Reliability-based Design Optimization Using Local Radial Basis Function Interpolations

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Abstract

Every structural design should satisfy several criteria; economical aspects as well as a reliability of the structural system rank belong to the most important ones. The reliability-based design optimization (RBDO) seeks such designs that comply both of the above criteria. Despite the growing performance of computers, a reliability assessment is still computationally expensive especially for small failure probabilities. Therefore, researchers look for novel techniques for the computational cost reduction [1, 2, 3]. In simulation techniques often used for the reliability assessment, the largest part of the computational time is devoted to a repeated evaluation of a performance function represented e.g. by a finite element model. However, the original model can be replaced by a surrogate model that has a similar response but it is faster to evaluate. Several samples still have to be evaluated with the original model; these samples are used for the surrogate model construction subsequently. The precision of the surrogate model grows particularly with a number of the construction samples. Interpolation surrogate models such as Kriging or Radial basis functions (RBF) are still computationally expensive since every construction sample increases a dimension of a linear system. The needed number of the construction samples grows with a number of dimensions of the design space as well as with its expansion.

This paper focuses on a reduction of the computational effort spent on the RBF model evaluation during RBDO. The classical global RBF model comprises links between all support points, where the links are represented by a dense design matrix. In this work, only data from the closest neighborhood of each support point are considered [4]; the inclusion of the nearest surroundings consequently provides a sparse design matrix, which is faster to solve. The proposed procedure is tested on several RBDO examples and the data together with the procedure efficiency are compared to the RBDO utilizing the global RBF model.

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References

1. C. Bucher. Asymptotic sampling for high-dimensional reliability analysis. Probabilist Eng Mech 24 (2009) 504-510.
2. V. Dubourg and B. Sudret and F. Deheeger. Metamodel-based importance sampling for structural reliability analysis. Probabilist Eng Mech 33 (2013) 47-57.
3. U. Alibrandi and A.M. Alani and G. Ricciardi. A new sampling strategy for SVM-based response surface for structural reliability analysis. Probabilist Eng Mech 41 (2015) 1-12.
4. G. Yao and J. Duo and C.S. Chen and L.H. Shen. Implicit local radial basis function interpolations based on function values. Appl. Math. Comput. 265 (2015) 91-102.