Nonintrusive Uncertainty Quantification for crashworthiness simulations

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ABSTRACT

Crash worthiness numerical simulation is critical for the validation of automotive design. It saves time-consuming and costly experimental tests that frequently result on failing the strict and demanding safety requirements. One important issue in these tests (both experimental and numerical) is the dispersion of the results: the very same design may behave correctly in one test and fail another one due to perturbations affecting initial input data or the evolution of the crash itself.

In order to quantify the uncertainty of the output, input data (material properties, geometry, loads…) is to be considered as stochastic (input parameters are random variables). In the context of industrial crashworthiness simulations, it is extremely difficult to be intrusive into the code to be used (in this case VPS Pam-Crash). Thus, a nonintrusive approach in which the code is used as a black box is devised. However, in order to save the number of samples of the parametric design space, methodologies assuming some behavior of the resulting probability distribution, like Polynomial Chaos, are preferred. The approach presented in this work combines a smart sampling strategy based on a first exploration of the parametric space and a latter regional sampling where the mechanical response is easier to describe using nonintrusive techniques.

The idea is to identify the zones of the design space producing different collapse mechanisms by a smart nonintrusive exploration. Thus, it is possible to classify the different mechanisms with Machine Learning techniques and to refine the Monte Carlo sampling in the zones of interest. The performance of the methodologies presented is demonstrated in examples of industrial interest.

REFERENCES

[1] Sudret, B., "Polynomial chaos expansions and stochastic finite element methods", Reliability in Geotechnical Engineering, CRC Press, pp.265-300, (2015)