A Multiobjectivization Approach for Vehicle Routing Problems

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Abstract. This paper presents a new approach for vehicle routing problems (VRPs), which are defined as problems of minimizing the total travel distance. The proposed approach treats VRPs as multi-objective problems using the concept of multiobjectivization. The multiobjectivization approach translates single-objective optimization problems into multi-objective optimization problems and then applies EMO to the translated problem. In the proposed approach, a newly defined objective related to assignment of customers is added, because the assignment has a more important influence on the search results than routing in VRPs. We investigated the characteristics and effectiveness of the proposed approaches by comparing the performance on conventional approaches and the proposed approaches.

Keywords: Vehicle Routing Problems(VRPs), Multiobjectivization.

1 Introduction

Vehicle Routing Problems (VRPs) are well known combinatorial optimization problems arising in many distribution and transportation systems, such as postal delivery, school bus routing, newspaper distribution, etc. VRPs have attracted a great deal of attention in recent years due to their wide applicability and economic importance.

VRPs can be described as the problem of minimizing the route cost from one depot to a set of geographically scattered customers (points, cities, stores, etc.). The routes must be designed in such a way that each customer is visited only once by exactly one vehicle, all routes start and end at the depot, and the total demands of any route must not exceed the capacity of the vehicle. In general, the objective of VRPs is to find the minimum number of routes or the minimum total travel distance [2]. As VRPs are good for exercising new heuristic search techniques and have a high degree of complexity, metaheuristics such as Local Search (LS) [1], Tabu Search (TS) and Genetic Algorithms (GA) [10] have been proposed over the last number of years [2].

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On the other hand, there has been a great deal of progress in the study of evolutionary computation of multi-objective optimization (EMO) over the last decade [5]. In the field of EMO, there have been a few reports concerning the unique approach of "multiobjectivization" [7]. The multiobjectivization approach translates single-objective optimization problems into multi-objective optimization problems and then applies EMO to the translated problem. The most important feature of multiobjectivization is that it provides more freedom to explore and to reduce the likelihood of becoming trapped in local optima by adding additional objectives.

In this paper, we propose a new approach for VRPs, which treats VRPs as multi-objective problems using the concept of multiobjectivization. There have been many studies using EMO to optimize multi-objective VRPs [9], with objectives including the number of routes and total travel distance or number of routes and duration of routes, etc. In these studies, EMO treats the original objective of VRPs directly as multi-objective.

On the other hand, our approach deals not only with the original objective of VRPs but also with newly defined objectives related to assignment of customers. Generally, VRPs seem to have two different determinations: the assignment of customers and the order of the route. The assignment of customers is known to have a stronger influence on the search than the order of the route in many studies [6]. Therefore, we expect that the proposed approach will get better solutions in minimization of the total travel distance than the approach using only the total travel distance as a single objective.

Main concern of this multiobjectivization is whether additional objectives will work to accelerate the search in the original problem. We investigated the characteristics and effectiveness of the proposed approach by comparing the performance of the conventional approach and multiobjectivization approach. In numerical experiments, we used Taillard's test functions as a benchmark problem. In addition, we used NSGA-II reported by Deb et al. [3] in implementing our approach. Through numerical examples, we showed that the proposed multiobjectivization approach can obtain the solution with good quality and little variation in VRPs.

2 Vehicle Routing Problem

This paper deals with the most elementary version of VRPs, the capacitated VRPs (CVRPs), which can be described as follows [2]:

- All vehicles start from the depot and visit the assigned customer points, then return to the depot. Here, a route is formed by the sequence of the depot and the customer points visited by a vehicle. Therefore the number of vehicles is same as the number of route. Moreover, each customer is visited only once by exactly one vehicle.