Reliability-based design optimization using step length adjustment algorithm

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Abstract

Reliability-based design optimization (RBDO) is regarded as a reasonable and powerful tool for structural optimization because of rational consideration of uncertainties. Probabilistic constraints evaluation in RBDO can be carried out using the performance measure approach (PMA) other than the traditional reliability index approach (RIA). In PMA, the probabilistic performance measure (PPM) is obtained through locating the minimum performance target point (MPTP) with the specified target reliability index in standard normal space, which is also called inverse reliability analysis. The advanced mean-value (AMV) method is well suitable for locating MPTP due to its simplicity and efficiency. However, AMV may converge very slowly, or oscillate and fail to converge if the performance function is concave and highly nonlinear. A step length adjustment (SLA) iterative algorithm, which introduced a "new" step length to control the convergence of the sequence, has been proposed by the authors. This step length is new because the line search process for step length selection is not needed and it may be constant during the whole iteration process or decrease successively several times using a self-adjust strategy. SLA is as simple as AMV and does not need the prior knowledge of convexity or concavity of the performance function as other modified algorithms do. It has been proved that the AMV method is a special case of the SLA algorithm when the step length tends to infinity.

In this paper, several deliberately designed numerical examples are used to compare SLA with AMV and other improved algorithms, including hybrid mean value method (HMV), chaos control (CC) method and modified chaos control (MCC) method. The results indicate that SLA is effective and robust. In RBDO, the design variables can be parameters of the probability distribution of the random variables, such as mean values. During the optimization, design variables change, i.e., mean values vary in the design space. One numerical example show that when the mean value vary, AMV cannot obtain convergent solution for PPM during some variation intervals, which will lead to failure in the optimization. However, SLA acquires the stable convergence solution for the whole variation interval. Then SLA is used to compute PPM and RBDO is executed. Several examples illustrated that RBDO with SLA is also effective and more robust than other algorithms.

Keywords: Reliability-based design optimization, Performance measure approach, Step length adjustment.