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Homogenization-based topology optimization for high-resolution manufacturable micro-structures, and optimal frame and truss design

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The objective of this work is to present a projection method to obtain high-resolution manufacturable structures from efficient and coarse-scale, homogenization-based topology optimization results [1]. The focus of this work is on compliance minimization of linear-elasticity problems, for which it is known that the optimal solution is in the space of layered materials, the so-called rank-n laminates [2]. Here rank-2 laminates are optimal for plane problems subject to a single load case, and rank-3 laminates are optimal for plane problems subject to multiple load cases.

In a very appealing approach Pantz and Trabelsi introduced a method to project the microstructures from homogenization-based topology optimization to obtain a solid-void design with finite length-scale [3]. The local structure is oriented along the directions of lamination such that a well-connected design is achieved. This work shall be seen as a simplification and improvement of the approach introduced by Pantz and Trabelsi [3]. We simplify the projection approach and introduce procedures for controlling the size and shape of the projected design, such that high-resolution (e.g. 1 million elements in 2D), near-optimal and manufacturable lattice designs can be achieved within a few minutes in a single processor Matlab code on a standard PC.

Furthermore, a novel method is presented to obtain a near-optimal frame structure. In an extension of the previous approach, we can obtain a frame structures based on a homogenization-based topology optimization model that is equivalent to Michell's problem of least-weight trusses. We introduce a simple frame optimization approach to optimize the extracted structures in a few minutes, such that the final designs perform close to analytical optima.

Keywords: Topology Optimization, Homogenization, Compliance Minimization, Michell Theory.

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