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Reliability Based Design Optimization Using Bayesian Reliability Neural Networks

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Abstract

There have been recently considerable attention in reliability based assessment and design such that the product quality is quantitatively expressed in terms of probability of failure in the context of probabilistic design under uncertainty. During the early stage in the study of the reliability based design, it has been assumed that the probability distribution of design parameter is known based on the large number of experimental and/or numerical sampling data under the aleatory uncertainty of physical systems. However, the design and manufacturing industries are frequently faced with the epistemic uncertainty due to the lack of sampling data and information. Recently, the Bayesian intelligence techniques have been studied in the context of probabilistic design under aleatory and epistemic uncertainties [1]. The present study explores the reliability based design optimization (RBDO) using Bayesian reliability neural network (BRNN) based approximate meta-models in order to accommodate both aleatory and epistemic uncertainties. The back-propagation neural network (BPN) architectures are employed to enhance the nonlinear behaviors of practical engineering design problems. The training and testing accuracies of BRNN are first validated according to the number of sampling data, and the approximate RBDO solutions obtained from BRNN are subsequently discussed in terms of how such approximate optimal solutions are as close as the exact solution and the target reliability. The proposed approach of BRNN based RBDO is explored using a nonlinear mathematical function problem and a structural optimization problem.

[1] Gunawan S., and Papalambros, P. Y., "A Bayesian Approach to Reliability-Based Optimization with Incomplete Information," Journal of Mechanical Design, Vol. 128, pp. 909-918, 2006.