Comparison Between Lamarckian and Baldwinian Repair on Multiobjective 0/1 Knapsack Problems

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Abstract. This paper examines two repair schemes (i.e., Lamarckian and Baldwinian) through computational experiments on multiobjective 0/1 knapsack problems. First we compare Lamarckian and Baldwinian with each other. Experimental results show that the Baldwinian repair outperforms the Lamarckian repair. It is also shown that these repair schemes outperform a penalty function approach. Then we examine partial Lamarckianism where the Lamarckian repair is applied to each individual with a prespecified probability. Experimental results show that a so-called 5% rule works well. Finally partial Lamarckianism is compared with an island model with two subpopulations where each island has a different repair scheme. Experimental results show that the island model slightly outperforms the standard single-population model with the 50% partial Lamarckian repair in terms of the diversity of solutions.

1 Introduction

Since 1990s, multiobjective 0/1 knapsack problems have been frequently used to evaluate the performance of various multiobjective metaheuristics including evolutionary multiobjective optimization (EMO) algorithms [4-7, 11, 16, 18]. When EMO algorithms are applied to multiobjective 0/1 knapsack problems, unfeasible solutions are often generated by genetic operations. That is, generated solutions do not always satisfy the constraint conditions. Thus several constraint handling methods have been examined in the application of EMO algorithms to multiobjective 0/1 knapsack problems (e.g., Ishibuchi & Kaige [4], Mumford [11], and Zydallis & Lamont [18]). Constraint handling methods for multiobjective 0/1 knapsack problems can be roughly classified into the following three categories:

Greedy Repair: An unfeasible solution is repaired by removing items until all the constraint conditions are satisfied. The order in which items are removed is prespecified based on a heuristic measure for evaluating each item.

Penalty Function: Objective functions are penalized when constraint conditions are violated.

Permutation Coding: Each solution is not represented by a binary string but a permutation of items. That is, the order of items is used as a string to represent each solution. A feasible solution is obtained from each permutation-type string by adding items to the knapsacks in the order specified by that string.

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In this paper, we concentrate on the comparison between two implementation schemes of greedy repair: Lamarckian and Baldwinian. In the Lamarckian implementation, a feasible solution is generated from an unfeasible one by removing items until all the constraint conditions are satisfied. That is, the genetic information of the unfeasible solution is modified by greedy repair as shown in Fig. 1. As a result, each population includes no unfeasible solutions. Since Zitzler & Thiele [16], the Lamarckian implementation has been implicitly used in almost all computational experiments of EMO algorithms with greedy repair on multiobjective 0/1 knapsack problems [4-7, 11, 18].

On the other hand, the genetic information of an unfeasible solution is not changed in the Baldwinian implementation where greedy repair is used only to evaluate the fitness value of each solution. As shown in Fig. 2, the same feasible solution as in Fig. 1 is generated from the unfeasible solution by greedy repair. This feasible solution is used only to assign the fitness value to the unfeasible solution. As a result, each population becomes a mixture of feasible and unfeasible solutions.

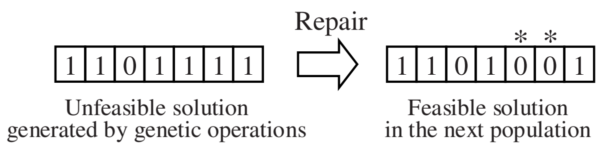

Fig. 1. Illustration of the Lamarckian implementation of greedy repair

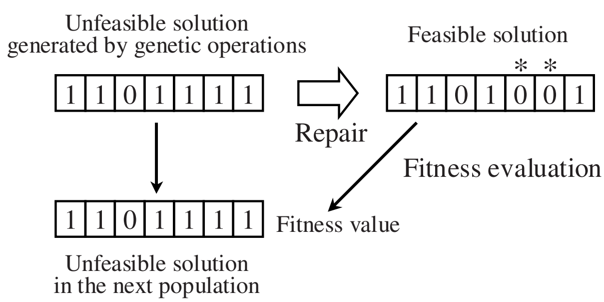

Fig. 2. Illustration of the Baldwinian implementation of greedy repair

In this paper, we first briefly explain multiobjective 0/1 knapsack problems and two repair methods examined in Ishibuchi & Kaige [4] and Zydallis & Lamont [18]. The two repair methods are the maximum ratio repair and the weighted scalar repair. Next we examine the two implementation schemes (i.e., Lamarckian and Baldwinian) of these repair methods. The two implementation schemes are compared with each other through computational experiments on multiobjective 0/1 knapsack problems in Zitzler & Thiele [16] using the NSGA-II algorithm of Deb et al. [2]. While better results can be obtained by memetic EMO algorithms (e.g., MOGLS [6]) for