The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

The effects of noise on reliability analysis

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Keywords: *Structural reliability, Active learning, Surrogate models, Noisy models*

Surrogate models have been increasingly used in uncertainty quantification to alleviate the cost of assessing expensive computational models in the past decades. More recently, surrogate models have been combined with reliability estimation algorithms in the so-called *active learning* paradigm [1, 2] to perform complex simulation-based reliability analysis within an affordable computational budget. In this scenario, the goal is to estimate the failure probability of a particular system given the uncertainty in the input parameters of the limit-state function while minimizing the number of calls to the limit-state function.

Since reliability analysis often deals with small failure probabilities, minor disturbances in the limit state function, such as noise, can cause significant variability in their estimation. Because this issue has been rarely addressed in the literature, this contribution focuses on studying the effects of noise in assessing the failure probability. Random noise is added to a selection of benchmark limit state functions, and the probabilities of failure of the exact and noisy models are assessed through direct Monte Carlo simulation. Then, state-of-the-art active learning reliability algorithms with regression-based (and hence denoising) surrogates are used to estimate the probability of failure of the noisy models. Our results show that surrogate-based reliability analysis can rapidly converge to the probability of failure of the noise-free models even when Monte Carlo simulation fails. Therefore, we conclude that reliability analysis of noisy models is a particular case where regression-based surrogate models combined with active learning methods may provide a more accurate solution when compared to Monte Carlo simulation, due to their de-noising properties.

References

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