A scalable technique for numerical integration in cut cells based on 3D CAD models

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ABSTRACT

Unfitted finite element methods are useful techniques to simulate problems defined on 3D complex domains. In this context, the conventional approach is to represent the problem geometry using level-set methods. Geometrical data based on level-set functions allow efficient procedures (usually based on marching cubes algorithms) for the generation of integration cells in cut elements. However, real-world engineering applications consider often 3D CAD data for the geometrical definitions. This makes challenging the usage of standard unfitted techniques, since there is not a general and accurate way to translate 3D CAD models into level-set functions.

In this work, we explore a novel technique in order to generate integration grids in cut cells. In contrast to level-set methods, our methodology can be feed up directly from high order CAD models described by NURBS. Our goal is to develop a methodology that captures the geometrical entities provided by the CAD model (i.e., points, lines, and surfaces) with high order approximations, and that is usable in large-scale parallel computations. For the high-order geometry representation, we consider an approach similar to [1]. On the other hand, in order to find collisions between CAD entities and cells in the background, we consider an efficient implementation based on parallel octree meshes provided by the P4EST library [2].

The technique is implemented in the large-scale finite element package FEMPAR [3] and it is used in large parallel runs in combination with the AggFEM method [4].

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