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Topology Optimization of Continuum Structures Subjected to Filtered White Noise Stochastic Excitations

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Abstract

This work addresses the challenge of topology optimization for continuum structures subjected to non-white noise stochastic dynamics. The objective is to manipulate the variance of the stochastic response of a linear continuum structure through design. The excitation is modeled as filtered white noise and the solution and sensitivities are obtained using the augmented state space formulation in the frequency domain. To reduce the computational cost and maintain high accuracy, closed-form solutions are utilized for evaluating the response variance and modal truncation is adopted to reduce dimension (the effect of which is investigated). The Solid Isotropic Material with Penalization Method is used together with the Heaviside Projection Method to achieve a clear distinction between solid and void regions in the structure, and the gradient-based optimizer Method of Moving Asymptotes informed by sensitivities of the real and complex eigenvectors is used to evolve the design. The algorithm is demonstrated on design problems of minimizing the variance of stochastic response under a volume constraint and several numerical examples are provided to show the effectiveness of the method. Solutions are compared to conventional maximum stiffness solutions and, as to be expected, show markedly improved response under the considered stochastic dynamic excitation.

Keywords: Robust topology optimization, design under uncertainty, random vibrations, stochastic excitation, filtered white noise, stochastic dynamics