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Level set analysis of topological optimization in 2D structures using Boundary Element Method

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ABSTRACT

Key words: Topological optimization. Level set method. Boundary element method.

The present study applies an evolutionary approach to determine the optimal geometry of 2D structures by coupling the Boundary Element Method (BEM) and Level Set Method (LSM). Topological optimization is a scientific domain that aims to design structural components with appropriate security levels using the minimum amount of material. Therefore, this type of optimization aims to achieve the optimal structural geometry, i.e. the shape that leads to the minimum requirement of material respecting constraints related to stress state at any point of the structure.

As this problem involves moving boundaries conditions, BEM becomes well adapted to solve him due to the non-requirement of domain mesh. Moreover, the velocity of moving boundaries is determined by Von Mises stress. Thus, as BEM is efficient to evaluate internal stresses and displacements, BEM is recommended to model this complex and important engineering problem.

The proposed algorithm consists of three parts: mechanical model, topological optimization and structure reconstruction. The mechanical model is composed by BEM algebraic equations. Singular and hyper-singular representations are available in the computational code. The topological optimization is performed using LSM. The body's geometry is determined by the Level Set (LS) function evaluated at its zero level, as presented by [1]. The reconstruction process concerns the remeshing procedure. As the boundary moves at each iteration, the body's geometry change and a new mesh has to be constructed.

During the optimization process the proposed algorithm introduces automatically internal cavities. It is introduced according to the intensity of Von Mises stress at the cavity centre. The zero level set contours describe internal and external geometries which are discretized by linear boundary elements. It is important to mention that the proposed coupling procedure allows the determination of optimal structural geometry without filters application.

The proposed numerical model was applied to several benchmarks available in literature. According to the obtained results, good agreement was observed among them demonstrating the efficiency of the proposed model. Therefore, it was possible to advance in the field of applications of BEM and to develop innovative solutions to complex engineering problems.

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