Design and Optimization of Conforming Lattice Structures

Jun Wu[1,*], Weiming Wang[1] and Xifeng Gao[2]

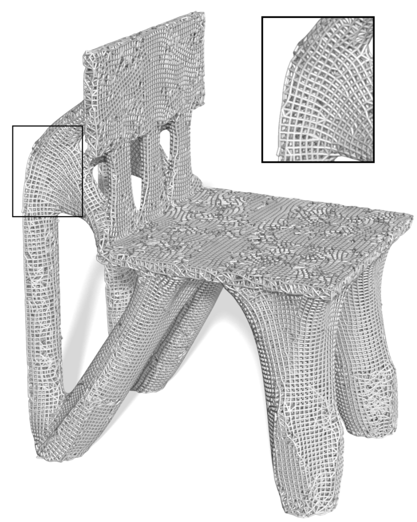
[1] Department of Design Engineering, Delft University of Technology
Landbergstraat 15, 2628 CE Delft, The Netherlands
*E-mail: j.wu-1@tudelft.nl

[2] Department of Computer Science, Florida State University
1017 Academic Way, Tallahassee, FL 32304, USA

ABSTRACT

Lattice structures possess exceptional mechanical, thermal and acoustic properties. The (mechanical) properties of lattices depend not only on the solid material of which struts are made, but also on the topology and shape of struts. Especially since recent advances in additive manufacturing enable a cost-effective fabrication of lattices, there has been a growing interest in exploring the potential of lattices in engineering design.

We present a novel topology optimization method for designing conforming lattice structures in both 2D and 3D. Our method concurrently optimizes shape as well as the orientation and scaling of orthotropic lattices within the shape. Inside the optimized shape, the optimized lattices are aligned with principal stress directions resulting from forces acting on the lattices. The lattices also conform to the boundary of the optimized shape. The figure on the right shows an optimized lattice chair.



Given design specifications including design domain and boundary conditions, our method to generate conforming lattices consists of two major steps. The first is a homogenization-based topology optimization method that concurrently optimize the shape (and its topology), the orientation and the scaling of the to-be-generated lattice structure. Rather than optimizing the thickness of hollowed squares distributed the design domain [1, 3], we fix the thickness of hollowed cells and optimize the per-axis scaling of individual cells. This ensures a uniform thickness of struts while enabling a high degree of anisotropy in the lattice distribution. The second step takes the anisotropic directional field extracted from the orientation and scaling fields from the first step, and generates a lattice-like graph which conforms to both the shape boundary and the tensor field. It extends the fast and robust instant meshing technique [2] from generating isotropic meshes to producing anisotropic graph.

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