-dimensional problems of solid mechanics, Computer Methods in Applied Mechanics and Engineering (2008).