

Robust Design Optimization Under Uncertain Structural Parameters by Stochastic Simulation-Based Approach

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Key Words: *Robust design optimization, optimization under uncertainty, parameter uncertainty, genetic algorithm, mean–variance.*

The inherent uncertainty in the structural parameters directly affects the structural performance, and its variation may lead to improper designs and catastrophic consequences. When subjected to uncertainty, the structure design must be optimized to get an insensitive design using a Robust Design Optimization (RDO) technique. Such design aims to find a system design in which the structural performance is less sensitive (insensitive) to the uncertainty of the inherent structural parameter without eliminating them [1]. This is usually achieved by simultaneously minimizing the mean and variance of the structural performance function. Various RDO approaches, such as those based on Taylor series expansion [2] simulation-based methods [3], dimension reduction [4], and metamodel [1], can effectively take into account these uncertainties. However, the computational efficiency and accuracy in evaluating the mean and variance of the performance function remain a challenging task. To obviate this limitation, a novel stochastic simulation-based approach is proposed in the present work. The proposed approach is built on an ‘Augmented optimization problem,’ in which design variables are artificially considered as an uncertain parameter. An unconstrained Genetic algorithm (GA)-based optimization approach is formulated to determine the optimal solution. As the mean and variance frequently conflict with each other, so to obtain the Pareto optimum, a linear scalarized objective function is adopted. To demonstrate the proposed approach, RDO of a four-bar and 10-bar truss structure is performed. The results obtained are compared with the conventional Monte Carlo simulation approach and confirm that the proposed approach yields accurate results. This paper allows the designers to design the insensitive structure systems by minimizing the variance of performance function. Moreover, the proposed RDO approach is not limited to the civil structures only, but it can also be enforced in the design of any realistic linear/nonlinear structures and systems such as machine components (like clutches, gears, etc.), aerospace, etc., having uncertainties in their geometry or material, such as the residual strain, modulus, thickness, density, etc.

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