Design under Uncertainty using Subjective and Objective Information

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Abstract

Early in the engineering design cycle, it is difficult to quantify product reliability due to insufficient data to model uncertainties. Probability theory can not be therefore, used. Design decisions are usually based on imprecise and incomplete information. In practical engineering applications, information regarding the uncertain variables and parameters may exist in the form of 1) expert opinions, 2) samples with limited in number sample points, and 3) actual probabilistic distributions. Uncertainties with sufficient and insufficient information may therefore, exist simultaneously.

Most of the existing optimal design methods under uncertainty can not handle this; see Mourelatos and Zhou (2006). They have to either discard some valuable information or postulate the existence of additional information. In this paper, a design under uncertainty methodology is proposed which handles input uncertainty in the form of expert opinions, limited in number sample points, and actual probabilistic distributions. Also expert opinions and limited number of available sample points can be used simultaneously, to characterize the same random variable. If limited sample points are available, the bootstrap method is used to create different samples by rearranging the available sample points. For each sample, a probabilistic distribution is determined from the Pearson or Johnson families of distributions using a moment matching method; see Johnson and Kotz (1972). All distributions from the different bootstrap samples form a probability-box structure which includes the true distribution. Finally, an efficient probabilistic re-analysis method is used to propagate the input probability-box; see Zhang, Nikolaidis and Mourelatos (2009). Examples are used to demonstrate the proposed methodology.

References

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