EXTENDED VIRTUAL ELEMENT METHOD FOR TWO-DIMENSIONAL FRACTURE MODELING IN LINEAR ELASTICITY

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The virtual element method (VEM), first proposed in [1], is a stabilized Galerkin scheme deriving from mimetic finite differences, which allows for very general polygonal meshes, and does not require the explicit knowledge of the shape functions within the problem domain. In the VEM, the discrete counterpart of the continuum formulation of the problem is defined by means of a suitable projection of the virtual shape functions onto a polynomial space, which allows the decomposition of the bilinear form into a consistent part, reproducing the polynomial space, and a correction term ensuring stability. In [3], drawing inspiration from the extended finite element method (X-FEM) [2], we proposed an extended virtual element method (X-VEM) for the Laplace problem with singular or discontinuous solutions.

In the present contribution, we expand on our previous work and devise an X-VEM for two-dimensional elastic fracture problems, in which we extend the standard virtual element space with the product of vector-valued virtual nodal shape functions and suitable enrichment fields, which reproduce the singularities of the exact solution [4]. We define an extended projection operator that maps functions in the extended virtual element space onto a set spanned by the space of linear polynomials augmented with the enrichment fields. In particular, for the crack tip singularity, we adopt, as enrichment fields, scaled mode I and mode II crack opening asymptotic displacements fields. Once the element projection matrix has been computed, consistency matrix is obtained as in standard VEM, while the stabilization part must be suitably constructed. We present several numerical examples in 2D elastic fracture to assess convergence and accuracy of the proposed method for both quadrilateral and general polygonal meshes.

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