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A Design Optimization Formulation for Problems with Random and Fuzzy Input Variables Using Performance Measure Approach

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ABSTRACT

To obtain reliable designs, aleatory and epistemic uncertainties are considered recently in the structural analysis and design optimization. The reliability based de-sign optimization (RBDO) method [1] is used when the amount of input data is sufficient enough to create accurate statistical distribution. On the other hand, when the sufficient input data are not available due to limitations in time, human, and facility resources, the optimum design may not be reliable if RBDO method is used. To deal with the situation that input uncertainties have insufficient information, a possibility (or fuzzy set) method can be used for structural analysis and possibility based design optimization (PBDO) [2]. However, in many industry design problems, we may have to deal with design problems that involve with the mixed input statistical random and fuzzy variables simultaneously. For these problems, RBDO may yield unreliable optimum designs because of insufficient data. On the other hand, treating the random variables as fuzzy variables and invoking PBDO to solve the mixed design variable problem may yield too conservative designs with higher optimum costs. This paper proposes a new mixed variable design optimization (MVDO) problem based on the performance measure approach (PMA) [1]. To evaluate the possibilistic constraint in MVDO, a sub-optimization problem for inverse analysis is carried out using a hyper-cylinder domain. To solve this sub-problem efficiently and effectively, a new numerical algorithm, maximum failure search (MFS) method, is proposed in this paper by combining the enhanced hybrid mean value (HMV+) method [3] for the inverse reliability analysis in RBDO and the maximal possibility search (MPS) method [2] for the inverse possibility analysis in PBDO. Some mathematical examples are used to demonstrate the efficiency and effectiveness of the proposed numerical MFS method. Some physical design examples are used to compare the proposed MVDO results with RBDO and PBDO results.

References

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