RELIABILITY AND ROBUSTNESS IN ENGINEERING DESIGN

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Mathematical optimization plays an important role in engineering design, leading to greatly improved performance. Deterministic optimization however, can lead to undesired choices because it neglects input and model uncertainty. One way to achieve better results from design optimization is to explicitly incorporate uncertainty in the optimization techniques. Reliability-based design optimization (RBDO) and robust design seek to improve optimization in this way. A design is called reliable if it meets all performance targets in the presence of variation/uncertainty and robust if it is insensitive to variation/uncertainty. Ultimately, a design should be optimal, reliable, and robust. Usually, some of the deterministic optimality is traded-off in order for the design to be reliable and/or robust. This paper describes the state-of-the-art in assessing reliability and robustness in engineering design and proposes new directions. The principles of deterministic optimality, reliability and robustness are first defined. Subsequently, the design compromises for simultaneously achieving optimality, reliability and robustness are illustrated. Emphasis is given to a unifying probabilistic optimization formulation for both reliability-based and robust design, including performance variation as an additional decision criterion. The robust engineering problem is investigated as a part of a "generalized" RBDO problem. Because conventional RBDO optimizes the mean performance, its objective is only a function of deterministic design variables and the means of the random design variables. The conventional RBDO formulation is expanded to include performance variation as a decision criterion. This results in a multi-objective optimization problem even with a single performance criterion in the reliability problem. A preference aggregation method is used to compute the entire Pareto frontier efficiently. A variety of examples illustrates the concepts and demonstrates their applicability.