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Maximum Eigenfrequency-Based Topology Optimization Design Considering Non-Stochastic Uncertainty Problem

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Abstract

This study shows how uncertainties of data like material properties quantitatively have an influence on structural topology optimization results for dynamic problems, here such as both optimal topology and shape. In general, the data uncertainties may result in uncertainties of structural behaviors like deflection or stress in structural analyses. Therefore optimization solutions naturally depend on the uncertainties in structural behaviors, since structural behaviors estimated by the structural analysis method like FEM need to execute optimization procedures. In order to quantitatively estimate the effect of data uncertainties on topology optimization solutions of dynamic problems, a so-called interval analysis is utilized in this study, and it is a well-known non-stochastic approach for uncertainty estimate. Topology optimization is realized by using a typical SIMP method, and for dynamic problems the optimization seeks to maximize the first-order eigenfrequency subject to a given material limit like a volume. Numerical applications topologically optimizing dynamic wall structures with varied supports are studied to verify the non-stochastic interval analysis is also suitable to estimate topology optimization results with dynamic problems.

Keywords: Topology Optimization Design, Uncertainty, Dynamic Problem, Eigenfrequency

1. Introduction

In the recent years, there has been an increased interest in the simulation of structural systems with uncertainties. The interest in uncertain structural systems stems from the fact that uncertainties remain in most models of real world problems. Uncertainties arise either due to our lack of knowledge, or due to intrinsic variabilities of physical quantities. Data like domain geometry, material properties, or loads, are usually not known perfectly. Due to the uncertainties in the model, it is uncertain to what degree the prognoses of numerical simulations match reality and this fact is often ignored in traditional engineering practice. Clearly, it is desirable to quantify the uncertainties in the answer, and different approaches have been proposed for this as follows.

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