Engineering Risk Analysis Group
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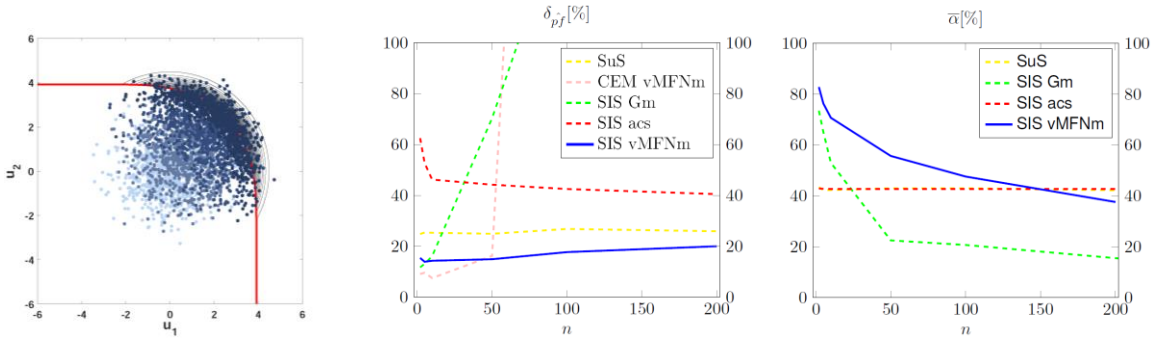
MSc thesis

Sequential Importance Sampling with a flexible mixture model

Emily Schran, October 2018

Background

Structural reliability assessment is characterized by small failure probabilities, which represent a challenge in their determination and simulation. Existing methods require either a high computational effort or lack in their variability for the estimation of failure probabilities in engineering systems. The introduced method aims to close this gap and combines the advanced simulation method of *sequential Importance Sampling* (SIS) with the flexible von Mises-Fisher-Nakagami distribution as its sampling density. The characteristic feature of the latter is the transformation of a random variable to its polar coordinate notation, which allows a more detailed customizable distribution of samples. In addition, multiple of these distributions are assembled in a mixture model improve the performance in multimodal problems. The issue of a heavily decreasing acceptance probability in the independent Metropolis-Hastings algorithm is a major concern in the evaluation of high dimensional reliability problems and limitation in the applicability of the sequential Importance Sampling approach so far.



a) scatter plot of an unimodal example with a concave shaped limit state function, the optimal Importance sampling density, and the samples generated within every level of the sequential procedure

b) comparison of the performance of the novel SIS vMFN mixture approach with other advanced sampling methods in term of the coefficient of variation and the average acceptance probability

Methodology

For the assessment of the quality of the introduced method multiple example problems representing a variety of structural reliability problems were evaluated and later compared to the quality of already existing approaches. Furthermore, a parameter study was carried out, to determine the sensitivity and to detect possible improvements of the method.

Conclusion

The novel combination of the von Mises-Fisher-Nakagami mixture and the SIS approach showed significant improvements in the quality of advanced sampling methods. Its performance underlines that the insertion of a flexible mixture model effects the desired application diversity for the field of rare event estimation.

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