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A quasi-algebraic multigrid approach based on Schur complements for linear systems associated with XFEM

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An algebraic multigrid method is proposed that is suitable for the linear systems associated with modeling fracture via extended finite element method (XFEM). The new method follows naturally from an energy minimizing algebraic multigrid framework and is suitable to be used as a preconditioner to accelerate Krylov subspace based iterative methods. The key idea is the modification of the prolongator sparsity pattern to prevent interpolation across cracks. The proposed method is quasi-algebraic since the geometric levelset information relating to cracks are used to modify the prolongator sparsity pattern. This levelset information is readily available from the XFEM discretization process. It is shown that algebraic multigrid using these modified transfer operators is highly efficient when applied to the Schur complement of the XFEM stiffness matrix in which the enriched degrees of freedom are condensed out. In the proposed method, suitable modifications are made to avoid the explicit computation of the Schur complement. Numerical experiments illustrate that the resulting method is scalable since the convergence properties are relatively insensitive to the mesh density and to the number of cracks or their location.