Short Abstract

Real-world engineering systems are characterized by inherent uncertainty arising from factors such as incomplete knowledge of the physical system and dynamic working environments. Traditional deterministic design optimization approaches often fall short in effectively addressing this uncertainty, leading to design failures. As a solution, reliability-based design optimization (RBDO) methods have emerged as efficient tools for designing such systems. Among the various RBDO methods, the single-loop method stands out as one of the most efficient. However, these methods face challenges related to convergence towards local solutions and oscillation when dealing with probabilistic performance functions. This work presents a novel methods, focusing on developing efficient and accurate single-loop RBDO methods. The proposed methods encompass a range of techniques. Firstly, a single-loop sequential optimization with approximate reliability analysis is introduced, utilizing the conjugate gradient search direction to approximate and update the most-probable target point (MPTP) along with shifting vector approach. In the second part of the thesis, an approximate single-loop chaos control method is proposed to minimize oscillation during the determination of the MPTP. An oscillation criterion is developed to track the oscillation of the MPTP in each iteration, dynamically applying the chaos control theory when necessary, or otherwise utilizing the conjugate gradient search direction to update the MPTP. To mitigate the possibility of getting trapped in local optima, the third part of the thesis introduces a single-loop RBDO formulation employing a shifting vector approach, ensuring feasibility for violated performance functions by incorporating target and trial vectors of differential evolution (DE) to guide the algorithm. DE is further enhanced through the design of a heuristic parameter controlling exploration and exploitation of the search space. The fourth part of the thesis addresses the multi-objective aspect of real-world problems in RBDO, proposing a single-loop formulation for multi-objective RBDO that achieves a reliable Pareto-optimal front. This formulation integrates the chaos control theory to reduce oscillation during the convergence of the MPTP, while a heuristic parameter is estimated using the hypervolume performance indicator. Different variants of mutant vectors are used for exploration in the search space. The shifting vector approach and chaos control theory are also integrated into the multi-objective RBDO formulation in the last part of the thesis. The proposed methods are thoroughly tested using diverse mathematical and engineering RBDO examples, with the reliability of the obtained solutions validated through Monte Carlo simulation (MCS). Comparative analyses against existing RBDO methods in the literature demonstrate the superiority of the proposed single-loop-based formulations and methods, yielding reliable optimal solutions with significantly reduced function evaluations.