Multi-scale topological optimization of 3D printable structures using computational vademecums

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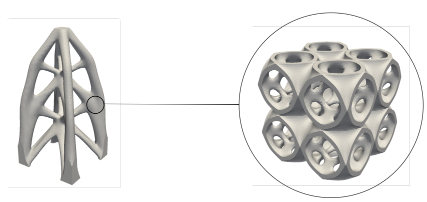
ABSTRACT

Regarding the increasing needs for predictable computer simulations from the industry, the development of numerical methods in structure design has become a key issue in the past decades. Among them, topology optimization has proved its efficiency for the design of complex structures with specific mechanical properties requirement. The latest advances in 3D printing processes make it possible nowadays to manufacture sophisticated structures and micro-architectured materials.

The multi-scale optimization framework of this work is based on the scale separation assumption. The two scales considered are the structure scale (refered to as the macro scale) under given boundary conditions and external loads, and the material scale within the structure (refered to as the micro scale). In this context, computational homogenization [1] provides a suitable framework to go through the different scales of consideration. However multi-scale topology optimization usually suffers from expensive computational costs due to the increasing number of design variable while combining the scales. In order to significantly decrease the calculation time, we propose a vademecum based approach. In an initial off-line step, a catalog of optimized micro-architectured materials covering a broad range of different mechanical behaviors is computed for the micro scale only. Different objective functions are tested such as the minimization of the micro-scale compliance under given macroscopic strain or the obtention of predefined elasticity tensor [2]. Thanks to the flexibility of most optimization tools, one can find other kind of objective functions at the micro-scale in the litterature such as the maximization of fracture resistance [3] . At the on-line step, that is the multi-scale step, the required optimal mechanical behavior is computed using homogenization techniques at each integration point of the macro structure. Then the corresponding micro-architectured materials are extracted from the catalog [4].

This method is tested for different kind of objective functions such as the minimization of the overall compliance of the structure or the design of predefined deformed shape under load. For the second kind of objective function, the small strain assumption is no longer valid and a hyper-elastic model is used.



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