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A stabilization technique for the regularization of nearly singular extended finite elements

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ABSTRACT

When the eXtended Finite Element Method is applied to two dimensional or three dimensional fracture problems with arbitrary crack geometries and unstructured meshes it often occurs that the global stiffness matrix is nearly singular. This in general is due to the fact that if a crack barely intersects an element and a standard jump enrichment scheme with or without shift is used there exists an almost linear dependence between some of the jump enriched degrees of freedom and the non-enriched degrees of freedom. There exist quite a few techniques to improve this situation by changing level sets or moving nodes and possibly changing the enrichment pattern [1]. However, most of these techniques lead to an at least slight change of the crack geometry which is undesirable. In [2] a global stabilization technique for the GFEM is presented for one dimensional problems that promises to overcome such problems as well. For standard finite elements stabilization techniques on the element level are known for a long time already. Most of them are based on the works of Flanagan and Belytschko [3].

In this contribution we present a stabilization technique based on an eigenvalue analysis of the element stiffness matrix. The element stiffness matrix as well as the corresponding right hand side is modified for all eigenmodes with small or even zero eigenvalues while all physically or numerically reasonable zero eigenmodes remain untouched. This technique has the advantage that the crack geometry is not modified. Examples are given for two and three dimensional fracture problems as well as for heterogeneities simulated using the modified absolute value enrichment where similar difficulties occur. Especially for large three dimensional problems where iterative equation solvers become necessary it is shown that this stabilization technique improves the robustness as well as the efficiency significantly while retaining the desired accuracy.

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