Multi-Objective Reliability-Based Design Optimization using Subset Simulation Enhanced by Meta-Models

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Abstract

This paper deals with a double-looped reliability-based design optimization (RBDO), in which the system reliability is assessed within the inner loop and a designing process is performed in the outer loop. A common approach expressed as a single-objective optimization is transformed into a multi-objective case providing results as an approximation of the Pareto front composed of the compromising solutions between cost and reliability.

The double-loop formulation of RBDO provides the most accurate approximation of the Pareto front but is computationally demanding especially if advanced simulation techniques are used for rare failure events. Nowadays, a *Subset simulation*, see Au (2001), is a popular method to obtain an estimate of small failure probabilities. Despite the reduction in evaluation time using a Subset simulation when compared to a crude Monte Carlo method, the computational effort is still high with a complex model as a performance function (e.g. a finite element model). The computational model can be replaced by its surrogate in order to reduce the computational costs. This *meta-model* fits the responses evaluated by the original model for the predetermined data, i.e. the Design of Experiment (DoE). Subsequently, the meta-model is updated via a multi-objective optimization with respect to two criteria, see Pospíšilová (2013): first, new samples are located in the vicinity of the limit state, which divides the space into a safe region and a failure domain, and second, these samples should also be placed in the sparsest position of DoE.

The described method is illustrated on several RBDO benchmarks each with two objective functions; the first objective is a cost function to be minimized, the second objective is a structural reliability expressed by a reliability index to be maximized.

References

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