Discrete Variable Design Optimization of Uncertain Structural Systems under Stochastic Excitation

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For many structural optimization problems the design variables must be selected from a list of discrete values. For example, cross-sectional areas for truss members have to be chosen from a list of commercially available member sizes. In this paper attention is directed to the structural synthesis of stochastic dynamical systems. In particular, the reliability-based optimization of uncertain structural systems involving discrete sizing type of design variables and subject to stochastic excitation is considered. The reliability-based optimization problem is formulated as the minimization of an objective function for a specified reliability. The probability that design conditions are satisfied within a given time interval is used a measure of system reliability. The basic mathematical programming statement of the structural optimization problem is converted into a sequence of explicit approximate primal problems of separable form. For this purpose, the objective function and the reliability constraints are approximated by using a hybrid form of linear and reciprocal approximations. The approximations are combined with an efficient simulation technique to generate explicit expressions of the reliability constraints in terms of the discrete design variables. The explicit approximate primal problems are solved by constructing continuous explicit dual functions, which are maximized subject to simple non-negativity constraints on the dual variables. The evaluation of the dual function is direct since it requires the minimization of a series of one-dimensional minimization problems. Validation calculations show that the number of reliability estimations required during the optimization process is very small. The proposed method represents a structural synthesis capability for discrete sizing problems which exhibits a computational efficiency approaching those achievable in pure continuous variable problems. Thus, this technique is expected to be useful in discrete variable structural synthesis of stochastic dynamical systems.

References

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