EMBEDDED TECHNIQUES FOR FINITE ELEMENT HEAT FLOW SPACE WITH A EMBEDDED DISCONTINUITIES (INTERFACE)

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ABSTRACT

This work explores the solution of heat conduction problem with embedded gap. The introduction of such gap implies that the physical solution contains a discontinuity, potentially in both the primary variable (the temperature) and in its gradients. Such feature makes difficult to approximate the solution with a standard, continuous, finite element approach, unless the mesh is body-fitted to the gap geometry. Perhaps eXtended Finite Element Method (X-FEM) [1-8] is a well known method with the ability to treatment of this difficulty by adding degrees of freedom with special (enrichment) functions to the *cut element* nodes. In X-FEM the numerical model consists of two types of elements at region near the discontinuity: fully enriched elements (the elements which are cut by the gap) and partially enriched elements or blending elements (the elements which are not cut but have one or more enriched nodes).

Here we introduce two distinct methods with the objective of capturing discontinuities within the element but without the blending elements issue. The first one consists in a *purely local* enrichment of the Finite Element (FE) space. The key difference of this method with respect to standard X-FEM is that we add two special functions whose amplitude is governed by two internal degrees of freedom, which do not depend on any of the neighboring elements. One of the features of this method is that since the new degrees of freedom are purely local, we can also define the additional Lagrangian Multipliers (to impose Dirichlet constraint at the discontinuity) *locally* to the enriched element and the system formed by the enrichment variables and the Lagrange Multipliers can be statically condensed at once prior to assembly. Therefore the graph of the final system to be solved is not change.

The second method with the ability to capture discontinuities within the element not by enrichment functions but by local modification in nodal shape function of the elements also has been explored. These modifications are local and can be computed element–by–element. So finally, it can be concluded, the proposed methods have the capability to be a suitable alternative to other existing finite element spaces with embedded discontinuities.

REFRENCES

1.
Sven, G. and R. Arnold, *An extended pressure finite element space for two-phase incompressible flows with surface tension*. 2007, Academic Press Professional, Inc. p. 40-58.

2.
Sawada, T. and A. Tezuka, *LLM and X-FEM based interface modeling of fluid thin structure interactions on a non-interface-fitted mesh.* Computational Mechanics, 2011. **48**(3): p. 319-332.

3.
Motasoares, C.A., et al., *An enriched space-time finite element method for fluid-structure interaction - Part I: Prescribed structural displacement*, in *III European Conference on Computational Mechanics*. 2006, Springer Netherlands. p. 399-399.

4.
Henning, S. and F. Thomas-Peter, *The extended finite element method for two-phase and free-surface flows: A systematic study*. 2011, Academic Press Professional, Inc. p. 3369-3390.

5.
Fries, T.-P. and T. Belytschko, *The extended/generalized finite element method: An overview of the method and its applications.* International Journal for Numerical Methods in Engineering, 2010. **84**(3): p. 253-304.

6.
Coppola-Owen, A.H. and R. Codina, *Improving Eulerian two-phase flow finite element approximation with discontinuous gradient pressure shape functions.* International Journal of Numerical Methods in Fluids, 2005. **49**(12): p. 1287-1304.

7.
Chessa, J. and T. Belytschko, *An Extended Finite Element Method for Two-Phase Fluid.* journal of Applied Mechanics, 2003. **70**: p. 10-17.

8.
Belytschko, T., et al., *Arbitrary discontinuities in finite elements.* International Journal for Numerical Methods in Engineering, 2001. **50**: p. 993–1013.