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COMPUTATIONAL OPTIMIZATION TOOLS FOR MATERIAL DESIGN OF ELASTIC PROBLEMS USING INVERSE HOMOGENIZATION

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Abstract: The objective of this work is to present new computational optimization tools which can be applied to obtain solutions of inverse homogenization problems related to elastic material design satisfying structural requirements. The specific problem that is studied in this work consists of determining the material micro-architecture, such that the elastic effective properties of this heterogeneous material copy those of a target elasticity tensor. The spatial distribution of the hard material phase within a given unit cell that satisfies the sought requirement is found through a rather conventional topology optimization problem [1]. In particular, we use a methodology that is based on a topology optimization algorithm using topological derivative and the level set function [2]. And the specific tools that we have developed in this computational context exploit two aspects of this problem: i) the symmetry of the target elastic tensor, and ii) the shape of the unit cell in where the optimum topology is sought [3]. Therefore, we present a comprehensive analysis of the connection between the target tensor physical features, i.e. its symmetry properties, and the material distribution in the microstructure. According to this idea and assuming periodic micro-architectures, we analyze several Bravais lattices and the plane wallpaper groups in order to study the way in which the symmetries of these patterns are reflected in the homogenized elasticity tensor. We analyze the Wigner-Seitz cells, i.e. the primitive cells, of the subjacent Bravais lattices that preserve all the symmetries and the corresponding implementation of the plane wallpaper groups. Finally, using the connection between physical properties and micro-structural patters, we propose a procedure for the inverse problem that selects the most convenient external boundary shape of the unit cell in where the topology optimization problem is solved, as well as the necessary geometrical symmetries to be imposed to the material distribution within the unit cell that guarantee the symmetry of the homogenized elastic tensor of the designed micro-architecture material. In the search of new extreme material classes, the proposed tools aim to facilitate the inverse design by obtaining simple micro-architecture solutions. [1] Bendsoe, M. P.,