THE SHIFTED BOUNDARY METHOD AND THE SHIFTED FRACTURE METHOD

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Abstract. Embedded/immersed/unfitted boundary methods obviate the need for continual re-meshing in many applications involving rapid prototyping and design. Unfortunately, many finite element embedded boundary methods (cutFEM, Finite Cell Method, etc.) are also difficult to implement due to: (a) the need to perform complex cell cutting operations at boundaries, (b) the necessity of specialized quadrature formulas, and (c) the consequences that these may have on the conditioning/stability of the ensuing algebraic problems.

We present a new, stable, and simple embedded boundary method, named "Shifted Boundary Method" (SBM), which eliminates the need to perform cell cutting[1, 3]. Boundary conditions are imposed on a surrogate discrete boundary, lying on the interior of the true boundary interface. We then construct appropriate field extension operators by way of Taylor expansions, with the purpose of preserving accuracy when imposing the boundary conditions. We demonstrate the SBM in applications involving solid [4] and fracture mechanics [5]; thermomechanics; and CFD [2].

In the specific case of fracture mechanics, the SBM takes the name of Shifted Fracture Method (SFM), which can be thought of a method with the data structure of classical cohesive fracture FEM but with the accuracy and mesh-independence properties of XFEM. We show how the SFM has superior accuracy in capturing the energy released during the fracture process and how the method can be combined with phase-field approaches to simulate crack branching and merging.

References

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