Generalized shape optimization with X-FEM and Level Set description applied to stress constrained structures

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ABSTRACT

Recently the extended finite element method (X-FEM) has been proposed (see [1]) as an alternative to remeshing methods. The X-FEM method is naturally associated with the Level Set description of the geometry to provide an efficient treatment of problems involving discontinuities and propagations. Up to now the X-FEM method has been mostly developed for crack propagation problems, but the potential interest of the X-FEM method and the level set description for other problems like topology optimization was identified early (see [2]). In this paper, the authors present an intermediate approach between parametric shape and topology optimization by using the X-FEM and Level Set Description. The method takes benefit of the fixed mesh work using X-FEM and of the smooth curves representation of the Level Set description. One major characteristic of the approach is to be able to model exactly void and solid structures.

The statement of the optimization problem is similar to classical shape optimization: Design variables are the parameters of basic level set features (circles, rectangles, etc.) or NURBS control points, while various global (compliance) and local responses can be considered in the formulation. Conversely to shape optimization, structural topology can be modified since basic Level Sets can merge or separate from each other. A central issue is the sensitivity analysis and the way it can be carried out efficiently. The paper also treats carefully the problem of the numerical integration of FE stiffness matrices, accuracy of X-FEM results. A special attention is paid to stress constrained problems.

Numerical applications revisit some classical 2D benchmarks from shape and topology optimization and illustrate the great interest of using X-FEM and level set description.

References

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