An enhanced derivative λ-PDF method for uncertainty quantification and analysis of mechanical structures

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Abstract

Uncertainty quantification and analysis plays an important role in the mechanical engineering science. In recent years, some advanced approaches for uncertainty quantification and analysis of mechanical structures have been investigated by many researchers. One of the typical representatives is the derivative lambda probability density function (λ-PDF) method, in which the uncertainty of random variables with arbitrary distribution can be quantified in a unified framework. However, this method still has a limited range of fitting region, leading to the uncertainty quantification and analysis for mechanical structures with large skewness and kurtosis values encounter difficulties. To solve such an intractable problem, an enhanced derivative λ-PDF method for uncertainty quantification and analysis of mechanical structures is proposed. To start with, a mathematical model for random variable is built to quantify the uncertainties of mechanical structures. Then, the univariable and bivariate dimension reduction methods are used for acquiring the first-four order statistical moments of mechanical structural responses to further realize the moments propagation. Next, the probability density function (PDF) and cumulative distribution function (CDF) of mechanical structural responses are approximated by the enhanced derivative λ-PDF model. Finally, some demonstrative examples are engaged to illustrate the effectiveness of the enhanced derivative λ-PDF method. In this study, the range of original fitting region is expected implementation extension to further enhance its applicability of the derivative λ-PDF method for mechanical structures with large skewness and kurtosis.

Keywords: Uncertainty quantification; Uncertainty analysis; Derivative λ-PDF; Dimension reduction method; Statistical moments