

## Risk-averse topology optimization under random fields using stochastic expansion methods

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### ABSTRACT

Although significant numerical and theoretical developments have been achieved in Topology Optimization Under Uncertainty (TOUU), several computational challenges still remain. One of them stems from the fact that when the solution of the underlying PDE is expensive, one can only afford to solve a few hundred samples, which is far from the required number for estimating a probability of failure. This drawback is exacerbated in high-dimensional spaces.

This study is concerned with the accurate and efficient solution of TOUU problems involving probabilities of failure in their formulation. For this purpose, an approach based on the use of anisotropic stochastic expansion methods is proposed. This approach is especially well suited for risk-averse and reliability-based topology optimization, which involve the computation of probabilities of failure in the functional cost and/or in the constraints. The evaluation of probabilities of failure of the cost functional requires integrations over failure regions. Due to the non-differentiable character of the cost functional, this work proposes a numerical approximation of this functional and its sensitivities by combining a non-intrusive polynomial chaos approach for uncertainty propagation with a Monte-Carlo sampling method. This approach permits an accurate and efficient estimation of quantities of interest such as statistical moments and failure probabilities. Furthermore, the proposal provides a unified framework to address some of the different formulations that incorporate, in a wide sense, the concept of “structural robustness”, namely, robust design [1], reliability-based and risk-averse topology optimization. Some numerical experiments including loading and material uncertainty and random fields are presented to illustrate the proposal.

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### REFERENCES

- [1] J. Martínez-Frutos, D. Herrero-Pérez, M. Kessler, F. Periago, “Robust shape optimization of continuous structures via the level set method”, *Comput. Methods Appl. Mech. Engrg.*, **305**, 271-291 (2016).