The System Optimization and the Benchmark Problem for Industrial Application

Investigating R&D Committee on System Optimization and Benchmark Problems for Industrial Application

Contents

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1. Introduction

The newest trend in system optimization and a benchmark problem for industrial applications are investigated in this IEEJ R&D technical report.

The aim of this report is to contribute to the development of industry by conducting a systematic inquiry, clarifying present and future developments, encouraging closer cooperation with researchers, and increasing the exchange of information about the latest research.

Engineering developments that increase efficiency are promoted in all industrial sectors. The type of problem to which this technology is applied can be formulated as an optimization problem, that is, the problem of "finding the best solution to the objective function subject to the given constraints." The approach to finding a solution is to apply an optimization technique based on the features of the system.

However, in the field of industrial applications, it is becoming very difficult to use conventional optimization techniques, since such systems are becoming increasingly large scale and complex, with rapid changes in the surrounding environment and increased uncertainty.

Moreover, it is difficult to present a mathematical formulization that correctly expresses such complexity and uncertainty. Since this approach is often applied to an industrial sector before it has been fully developed from a theoretical standpoint, the original problem may be distorted.

Therefore, there is a strong need to extract from industry these complicated optimization problems for which the true optimal solutions are unknown, and to use them to create new benchmark problems. This means developing new optimization techniques for these complicated systems, and clarifying implementation guidelines based on the characteristics of the problems to be solved.

When an optimization technique is newly developed or improved, it could be used to solve a benchmark problem; it is expected that the solution could then be implemented for the design, planning, operation, and control of a real system.

In recent years, methods for optimizing the design and construction of large-scale and complicated systems have attracted attention because they introduce technologies for basic processes, such as evolution, learning, adaptation, and emergence.

In these methods, there are metaheuristics for optimizing methods that are hinted at by natural processes, such as evolution, swarm intelligence, and immune functions, or by learning methods, such as neural networks which are based on process in the brain, reinforcement learning, fuzziness, and chaos.

In this area, the applied research has been actively performed in parallel with the development of the algorithm, and in some fields, benchmark problems have been created. On the other hand, it is necessary to develop a new system optimization algorithm that can address the increasingly diverse industrial applications and to clarify the characteristics of the associated problems.

For this purpose, it is important that researchers and engineers in the academic environment meet together with those in industry of various backgrounds, and that they work together on investigations and research.

Significant progress can be made by conducting systematic investigations into the newest methods for system optimization, developing benchmark problems for industrial applications, and releasing the results widely.

The IEEJ R&D Technical Committee for "**System optimization and benchmark problems for industrial applications**" consisted of a total of 25 individuals drawn from a university, an electric company, and a research institution. It was launched in January 2013 and performed the following functions:

1) Investigated the newest trends in system optimization algorithms;
2) Created an optimization benchmark problem for industrial applications, and investigated an example of such an application;
3) Considered future topics and approaches for industrial applications of system optimization algorithms.

This committee met twelve times and considered fifteen case studies during the two years it was active, from January 2013 to December 2014.

In addition, a joint research conference was held with the IEEJ R&D system technical committee of Electronics, Information and Systems. This took place at the Oarai Hotel, Ibaraki on December 6, 2014.

Six optimization benchmark problems that were based on real problems currently being tackled in the industrial world were studied, and these were presented at a symposium session of the IEEJ annual conference on March 18, 2014.

The research results of this technical committee were published at SAMCON2015 (First IEEJ International Workshop on Sensing, Actuation, and Motion Control), which took place in March 2015. As a compilation of these activities, six benchmark problems and some examples of solutions for industrial applications are presented on the web page in both Japanese and English.

This technical report summarizes the results of this research.

Chapter 2 presents the main idea of this report as a conspectus of the trends in system optimization and discusses the concept of a substantial benchmark problem.

In Chapter 3, we explain classical optimal design benchmark