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

A Novel Anti-optimization Method for Structural Robust Design under Uncertain Loads

Zhifang Fu [1], Chunjie Wang[1,2], Junpeng Zhao[1]

[1]School of Mechanical Engineering and Automation, Beihang University, Beijing 100191, China; zhifang_fu@buaa.edu.cn
[2]State Key Laboratory of Virtual Reality Technology and Systems, Beihang University, Beijing 100191, China;

Abstract

The loads are uncertain in most practical situations, and the designer must take the effects of the uncertainty into consideration. Robust design aims to find a configuration set in which the structural performance is least sensitive to uncertain parameters. The theory of convex models is a popular approach to robust design, which was investigated in detail by Ben-Haim and Elishako [6]and Elishako et al. [7]. and it is implemented on the constraints by the use of an anti-optimization process. The approach is actually a two-level optimization problem, at the outer level, it obtains the best design by optimizing the design variables, while at the inner level it seeks the worst condition for a given design from anti-optimization.

After the anti-optimization method is proposed, many researchers have applied it to the theory and practice. Marco Lombardi et al.[8] described a technique for design under uncertainty based on the worst-case-scenario technique of anti-optimization.Marco Lombardi [9] compared two different approaches which use anti-optimization, namely a nested optimization and a two steps optimization.

In this paper, a new anti-optimization technique is used to alleviate the computational burden with the help of the axial stress forces in members of the truss under each load respectively. The axial forces are the main information in the anti-optimization process which can be easily found by finite element analysis, and the sign of the forces decide the value of the loads in the corresponding constraints. The optimum of the structure is achieved by minimizing the value of the objective function subject to the worst-case constraints under uncertainty loads while the robustness is ensured by the anti-optimization process conducting the worst-case-scenario. The robust design of a 10-bar and a 25-bar truss under uncertain loads are carried out to demonstrate the effectiveness of the present method.

References

[6] Ben-Haim Y, Elishakoff I. Convex models of uncertainty in applied mechanics[M]. Elsevier, 2013.
[7] Elishakoff I, Haftka R T, Fang J. Structural design under bounded uncertainty—optimization with anti-optimization. Computers & structures, 53(6): 1401-1405, 1994.
[8] Lombardi M, Haftka R T. Anti-optimization technique for structural design under load uncertainties. Computer methods in applied mechanics and engineering, 157(1): 19-31, 1998.
[9] Lombardi M. Optimization of uncertain structures using non-probabilistic models. Computers & structures, 67(1): 99-103, 1998.