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Direct Simulation of 'dirty' geometries using the Finite Cell Method

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'Dirty' geometries in the context of numerical simulations are geometrical CAD (Computer Aided Design) models, which are mathematically invalid, i.e. it is not unambiguously possible to distinguish whether a point lies inside or outside. These imprecise models are very common due to the different requirements between CAD models and simulation suited models. Whilst CAD models must fulfill mainly visual demands and hence allow small-scale inaccuracies, structural simulation models typically need to be mathematically valid, or at least watertight.

Flaws often occur at the joint between surface patches. The most common geometrical flaws are gaps or openings, overlaps, and intersections. But also, topological errors arise, such as double or wrongly oriented entities. In the past decades, a lot of effort has been spent to develop different geometry healing methods. However, these methods are not always able to detect flaws or correctly reconstruct the model.

Based on the Finite Cell Method (FCM) [1], which is a high-order embedded domain method, we developed a robust algorithm allowing a numerical simulation directly on the flawed CAD model. At its core, the method combines the robustness of an octree reconstruction with the precision of the ray-casting method. Because the underlying model remains mathematically invalid, the accuracy of this method compared to a correct model remains limited. As however, flaws occur typically at the boundary of patches, this error is localized and restricted to the smallest octree cells [2].

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