Robust design with uncertain data and response surface approximation

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Abstract

The challenging task in computational engineering is to model and to predict numerically the behavior of engineering structures in a realistic manner. Beside sophisticated numerical procedures to map physical phenomena and processes, an adequate description of available data covering the content of provided information is of prime importance. Applying imprecise probabilities, objective components of the uncertainty as well as subjective components can be considered simultaneously, see Möller and Beer (2008). A sophisticated procedure to handle imprecise probabilities provides the uncertainty model fuzzy randomness. On this basis, fuzzy random functions are introduced which are mapped onto the fuzzy random result functions by means of the fuzzy stochastic analysis. A numerical realization of fuzzy stochastic analysis is enabled by the bunch parameter representation of fuzzy random functions and is described in detail in Möller et al. (2007).

Applying the α-discretization to the fuzzy bunch parameters, optimization problems are solved in order to determine α-level sets of the fuzzy bunch parameters in the result space. This algorithm is referred to as fuzzy analysis. Within this fuzzy analysis, stochastic analyses, e.g. applying Monte Carlo simulation, are processed repeatedly. For each realization of the stochastic analysis, the deterministic fundamental solution is carried out. The repetition of the stochastic analysis and of the deterministic fundamental solution increases the computational costs considerable. The numerical efficiency can be improved replacing the expensive analysis by response surface approximation, e.g., committee machines, composite networks, see Liebscher et al. (2007). Furthermore, new algorithms are introduced on the basis of a patchwork-like approach. The results of the fuzzy stochastic analysis are exemplarily utilized for robustness assessment and sensitivity analysis.

References

Liebscher, M., M. Beer, S. Pannier, M. Thiele, and W. Graf. Sampling schemes for crashworthiness investigations in view of robustness and reliability. In M. Papadrakakis et al., editors, *1st COMPDYN,* Rethymno, Crete, June 2007, CD-ROM.

Möller, B. and M. Beer. Engineering computation under uncertainty – Capabilities of non-traditional models. *Computers & Structures*, 86(10):1024–1041, 2008.

Möller, B., W. Graf, J.-U. Sickert, and U. Reuter. Numerical simulation based on fuzzy stochastic analysis. *Mathematical and Computer Modeling of Dynamical Systems*, 13(6):349–364, 2007.