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論　文　内　容　の　要　旨

A multi-objective optimization problem involves several conflicting objectives. A multi-objective optimization algorithm aims to get a set of Pareto optimal solutions that capture the trade-off relationship between objectives when they are optimized simultaneously. Almost all real-world problems are formulated as multi-objective optimization problems. Multi-objective evolutionary algorithms are reported as effective methods that are able to obtain an approximation of the Pareto optimal set in a single run. Evolutionary multi-objective optimization is one of the hottest research areas. However, there are many issues to apply multi-objective evolutionary algorithms to real-world optimization problems.

In real world multi-objective design optimization problems, it is important to obtain useful design knowledge rather than deriving a particular exact optimal solution. Therefore, an analysis method for extracting useful information for understanding the problem from the optimal solution set obtained by multi-objective optimization are needed. Then, in many practical situations the decision maker has to pay special attention to decision space in order to determine the potential constructability of a solution. For example, preferences for particular values of decision variables could appear due to unexpected operational constraints, such as the availability or lack of materials with particular specifications in manufacturing applications. Also, it may be necessary to introduce new equipment depending on the combination of decision variables.

In such case, the decision maker needs to consider not only information of trade-off between objective functions but also the information between design variables and objective functions, which is that information of trade-off between characteristics of the product and its realizability. Although ordinary we consider adding evaluation functions for realizability of the design variables as objective functions in such case, solution search becomes more difficult due to an increase in the number of objective functions. Furthermore, real world problems often have many evaluation functions with high calculation cost. There are also many problems using simulation for solution evaluation. Such problems require much time to evaluate a solution. This becomes an issue for evolutionary algorithms since several solutions are evaluated at every iteration of the algorithm.

This work focuses on solving issues on a practical application of a multi-objective optimization and solution analysis methods for efficient decision making. Visualization of the solution space using a scatterplot matrix with colored solution sets based on an index that measures convergence / diversity in the multi-dimensional objective space is proposed. This allows to extract useful information to understand the features of the problem from the optimal solution set obtained by the optimization algorithm. The analysis method is applied to real world problems to verify its usefulness. Then the application of the algorithm is investigated for deriving practical desirable solutions considering the manufacturability of design variables to the real world problem. The algorithm is aimed to obtain optimal solutions as well as solutions with preferred settings on decision space that are close to the Pareto front. For this purpose, an algorithm for searching for the practical desirable solutions with problem reformulation is developed and applied to benchmark and a real world problem. In addition, a machine learning enhanced method for multi-objective optimization is proposed, which learn important variables for evolution from obtained solutions. The algorithm with the proposed method is expected to reduce the number of times to evaluate solutions and improve convergence of solutions to POS. Its usefulness is verified with benchmark multi- and many-objective problems.

The Pareto optimal solutions analysis method can obtain knowledge useful for design, so it is useful as a tool for getting new awareness for design of products. Since the practical desirable solution search can obtain trade-off information between improvement of the objective function and ease of implementation of the design variable, in manufacturing it contributes to decide an appropriate compromise point in consideration of manufacturability. Acquisition of design information by these two studies contributes to reduction of lead time of product development and reduction of life cycle cost of products. Then, the machine learning enhanced method would contribute to reduce calculation cost of evaluation by converging quicker and requiring less iterations. Multi-objective optimization with evolutionary algorithms can generate creative and efficient innovative solutions to novel problems. However, in addition to derive better optimal solutions, research considering actual application such as in the presented in this study is very important to facilitate technology development to industries and to create innovation.