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3D SHAPE OPTIMIZATION WITH X-FEM AND LEVEL SET DESCRIPTION

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ABSTRACT

Structural shape optimization, which had received attention since the beginning of the eighties, aims at finding the shapes of internal and external boundaries of a device. The method has well succeeded in improving the design of structures against various criteria such as restricted displacements, stress criteria, eigenfrequencies, etc. However, this technique has been quite unsuccessful in industrial applications because the major difficulty of shape optimization approach is related to the mesh management problems coming from the large shape modifications. The main technical problems stems from the sensitivity analysis. Derivatives have to be regarded as material derivatives and the sensitivity analysis requires the calculation of the so-called velocity field related to mesh modifications. If 2-D problems are quite well mastered, 3-D and shell problems are still difficult to handle in the most general way. It turns out that shape optimization remains generally quite fragile and delicate to use in industrial context. To circumvent the technical difficulties of the moving mesh problems, a couple of methods have been proposed such as fictitious domain approach, fixed grid finite elements and the projection methods.

The present work relies on the application of the extended finite element method (X-FEM), which has been proposed as an alternative to remeshing methods by Moës *et al* [1], to a classical shape optimization framework. The X-FEM method is naturally associated with the Level Set description of the geometry to provide an efficient treatment of problems involving moving boundaries or discontinuities. Hence, the method takes benefit of the fixed mesh work using X-FEM, of the smooth curves representation of the Level Set description and is able to model exactly void and solid structures conversely to topological optimization.

This works differs from the approach proposed by Belytschko *et al* [2] and Wang *et al* [3] as the design variables of the optimization problem are the parameters of basic level set features [4] (circles, rectangles, etc.) or NURBS control points, while various global

(compliance, eigenfrequencies) and local responses (stress [5]) can be considered in the formulation.

Numerical applications illustrate the interests and the drawbacks of using X-FEM and level set description on several 2D/3D applications considering compliance, stress, eigenfrequencies as objective and constraints functions. Treatment of constant and configuration dependent loads is also considered.

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