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

A hole insertion method for sequential linear programming level-set topology optimisation

Christopher J. Brampton[1], Peter D Dunning[1], and H. Alicia Kim[1]

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

Abstract

Conventional level-set optimization uses an implicit signed distance function to define the structural boundary, updated by solving a Hamilton-Jacobi type PDE. Recently, the Sequential Linear Programming (SLP) level-set method was introduced to solve general constrained optimization problems [1]. This method formulates an optimisation sub-problem to attain the boundary update velocity function, solved using SLP. The SLP level-set method can handle multiple constraints and simultaneously optimise non-level-set design variables. The conventional level-set method can change topology by merging holes, but new holes are not naturally created. Therefore level-set topology optimisation often starts with a set of initial holes, however final solutions can be dependent on initial hole configurations. To address this issue for the SLP level-set method we introduce a hole insertion method.

The hole insertion method uses a secondary level-set function to determine when and where to create holes in the structure while the primary level-set function represents the structural boundary. The secondary level-set function is initialised at a uniform positive value across the internal structure. Holes are inserted at locations where the optimisation update velocity makes the secondary level-set function negative. Sensitivity analysis evaluates the effect of a change in the secondary level-set function on the objective and constraints. The update velocity is formulated as a linear combination of these topological sensitivity fields. The weights for the linear combination are added to the SLP sub-problem and solved simultaneously with the boundary update velocity. To avoid hole insertion interfering with the boundary update, holes can only be inserted away from the boundary. The updated primary and secondary level-set functions are then combined adding new hole boundaries to the structural boundary. The method will be demonstrated on a range of structural optimisation problems.

[1] P.D. Dunning, H.A. Kim, Introducing the sequential linear programming level-set method for topology optimization, Structural and Multidisciplinary Optimization, DOI 10.1007/s00158-014-1174-z, 2014.