An Integrated Framework for Uncertainty Propagation with Hybrid Uncertain Variables based on Dimension-reduction Method

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Abstract: In this work, we proposed an integrated framework for uncertainty representation and propagation that can bring two types of hybrid uncertainty problems into account. The fundamental of development of this work is the employment of the dimension-reduction method(DRM) that decomposes the hybrid uncertainty system into relatively simplified system. Based on the method, two typed of strategies are explored for the implementation of the proposed approach: for the uncoupled hybrid type (input variables are described by both intervals and probabilistic variables), by using the DRM, the system is decomposed into the probability part and interval part, then using the Gauss-Hermite integral for moment calculation of the probability part and using DRM again to deal with the interval part. for the coupled hybrid type (input variable distribution parameters described by intervals), combine the DRM and moment match method to acquire the bounds of the first four moments, then obtain the final P-box by fitting the Johnson distribution. Conversion of the original system to simplified system enables the use of computationally efficient methods for hybrid uncertainty propagation. Overall, several numerical examples and engineering examples are presented to illustrate the benefits of our proposed method.

Key words: Hybrid uncertainty, Dimension-reduction, Uncertainty propagation, Moment matching, P-box,

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