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Non-parametric approach for uncertainty-based multidisciplinary design optimization considering discrete information

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Abstract

Uncertainty-based multidisciplinary design optimization (UMDO) has been widely acknowledged as an advanced methodology to address competing objectives and reliable constraints of complex systems by coupling relationship of disciplines involved in the system. One of the hot issues in the UMDO research is uncertainty propagation in the multi-disciplines because it makes multidisciplinary analysis (MDA) difficult in a complex system. In an MDA phase, the traditional methods regard uncertainty as a certain parametric distribution, for instance, normal distribution. However, in a realistic experiment and/or environment, uncertainties exist in discrete form because experiments or exploitations are limited by a cost problem or an environmental problem When the well-known probability density functions (PDF) cannot identify the phenomena or the distribution is misestimated in a uncertainty modeling step, a serious error can be caused. Therefore, a novel UMDO method directly adopting discrete information should be proposed.

In this paper, a non-parametric approach for UMDO is suggested to consider discrete information of uncertainty. In a non-parametric approach, because discrete information of uncertainty of variables is directly used, each discipline, experiment or simulation should combine discrete information of uncertainty of each variable. Thus, as a data transferring step, a sequence of autocorrelation is employed to make discrete samples uncorrelated before analysing disciplines at each iteration. And then, Kolmogorov–Smirnov (KS) test, which calculates maximum distance between empirical cumulative distribution functions of previous and current iterations, is employed to measure the uncertainty propagation of coupled variables. An MDA phase is terminated if the distance is within limits. At last, an uncertainty analysis based on Akaike information criterion (AIC) is proposed. AIC method selects the best fitted distribution from several candidate distributions. To verify the performance of the proposed method, mathematical and engineering examples are illustrated.

References

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