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A multi-resolution approach for multi-material topology optimization based on isogeometric analysis

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Abstract

A novel multi-resolution scheme to perform the multi-material topology optimization in the framework of isogeometric analysis (IGA) is proposed. To create high resolution optimized designs with a lower computational cost, a new variable parameter space is supplemented to define design density variables and represent the optimal material distribution utilizing the bivariate B-spline basis functions. These functions are simply obtained by $k-$refinement strategy in the IGA. The non-uniform rational B-spline (NURBS) basis functions are employed to exactly describe geometric domains and approximate unknown solutions in finite element analysis (FEA) as well. An alternating active-phase algorithm associated with the block Gauss-Seidel method is employed to convert a multiphase topology optimization problem under multiple volume fraction constraints into many binary phase topology optimization sub-problems with only one volume fraction constraint. Accordingly, the number of design variables depends only on one active phase in each of those sub-problems regardless of the number of material phases and is significantly decreased in comparison with the original problem. The Optimality Criteria (OC) method is used as an optimizer to update solutions for such sub-problems. The effectiveness and robustness of the proposed method are verified via testing various benchmark examples.

Keywords: Isogeometric analysis (IGA); B-splines/NURBS; $k-$refinement; Multi-resolution topology optimization (MTOP); Multi-material; Alternating active-phase algorithm.

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