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

Development of Automatic Cell Decomposition for the Discontinuous Finite Cell Method (DFCM)

Background and Motivation

The FCM is a high-order embedded domain method that enables the simulation of complex geometries using simple structured meshes. Recently, a novel extension known as the **Discontinuous Finite Cell Method (DFCM)** has been developed. DFCM combines ideas from the Finite Cell Method and discontinuous Galerkin formulations, allowing for weak enforcement of boundary and interface conditions via numerical fluxes and Nitsche-type methods. One of the key challenges in DFCM is the robust and efficient treatment of **cells containing multiple materials or several disconnected material islands**. Such configurations arise naturally in problems involving complex geometries, evolving interfaces, or multi-material domains. To fully exploit the flexibility of DFCM, an **automatic and reliable decomposition of such cells** is required. The project will be supervised closely, with regular meetings and technical guidance. Existing 2D and 3D DFCM implementations will be provided as a starting point, allowing the group to focus on the core algorithmic challenges.

Project Objective

*The goal of this group project is to **design and implement an automatic cell decomposition strategy** for multi-material cells and cells containing multiple material islands within the DFCM framework.*

The developed algorithms will:

- *Detect complex material configurations inside a finite cell,*
- *Decompose cells into suitable subcells or material-consistent regions,*
- *Preserve numerical stability and accuracy,*
- *Interface seamlessly with the DFCM formulation and flux coupling strategy.*

Scope of Work

The project will include the following tasks:

- *Study of the DFCM formulation and its treatment of interfaces and discontinuities,*
- *Analysis of typical multi-material and multi-island cell configurations,*
- *Design of algorithms for automatic cell detection and decomposition,*
- *Implementation of the proposed methods in provided **2D and 3D DFCM base codes**,*
- *Verification and testing using representative benchmark problems,*
- *Documentation of the developed algorithms and software components.*

*The project focuses on **algorithmic development and implementation**, not on writing a solver from scratch. Core DFCM codes and example setups will be provided by the supervisor.*

Tasks

- *Implemented a working prototype for automatic cell decomposition in DFCM,*
- *Gained hands-on experience with advanced finite element and immersed methods,*
- *Developed skills in scientific programming, algorithm design, and team-based software development,*
- *Contributed to an active and evolving research framework in computational mechanics.*

Prerequisites and Candidate Profile

*Strong interest in **computational mechanics** and numerical methods; be **task-oriented, motivated, and hard-working**, enjoy working in a **team-based software development environment**; basic experience in programming (e.g., MATLAB).*

Supervisor

Prof. Jamshid Parvizian, Chair of Computing in Civil and Building Engineering, jamshid.parvizian@tum.de