Chair of Computational Modeling and Simulation
TUM School of Engineering and Design
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Modeling:
Mathematics:
Programming:
Science:

Software Lab: Optimized Data Structure for Discontinuous Finite Cell Method

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.

Optimizing Data Structures for Computational Efficiency

- Objective: Develop and implement an optimal data structure to improve memory usage, computational efficiency, and scalability for large-scale DFCM simulations.
- Expected Outcome: A modular, scalable, and efficient data management system that supports large-scale DFCM simulations.

Task

- Analyze the current data structure for nodes, elements, and connectivity to identify bottlenecks.
- Explore and implement modern data structures (e.g., sparse matrices, octrees, or hash maps) for handling large, structured/non-conforming grids.
- Integrate parallelization techniques where applicable to improve performance.
- Test the optimized data structures with both 2D and 3D problems to ensure scalability and accuracy.

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).