Topology Optimization of Lattices by Adaptative Processes

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ABSTRACT

The fabrication of lattice structures by conventional subtractive processes is a very difficult task. However, the democratization of additive manufacturing procedures such as Electron Beam Melting (EBM) or Selective Laser Sintering (SLS) now allows the creation of rather complex lattice structures. These lattice structures draw attention due to their good mechanical properties combined with their low mass.

The subtractive fabrication methods induced significant constraints on the geometry of mechanical part, whereas additive manufacturing technologies give engineers more freedom. In order to guide the design of mechanical parts (respecting some geometrical and physical requirements), topology optimization methods are employed. Among these methods, the Solid Isotropic Material Penalization (SIMP) is one widely used [1]. Some variants of the SIMP were even developed in order to create lattice structures [3]. In this talk, we propose another approach akin to the one presented in [2] to optimize the topology of lattices that consist in the following two strategies:

1. Adaptation of the design space of the topology problem (the position of the nodes constituting the lattice) by solving a succession of shape optimization problems with increasing number of design parameters (see Figure 1);

2. Adaptation of the physical model describing the mechanical properties of lattice structures.

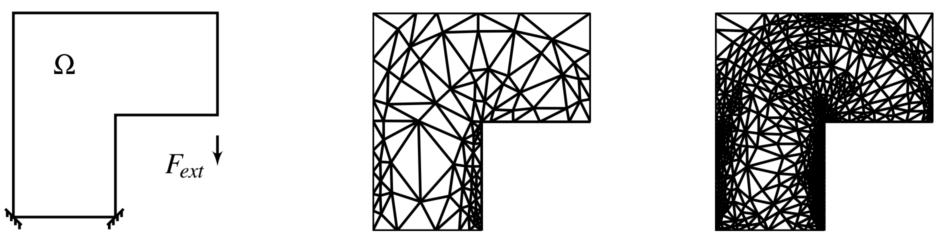

Figure 1: Geometry and its loadings (left), lattices obtained at an early stage (center) and at a later stage (right) of the optimization process (retrieved from [4]).

Our work mainly focuses in the detailed description of the shape optimization problem, especially the objective function (the energy of deformation) and the constraints (both equilibrium and geometrical). To this end, a consistent framework is developed in order to describe the mechanical properties of lattice structures. This framework allows the creation of an hierarchy of physical models of increasing complexity. This same framework also allows the description of the geometry of lattices, geometry that will be optimized through shape optimization problems.

This description of the shape optimization problems thus allows us to analyze in details the proposed procedure. More precisely, we will discuss the existence and uniqueness of the solution of the shape optimization processes. We will finally present some numerical examples that illustrate the performance of the method.

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