Design under Uncertainty using a Combination of Evidence Theory and a Bayesian Approach

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Abstract

Early in the engineering design cycle, it is difficult to quantify product reliability due to insufficient data or information to model uncertainties. Probability theory can not be therefore, used. Design decisions are usually based on fuzzy information which is imprecise and incomplete. Various design methods such as Possibility-Based Design Optimization (PBDO) [1, 2] and Evidence-Based Design Optimization (EBDO) [3] have been developed to systematically treat design with non-probabilistic uncertainties. In practical engineering applications, information regarding the uncertain variables and parameters may exist in the form of sample points, and uncertainties with sufficient and insufficient information may exist simultaneously. Most of the existing optimal design methods under uncertainty can not handle this form of incomplete information. They have to either discard some valuable information or postulate the existence of additional information. In this paper, a design optimization method is proposed based on evidence theory, which can handle a mixture of epistemic and random uncertainties. Instead of using "expert" opinions to form the basic probability assignment [4], a Bayesian approach is used using a limited number of sample points. Examples demonstrate the merit of the proposed design optimization method.

References

[1] Mourelatos, Z. P., and Zhou, J., "Reliability Estimation and Design with Insufficient Data based on Possibility Theory," *AIAA Journal*, 43(8), 1696-1705, 2005.
[2] Choi, K. K., Du, L., and Youn, B. D., "A New Fuzzy Analysis Method for Possibility-Based Design Optimization," *10th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference*, AIAA 2004-4585, Albany, NY, 2004.
[3] Mourelatos, Z. P., and Zhou, J., "A Design Optimization Method using Evidence Theory," *ASME Journal of Mechanical Design,* 128(4), 901-908, 2006.
[4] Ross, T. J., *Fuzzy Logic with Engineering Applications*, McGraw Hill, 1995.