Lehrstuhl für Baustatik und Baudynamik | RWTH AACHEN UNIVERSITY

Master thesis

Topology optimization using Voronoi meshes

Background

The development of high-performance materials as well as the progress made in additive manufacturing enable novel and complex geometric designs for structures in civil engineering. Due to these complexities, the generation of proper finite element meshes may be a difficult task. Additionally, minimal material usage without loss of structural integrity is pursued.

To achieve the aforementioned, two concepts can be combined. On the one hand, the difficulties in mesh generation can be overcome by making use of Voronoi tessellations. This highly efficient meshing strategy allows for a polygonization of practically any structure, however, requires special finite element formulations due to the polygonal element geometries. On the other hand, topology optimization is a method used to determine the optimal material distribution of a structure, while maximizing e.g. its stiffness. The numerical instabilities observed in topology optimization (e.g. the occurrence of checkerboard patterns) could be resolved by the use of numerically stable mixed polygonal finite elements.

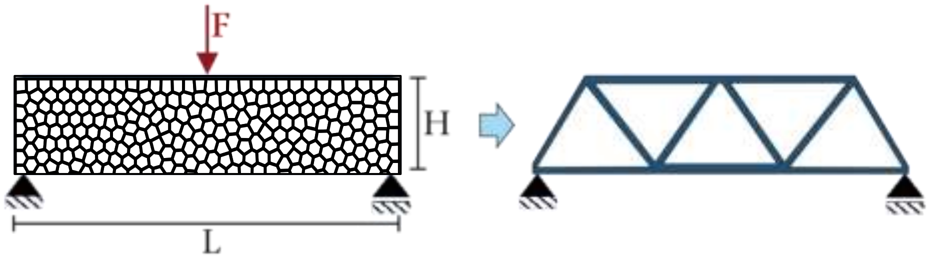

Figure: Topology optimization of a beam with Voronoi discretization subjected to a point load.

Task

The main task of this thesis is the implementation of a topology optimization method in Python and its application to structures that are discretized using Voronoi meshes. The suitability of this kind of meshes for topology optimization purposes should be examined. In this context, numerical instabilities, like checkerboard patterns, mesh dependency and islanding should be examined in detail.

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