

Convergence Improvement of Reliability-Based Multiobjective Optimization Using Hybrid MOPSO

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In this study, the improvement of convergency and Pareto solution searching performance for the authors' proposed reliability-based multiobjective optimization (RBMO) algorithm is proposed. The RBMO algorithm integrates the hybrid multiobjective particle swarm optimization (MOPSO) for handling the constraint satisfaction technique using gradient information of constraints with a concept of the single-loop-single-vector method (SLSV).

The hybrid MOPSO has a function to move the design candidate with constraint violation to the feasible region using sensitivity information of the violated constraints and then to the feasible boundary using bi-section method. This strategy for moving the design candidate to the feasible boundary is suitable for searching the Pareto solutions for engineering design problems, since most engineering design problems have Pareto optimum candidates at the feasible boundary. Additionally, making use of sensitivity information is suitable for reliability-based design problem, because the evaluation of the reliability index requires the gradient of the reliability constraints. The proposed RBMO algorithm uses the concept of SLSV method that makes use of a proper approximation of the design point. The gradient of limit state function is approximated by using the target reliability index and the gradient evaluated at the design point of the previous iteration.

The authors previously demonstrated the efficiency of the algorithm through several numerical examples. Though the method requires iterative evaluations for moving the design candidate with constraint violation to the feasible region, the algorithms totally have a good convergence performance for the most design problems. For example, Pareto solutions that lie on the feasible boundary are found in earlier searching stage. However, some design candidates requires huge numbers of calculations until the candidate moves to feasible region, when the violated constraint conditions are shifted frequently during the constraint satisfaction process.

This study proposes the improvement method by eliminating such zigzag iterations based on an idea from modified SLSV method or the conjugate mean value method. The methods were proposed to resolve the convergence problem for the reliability-based optimization by modifying the searching direction. The key idea of the proposed method is to select a kind of average direction of the previous searching directions as the current moving direction, when the successive searching direction that is determined from the sensitivity of constraint conditions is drastically shifted. The efficiency of the proposed method is demonstrated through several benchmark design problems by comparing the convergence property of the improved method with that of the original hybrid MOPSO with SLSV method. Then, some properties of RBMO design problems are discussed.

Keywords: Reliability-based multiobjective optimization, Hybrid multiobjective PSO, Single loop reliability-based optimization, Sensitivity analysis