A Hierarchical Neighbourhood Search Method for Topology Optimization

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In topology optimization of continuum structures, a fixed design domain is given. The infinite dimensional problem then deals with finding an optimal subdomain of the given design domain to fill with material. In practice, the design domain is discretized, so that the objective and constraint functions can be computed via the finite element method. The design of the structure is represented by binary design variables indicating material or void in the various finite elements.

We present a hierarchical neighbourhood search method for solving topology optimization problems defined on discretized linearly elastic continuum structures. Two different designs are called neighbours if they differ in only one single element, in which one of them has material while the other has void. The proposed neighbourhood search method repeatedly jumps to the ``best'' neighbour of the current design until a local optimum has been found, where no further improvement can be made. The ``engine'' of the method is an efficient exploitation of the fact that if only one element is changed (from material to void or from void to material) then the new global stiffness matrix is just a low rank modification of the old one. To further speed up the process, the method is implemented in a hierarchical way. Starting from a coarse finite element mesh, the neighbourhood search is repeatedly applied on finer and finer meshes. Numerical results are presented for minimum weight problems with constraints on respectively the stiffness of the structure, strain energy densities in all non-void elements, and von Mises stresses in all non-void elements.