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The Discontinuity-Enriched Finite Element Method (DE-FEM) for Simulating 3-D Fracture Problems

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The Discontinuity-Enriched Finite Element Method (DE-FEM) has been recently proposed to solve problems with both weak and strong discontinuities using a unified formulation [1]. In comparison with the eXtended/Generalized Finite Element Method (X/GFEM), DE-FEM places enriched degrees of freedom (DOFs) at nodes created only along discontinuities, which not only simplifies the computer implementation, but also the imposition of Dirichlet boundary conditions. Here, we extend this new approach to simulate 3-D finite element models.

To tackle complicated 3-D problems, a geometric engine is implemented to handle all possible cases of tetrahedral elements split by discontinuities. This geometric engine not only marks volumetric elements crossed by discontinuities and creates enriched nodes at the intersections, but also generates new integration elements and stores relationships between original (parent) and new (children) elements into a hierarchical tree data structure. It also has the capability of handling multiple cracks (interfaces) with diffenent front shapes. In order to evaluate enrichment functions, a hierarchical algorithm that uses the aforementioned tree data structure is proposed. As a result, an arbitrary number of discontinuities within a single element can be handled.

Several numerical examples are introduced to demonstrate the performance of DE-FEM in handling 3-D problems with strong discontinuities. We show through a discontinuous patch test DE-FEM's ability to recover two independent kinematic fields across a crack. We also demonstrate that DE-FEM has good performances in convergence studies and extracting stress intensity factors.

REFERENCES

[1] A. Aragón and A. Simone, The Discontinuity-Enriched Finite Element Method. *Int. J. Numer. Meth Eng.*, Vol. **112**, pp. 1589-1613, 2017.