Enabling the evidence theory through non-intrusive parametric model order reduction for crash simulations

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Abstract

To improve the crashworthiness of cars, it is crucial for vehicle safety departments to consider uncertainties. In addition to hardware crash tests, finite element simulations (FES) serve to assess the behavior in a crash scenario. As these black-box simulations are computationally expensive, e.g. due to the huge number of finite elements, uncertainty quantification has prohibitively high cost. We therefore propose to approximate the FES using non-intrusive parametric model order reduction (MOR).

The use of MOR requires model outputs of training simulations—called snapshots—resulting from different input parameter sets. Here, snapshots consist of the node displacements of all finite elements at specific time states. MOR strongly reduces the high dimension of the problem to a lower one, L, by performing a singular value decomposition. Afterwards, the lower dimensional subspace is approximated by L metamodels—one for each dimension. This study applies Gaussian processes.

Combining MOR with metamodels allows the reconstruction of the full FES. New parameter sets can be quickly evaluated, i.e. uncertainties can be rapidly propagated through the reduced model. This enables the use of the evidence theory for each key result of the FES. The resulting plausibility and belief curves help vehicle safety engineers to improve the crashworthiness under uncertainty.

References

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