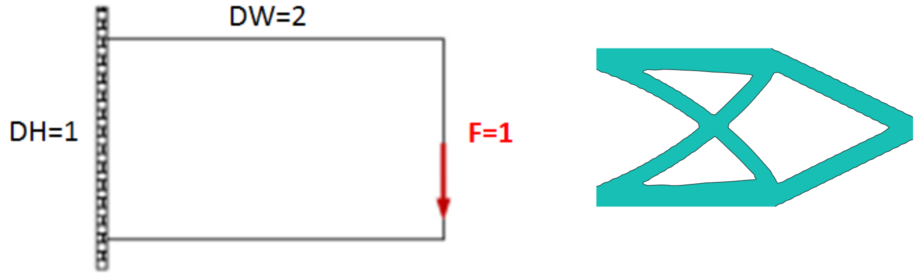
Improvements of component based topology optimization for 3D printing

Keywords: Computational Mechanics, Finite Elements, continuous optimization, 3D printing.



(a) (b)

Figure 1: Example of MMC. topology optimization of a cantilever beam Guo *et al.* [5] (a): problem definition for the short cantilever beam problem. (b): Optimal solution .

Context

Since the pioneering work of Bendsoe and Kikuchi [3], topology optimization which aims at finding appropriate material distribution in a prescribed domain in order to get optimized structural performances, has received considerable research attention. In the literature, numerous topology optimization approaches such as SIMP (Solid Isotropic Material with Penalization) approach (Bendsoe [2]; Zhou and Rozvany [11]; Mlejnek [7]), level set approach (Wang et al. [9]; Allaire et al. [1]) and evolutionary approach (Xie and Steven [10]) have been proposed. Most of the existing approaches actually do topology optimization in an implicit way. This means that in these approaches the optimal structural topology is identified either from a black-and-white pixel image (in SIMP approach) or from the level set of a Topology Description Function (TDF) defined in a prescribed design domain (in level set approach). Possible problems associated with the implicit methods can be summarized as follows. Firstly, it is difficult to give a precise control of the structural feature sizes, which is very important from manufacturing point of view, under the implicit topology optimization framework Furthermore, it is also not easy to establish a direct link between the optimization models and computer-aided-design (CAD) modeling system under the implicit framework since structural geometries are represented in totally different ways in these two settings. Secondly, the number of design variables involved in implicit topology optimization approaches is relatively large especially for three dimensional problems. The higher the resolution, the more design variables. Thirdly, in implicit approaches, analysis model and optimization model are always strongly coupled. Sometime this may lead to severe numerical problems (e.g., checkerboard pattern, spurious local vibration/buckling modes) which may prevent the optimization algorithms from converging to meaningful solutions especially when topology optimization problems in multiphysics settings are considered. With the aim of doing topology optimization in a more explicit and geometrical way, a so-called moving morphable components based topology optimization framework, which is quite different from the existing ones, is established in (Guo et al. [5]). The distinctive feature of this approach is that a set of morphable components are used as building blocks of topology optimization and the optimal structural topologies are found by optimizing the shapes, lengths, thicknesses, orientations and layout (connectivity) of these components. Figure 1 illustrates the basic idea of this approach schematically. Recently, the same idea has also been adopted in (Norato et al. [8]) based on the SIMP framework for topology optimization of continuum structures made of discrete elements or in (Raze and Morlier 2016) based on the MNA (Moving Node Approach). Previous work [4] in 3D printing can be found here:

`https://github.com/mid2SUPAERO/MNA_AdditiveManufacturing`

A comparison will be made with AM filter [6] on several classical testcases.

Tools

After a literature review, you will need to use a research code existing in MATLAB language and develop a few more bricks and methods comparison. The existing framework needs to be optimized to run in 2D and 3D using vectorization. A major challenge consists in develop analytical evaluation of gradients. The projection function can still be improved in order to get a more smooth convergence of the optimization solver and a non-gray solutions.

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