A diffuse modeling approach for embedded interfaces

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ABSTRACT

In the numerical analysis of heterogeneous materials, weak discontinuities arise in the field variables due to rapidly changing mechanical properties at material interfaces.

Details about the local topology of heterogeneous microstructures are typically taken from imaging methods or are given in terms of random distributions. To avoid costly meshing processes, the embedded domain method can be employed, where the physical domain is embedded into a regular background mesh, that is used for computation. In [1], the material interface is taken implicitly into account during numerical integration, using the B-spline version of the finite cell method. This approach leads to good convergence rates, but did not prevent the stress and strain oscillations that occur because weak discontinuities are modeled in terms of a continuous basis.

For that reason, we propose to regularize the material interface over a finite width ℓ, similar to phase field models. In the resulting diffuse interface region, the material properties are not defined. Instead of a simple interpolation, a homogenization is applied, that fulfills the kinematic compatibility across the interface and the static equilibrium at the interface.

The presented approach leads to optimal convergence rates outside of the diffuse interface for one-dimensional problems. This property is lost in higher dimensions, though. However, the application of an $h\ell$-adaptive refinement strategy, where the interface width ℓ and the element size h are reduced simultaneously, allows for an improved convergence to the sharp interface solution and a good resolution of the local stress and strain fields. For this purpose, an adaptive refinement strategy for truncated hierarchical THB-splines is applied [2].

The properties of the presented approach are demonstrated in one and two dimensional heterogeneous benchmarks of linear elasticity. Furthermore, the approach will be combined with the phase field model of brittle fracture to simulate crack propagation in heterogeneous materials.

REFERENCES

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