Shape Optimisation for Three Dimensional Linear Elasticity Using an Isogeometric Boundary Element Method with T-splines

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ABSTRACT

Isogeometric analysis (IGA) was first proposed by Hughes et al. [1] to merge the fields of analysis and computational geometry. The concept relies on the use of basis functions defined by Computer Aided Design (CAD) to define not only the geometry of the problem, but also to approximate the unknown fields during analysis. The use of such a strategy is compelling, since the task of mesh generation is greatly minimised (or completely circumvented) and the exact geometry is used at all stages of analysis. Much of the recent literature has focused on the use of Non-Uniform Rational B-Splines (NURBS) [5] which are ubiquitous throughout the CAD community, but they exhibit limitations such as the inability to produce water-tight geometries and global refinement algorithms that are not amenable for analysis. The present work makes use of T-splines [6] which produce water-tight geometries and, perhaps more importantly, the ability to locally refine the discretisation.

The boundary element method (BEM) has been shown to be a particularly suitable choice for IGA since all quantities defined by CAD pertain to the boundary of the problem, which is all that is required for BEM analysis. The method has been applied using NURBS for 2D linear elasticity [7] and for shape optimisation in 3D [2]. More recently, a BEM T-spline discretisation strategy has been applied [4]. The present paper builds on this work by applying BEM for shape optimisation using T-splines thus allowing extremely complex geometries to be analysed directly from CAD. We outline the BEM shape optimisation formulation and the use of T-splines as a basis for analysis. The optimisation solver used is gradient based, and sensitivity analysis is conducted using implicit differentiation and a regularised form of the boundary integral equation [3]. Through a collocation procedure, we show that accurate results can be obtained by testing against problems with closed-form solutions.

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