Neighborhood Exploration Strategies for a Sequence-aware MOEA/D to Solve a bVRPTW

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1 Context

With the increasing demand in terms of services (transportation, delivery, storage), comes an explosion of new challenges that have to be faced. Here, we are interested in the Vehicle Routing Problem with Time Windows (VRPTW). A logistic problem, where vehicles serve customers within a precise time interval. More precisely, we focus on a bi-objective VRPTW (bVRPTW) with a highly studied objective, that is the total transportation cost, and one rarely studied objective, being the total waiting time incurred when drivers arrive before the opening of the time window [1]. Using both of these objectives is interesting in common real-life situations, like the transportation of people, more precisely when a patient has a medical appointment, we do not want that he/she waits too much.

We use MOEA/D, a Multi-Objective Evolutionary Algorithm based on Decomposition [6] where the mutation step is replaced by a local search, and enhanced with Knowledge Discovery (KD) [2]. The KD process is based on the detection of highly frequent sequences of customers during the execution. Most LS available for the VRPTW only consider the total transportation cost, which is not enough when solving a bVRPTW. Moreover, LS steps are time-consuming, which is why different strategies exist to speed up the search and reduce the time allocated to neighborhood exploration. Indeed, we can explore more or less the neighborhood according to the strategy used. Since routing problems produce large neighborhoods, reduction techniques have been designed to avoid irrelevant moves. The most common one is probably the granular search introduced by [5]. However, it requires a proper definition of the distance between customers, which may not be obvious when several objectives are considered and are not in the same range of values.

2 Contribution

Our contribution consists of enhancing a basic local search, integrated into a MOEA/D framework, by considering new neighborhood mechanisms. First, we present a new strategy to explore the neighborhood of bVRPTW solutions inspired by the state-of-the-art permutation flow-shop scheduling problem [4]. It consists of dividing the neighborhood into subsets of neighbors. Contrary to the *best* strategy, which explores the whole neighborhood to apply the best improving move, or the *first* strategy, keeping the first improving solution, our proposed strategy, called *first-best*, explores a subset entirely before making a decision. Second, we define a new metric that considers not only the Euclidean distance between the customers (i.e. the transportation cost between them) but also their respective time windows to evaluate the

TAB. 1 – Average unary hypervolume obtained by the algorithms on the different categories of instances. Bold results are statistically better.

Category	C		R	
Class	C1	C2	R1	R2
$Ref_{MOEA/D}$	0.525	0.603	0.532	0.430
$LS_{MOEA/D}$	0.934	0.933	0.828	0.762
$KD\text{-}LS_{MOEA/D}$	**0.999**	**0.997**	**0.923**	**0.824**

waiting time. With such a metric, we hope to obtain a more accurate neighborhood, depending on the two objectives optimized. Two variants of the metric are proposed. One variant aggregates the cost and the waiting time with variable weights, while the other uses the same weights for the aggregation. These contributions are supported by a rigorous analysis of the different parameters used in the MOEA/D framework, through irace [3], to highlight the most influential ones. Therefore, each variant tested is tuned with irace to keep the configuration the best adapted for each one. Experiments are conducted on Solomon's benchmark (R, C) with instances of size 100, to evaluate the performance of each MOEA/D variant and validate the best-suited neighborhood mechanisms found by irace.

3 Conclusion and Perspectives

Three variants are compared. $Ref_{MOEA/D}$ is MOEA/D with the basic local search (i.e. *best* as exploration strategy and Euclidean distance as metric). $LS_{MOEA/D}$ is MOEA/D with the first-best strategy and the metric with variable weights. $KD\text{-}LS_{MOEA/D}$ is $LS_{MOEA/D}$ with the KD mechanism. For $LS_{MOEA/D}$ and $KD\text{-}LS_{MOEA/D}$, the strategy and the metric were chosen by irace during the tuning phase. The results obtained are available in Table 1. The results show that using the *first-best* strategy with the metric proposed leads to better results than using the *best* strategy with only the Euclidean distance as a metric. Moreover, the variant with the Knowledge Discovery mechanism also benefits from the strategy and the metric proposed.

In future works, we will investigate the adaptive side of the algorithm by automatically updating some parameters during the execution of the algorithm.

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