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Robust Topology Optimization under Multiple Independent Unknown-but-Bounded Loads

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Abstract

The optimal designs obtained from the deterministic topology optimization without considering the loading uncertainties may become vulnerable, or even lead to catastrophic failures. A two-level optimization formulation is often used in the Robust Topology Optimization (RTO) under uncertain loads. Various approaches have been reported to identify the critical loads associated with the worst structure responses. Because Convex Model approaches apply convex approximations to the original non-convex model at the lower level, the optimal designs obtained by these methods are greatly dependent on the quality of the approximation. In this paper, a new formulation based on the Wolfe duality for the RTO problems with multiple independent unknown-but-bounded loads is proposed. Following the two-level formulation, the lower level optimization problem for the worst multiple independent uncertain loading case is transformed by the Wolfe duality. Both the first order necessary conditions and the second order sufficient conditions are derived rigorously to validate the solution optimality despite of the non-convexity associated with the lower level formulation. Numerical examples are also presented to demonstrate the proposed approach.

Keywords*: Robust Design, Design Uncertainty, Topology Optimization, Structural Optimization, Worst Case Design, Unknown-but-bounded Loadings*

1. Introduction

Deterministic information about applied loadings, material stiffness and design boundary, commonly considered in topology optimization problems [1-3], may not be the best way to characterize the practical properties in many engineering applications. The optimal designs without taking account of the uncertainty of these factors may become vulnerable, or even