Isogeometric Optimal Design: A New Paradigm for Shape and Topology Optimization

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ABSTRACT

This paper presents a unified analysis and design method called "Isogeometric Optimal Design" through the seamless integration of CAD, CAE, and design optimization. In nonlinear topology optimization, the density method [1] and the level set method [2] encounter convergence difficulty in response analysis due to severe mesh distortion induced by sparse material distribution driven by the methods. Also, finite element based shape optimization requires complicated design parameterization. In the isogeometric approach, however, geometric properties are embedded into NURBS basis and control points whose perturbation provides continuous shape changes. Thus, exact geometry can be used in both response [3] and sensitivity analyses, where normal vector and curvature are continuous over the whole design space so that enhanced shape design sensitivity and consequently precise optimal design can be obtained [4]. Since homogeneous material and actual boundary are utilized, the convergence difficulty can be effectively prevented. For the convenient applications of the isogeometric approach to topological design, a configuration design sensitivity analysis (DSA) method is developed using the boundary integral equations. The shape variation of a domain naturally results in both shape and orientation variations so called configuration variation in a boundary integral equation method. To enhance the accuracy of configuration sensitivity, the CAD-based higher-order geometric information such as curvature as well as normal and tangent vectors is exactly embedded in the design sensitivity expressions. It is demonstrated that the consideration of orientation variations is essential and significant for the accuracy of configuration design sensitivity through the comparison with finite difference one using the conventional BEM. The developed isogeometric configuration DSA method turns out to be accurate compared with the analytic solution and the conventional DSA method.

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