Title of the PHD: Development of the AK methods for the high dimension reliability analysis

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Abstract:

The AK-MCS method (Active learning and Kriging – based Monte Carlo simulation) was first developed in 2011 during B. Echard PHD thesis [1] founded by ANR (APPROFI project). This method based on kriging meta-model aims at providing the failure probability estimation of a structure with a reduced number of mechanical calls. It is consequently especially dedicated to structural reliability analysis of complex structures with very time consuming mechanical models.

The efficiency of this method allows to go over academic applications and to consider real structures in the framework of industrial partnership (SNECMA DMA/DMS, CEA, ...) on component problems [2] and system analysis [3]. However, this method has two main drawbacks:

1. Structural reliability analysis with very small probability;
2. Its efficiency on high dimension problem;

The first point was partially solved using variance reduction techniques (importance sampling [4] and subsets simulations). The second one is always persistent and is the main objective of the proposed PHD. Indeed, the use of the AK methods is restricted to approximately 12 since specific industrial problematic, especially in tolerance analysis topic [5], need to reach several dozens of variables.

The proposed PHD subject aims at providing answers to the following interrogations:
- How efficient is the kriging to treat high dimension problems and which adaptations are necessary to consider such problems?
- How to drive a high dimension reliability analysis using the AK-MCS methods? The sensitivity analysis methods (FORM, Morris method, Sobol’ index, Borgonovo ...) will be considering as preliminary study or during the failure probability assessment in order to reduce the dimension of the problem.
- What are the options of the kriging to consider high dimension problem? Sparse grid method will be investigated in a mixed use with the AK method.

References

[1] ECHARD B., GAYTON N., LEMAIRE M.
AK-MCS: an Active learning reliability method combining Kriging and Monte Carlo Simulation
A reliability analysis method for fatigue design

[3] FAURIAT W., GAYTON N.
AK-SYS: an adaptation of the AK-MCS method for system reliability

A combined Importance Sampling and Kriging reliability method for small failure probabilities with time demanding numerical models

AK-ILS: an Active learning method based on Kriging for the Inspection of Large Surfaces