On the implementation of an advanced interior point algorithm for stochastic structural optimization

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ABSTRACT

Topic: Design under Uncertainty

Structural optimization by means of deterministic mathematical programming techniques has been widely accepted as a viable tool for engineering design. However in many structural engineering applications response predictions are based on models whose parameters are uncertain. Under uncertain conditions probabilistic approaches such as reliability-based formulations provide a realistic and rational framework for structural optimization which explicitly accounts for the uncertainties [1].

The objective of this contribution is to evaluate the feasibility of using a class of interior point algorithms in the context of reliability-based optimization problems of high dimensional stochastic dynamical systems. In particular, structural design problems involving dynamical systems under stochastic loadings are considered in this work. An optimization scheme based on the solution of the first-order optimality conditions is considered here [2]. The optimization problem is formulated as the minimization of an objective function subject to multiple design requirements including deterministic and reliability constraints. First excursion probabilities are used as measures of system reliability [3]. The corresponding reliability problems are expressed as multidimensional probability integrals involving a large number of uncertain parameters. Such parameters describe the uncertainties in the structural properties and excitation. The reliability measures are estimated by an advanced simulation technique [4]. All iterations given by the algorithm strictly verified the inequality constraints and therefore the iterations can be stopped at any time still leading to better feasible designs than the initial design. This property is particularly important when dealing with involved problems such as reliability based optimization of high dimensional stochastic dynamical systems. In these problems each iteration of the optimization process is associated with high computational costs. As a remedy for the large computational efforts, some parallelization capabilities of the proposed algorithm are exploited in the present work.

Numerical results show that the algorithm converge in few optimization cycles. This in turn implies that a limited number of reliability estimates has to be performed during the optimization process. Example problems, including involved structural finite element models, are solved quite efficiently without any change in the code and with the same set of parameters. It is concluded that the proposed optimization scheme provides an efficient tool for solving complex stochastic structural optimization problems.

References

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