Accuracy Improvement of MPP-Based Dimension Reduction Method Using the Eigenvectors of the Hessian Matrix

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Abstract

The main purpose of this study is to develop an accurate methodology for the most probable point (MPP)-based dimension reduction method (DRM) by proposing a proper orthogonal transformation to calculate a probability of failure more accurately. In this study, dependency of an axis direction is shown in the univariate DRM, indicating that the probability of failure can be differently calculated according to a different orthogonal transformation. In order to obtain a proper axis direction for DRM, the Hessian of a performance function is utilized in this study. By performing orthogonal transformation using eigenvectors of the Hessian matrix, axes of Gaussian quadrature points for numerical integration are selected along the principal eigenvector directions of the Hessian. In this way, the error incurred by the univariate dimension reduction is minimized, so the probability of failure can be calculated more accurately. Numerical examples verify the accuracy of the proposed method by comparing with existing MPP-based DRM.

Keywords: Dimension Reduction Method (DRM), Most Probable Point (MPP), First-Order Reliability Method (FORM), Hessian Matrix, Eigenvector.