A Parallel Double-Level Multiobjective Evolutionary Algorithm for Robust Optimization

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Highlights
1. A single-objective robust optimization problem is transformed into a bi-objective optimization problem.
2. A parallel double-level multiobjective evolutionary algorithm (PDL-MOEA) is developed to solve the transformed bi-objective optimization problem.
3. Compared with some state-of-the-art serial/parallel MOEAs, the proposed PDL-MOEA can achieve a group of better solutions with less time for robust optimization.

Abstract: Robust optimization is a popular method to tackle uncertain optimization problems. However, traditional robust optimization can only find a single solution in one run which is not flexible enough for decision-makers to select a satisfying solution according to their preferences. Besides, traditional robust optimization often takes a large number of Monte Carlo simulations to get a numeric solution, which is quite time-consuming. To address these problems, this paper proposes a parallel double-level multiobjective evolutionary algorithm (PDL-MOEA). In PDL-MOEA, a single-objective uncertain optimization problem is translated into a bi-objective one by conserving the expectation and the variance as two objectives, so that the algorithm can provide decision-makers with a group of solutions with different stabilities. Further, a parallel evolutionary mechanism based on message passing interface (MPI) is proposed to parallel the algorithm. The parallel mechanism adopts a double-level design, i.e., global level and sub-problem level. The global level acts as a master, which maintains the global population information. At the sub-problem level, the optimization problem is decomposed into a set of sub-problems which can be solved in parallel, thus reducing the computation time. Experimental results show that PDL-MOEA generally outperforms several state-of-the-art serial/parallel MOEAs in terms of accuracy, efficiency, and scalability.

Keywords: Evolutionary computation; Multiobjective evolutionary algorithm (MOEA); Robust optimization; Parallel computing.

1. Introduction

Uncertain optimization problem, which requires optimizing parameters with uncertainties, can be found in a wide range of real-world applications [1–5]. Commonly, for an uncertain optimization problem, the parameters with uncertainties are regarded as random variables following certain probability distribution. The optimal solution as well as the land scale of the search space may change with the parameter perturbation. Robust optimization [1, 3] is a popular stochastic approach to solve uncertain optimization problems with certain robustness, which refers to the ability of tolerating the perturbation of parameters. Since its inception in the 1950s, robust optimization has been successfully applied to solve problems from diverse fields, such as
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