Discrete Topology Optimization Based on Truss-Like Continuum

Kemin Zhou [1,2], Hae Chang Gea [1]
[1]Department of Mechanical and Aerospace Engineering, Rutgers,
The State University of New Jersey, Piscataway, NJ 08855, US
[2]College of Civil Engineering, Huaqiao University, Fujian, 361021, China

When the traditional topology optimization methods are applied to obtain a distinct structure, the middle densities were suppressed, which caused the numerical instabilities, such as the checkerboard pattern. In order to avoid this problem, additional image filtering or penalty techniques were used. Michell revealed the character of topology optimization that there was infinite number of members with infinitesimal space in topology optimal structure, which was named truss-like continuum. This trait insinuated us to find the optimal topology from truss-like continuum, which was the more possible to reach the optimal structure easily.

In this paper, the least weight truss with stress constraint was studied based on truss-like continuum material model. It was assumed that there was an infinite number of members distributed continuously in design domain initially. The structure was analyzed by the finite element method. The densities and orientations of members at nodes were taken as design variables: the densities of members were optimized by fully-stressed criteria and the orientations of members were aligned to the orientations of principal stresses. The members with densities below to a given critical value were removed and the critical value was increased at every iteration. The distinct topology was obtained in optimization process directly without further post-process. The distinct structural topology was obtained from the truss-like continua. No middle density was suppressed, therefore no numerical instabilities existed without an additional technique.

The figure 1 showed a numerical example. Four nodes rectangular elements of 64×40 were used. The optimal result after 64 iterations was shown in figure 2. The lines in figure 2 stood for the magnitudes and orientations of material at nodes. The contour of densities was shown in figure 3.

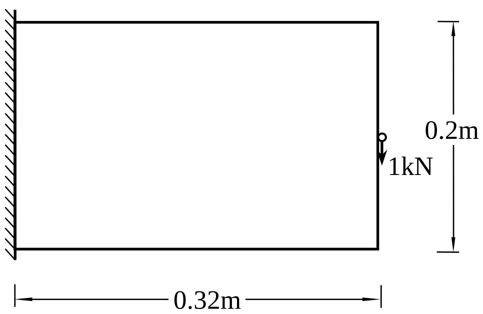

Figure 1 Mechanics model

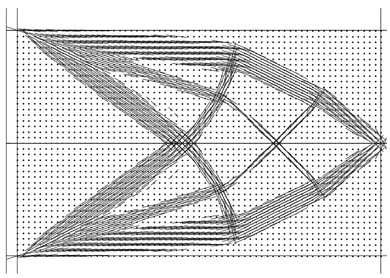

Figure 2 Optimal result

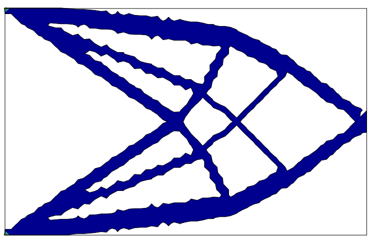

Figure 3 Contour of densities