Failure Probability Estimation via Bayesian Last Layer

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ABSTRACT

Reliability analysis for systems fundamentally requires estimation of its probability of failure, which is a multi-dimensional integral. In such complex systems, evaluating via computationally heavy models through direct Monte-Carlo can be arduous, as failure points become rarer. This hurdle is alleviated by use of surrogate models approximating the given system response, subsequently enabling more efficient inference. Nevertheless, the application of surrogate models is constrained by the dimensionality of the reliability problem. With this work, we seek to estimate failure probabilities of intermediate- to high-dimensional uncertain systems (in the order of several tens of random input variables) and tackle the curse of dimensionality. Hereby we setup the Bayesian Last Layer model as a surrogate, more specifically, we use the constrained, empirical Bayes version as per [1]. The surrogate is initially constructed using a small training set and then refined by expansion of the training set by use of an active learning strategy. These new data points are selected by a large inference set through the current surrogate model based on failure-relevant criteria [2]. The results are compared against well-established surrogate modelling techniques currently wide-spread in reliability analysis. This comparison ranges from sample efficiency, robustness to increased dimensionality and accuracy of failure probability estimation. The goal is to assess the effectiveness of the surrogate model relative to established surrogates and emphasize its advantages and limitations for high-dimensional reliability problems.

REFERENCES

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