11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Multiscale Topology Optimization Using Constraint Coordination

Peter D Dunning[1], H Alicia Kim[1]

[1] Department of Mechanical Engineering, University of Bath, UK.

Abstract

Multi-scale topology optimization aims to design a structure at two scales: the macro-scale, where the structure is optimized, and the micro-scale, where the material is optimized. Thus, material properties are tailored to the structural design and vice versa, which leads to lighter, more efficient structures.

Existing methods for simultaneous multi-scale topology optimization can be classified into two broad categories: uniform or non-uniform micro-structure approaches. The uniform approach assumes the material is a periodic micro-structure constant throughout the macro-structure. The non-uniform approach allows the micro-structure to vary within the macro-structure.

The solution method often used for the uniform approach is to consider both micro and macro-scale design variables in a single optimization problem. Chain rule derivatives are used to form a direct link between the macro-structure performance and micro-structure design variables. For the non-uniform approach this method can be computationally prohibitive, due to the large number of design variables. Therefore, a decomposed approach where appropriate sub-problems are devised for the micro-structure is often favored since the sub-problems can be solved in parallel. However, this approach requires appropriate sub-problems to be devised thus it cannot be directly applied to solve general problems.

A new multi-scale topology optimization method is introduced that can solve general problems and take advantage of decomposition. We show the key challenge is the appropriate setting of constraint boundaries in the decomposed sub-problems. A constraint coordination strategy is introduced to overcome this challenge. The method can be summarized as: 1) solve each sub-problem with initial constraint boundaries, 2) perturb constraint boundaries and re-solve to estimate derivatives of the optimal objective value with respect to the constraint boundaries, 3) solve auxiliary optimization problems to obtain modified constraint boundaries, 4) check for convergence, otherwise return to step (1).

The new method is demonstrated for uniform and non-uniform micro-structures using various structural optimization problems.