A Modified Kruskal’s Algorithm to Improve Genetic Search for Open Vehicle Routing Problem

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ABSTRACT

This article has proposed a modified Kruskal’s method to increase the efficiency of a genetic algorithm to determine the path of least distance starting from a central point to solve the open vehicle routing problem. In a vehicle routing problem, vehicles start from a central point and several customers placed in different locations to serve their demands and return to the central point. In the case of the open vehicle routing problem, the vehicles do not go back to the central point after serving the customers. The challenge is to reduce the number of vehicles used and the distance travelled simultaneously. The proposed method applies genetic algorithms to find the set of customers those are covered by a particular vehicle and the authors have applied the proposed modified Kruskal’s method for local routing optimization. The results of the new method are analyzed in comparison with some of the evolutionary methods.

KEYWORDS
Evolutionary Computation, Genetic Algorithms, Road Transportation, Shortest Path Problem, Vehicle Routing

INTRODUCTION

In today’s competitive world, distribution of goods is one of the important processes and it is the central focus point in the supply chain and logistics fields. Numerous companies are known for significant drops of their running costs due to the efficient coping with distribution networks. Therefore, several studies and research works are continuing to model and solve transportation problems, especially vehicle routing problems (VRPs) which are an extension of travelling salesman problem (TSP) (Martinovis & Bajer, 2012). There are several papers on TSP. Recently, Dong et al. (2016) have developed a new method to solve a special type of TSP problem. The challenge in Vehicle Routing Problem is to determine some set of paths for all the vehicles used to serve the customers. The open type of VRP is called open vehicle routing problem (OVRP) in which vehicles are not return back to the central hub called depot after visiting all the customers. Several publications applying different types of heuristic and metaheuristic methods for this problem have already been released. Brandao DOI: 10.4018/IJBAN.2019010104

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(2004) and Fu et al. (2005) used tabu search (TS) in the Open Vehicle Routing Problem having some limitations on capacity of vehicles and distance travelled. Tarantilis et al. (2005) used the list-based threshold accepting method to solve the Open Vehicle Routing Problem (OVRP) and this method also proposed how to solve the OVRP with more than one depots (Tarantilis & Kiranoudis, 2002). Pisinger and Ropke (2007) also proposed a heuristic based on neighborhoods search in this type of problem. Li et al. (2007) presented a travelling heuristic and a deterministic type of simulated annealing method in this problem. Fleszar et al. (2009) also designed a search method based on variable neighborhoods for the OVRP. Cao & Lai (2010) had designed OVRP with fuzzy demands. Zachariadis and Kiranoudis (2010) presented new a metaheuristic which is basically one type of local search technique. Li et al. (2012) used a variety of tabu search algorithm with metaheuristic of multi start adaptive memory programming in OVRP with heterogeneous type of vehicles, in which the capacity and costs per unit distance of vehicles are heterogeneous. Recently Marinakis and Marinaki, (2011) proposed a new algorithm for OVRP by mimicking the mating procedure of bee.

The original form of VRP uses one central point called depot and all the vehicles has to start from that and return back to it after giving the services to their customers. Every customer will be in different locations and they will have some demands. Every vehicle has to visit and give service to a set of customers assigned to that vehicle and there is a constraint in the capacity of those vehicles (Chiang & Hsu, 2014). OVRP was first introduced by Sariklis and Powell (2000). It is encountered in many real situations, for example, the organizations that hire vehicles from other transport organizations and in this case, those vehicles need not require returning to the depot after the completion of service (Cao & Lai, 2010) (Lin et al., 2014). But the situations where the vehicles have to return back, they follow the same route in which they came and then the visiting of customers will be just the opposite order. This fact implies that the OVRP is a case of searching the Hamiltonian path for all the vehicles whereas the basic form of VRP is a case of searching the Hamiltonian cycle for all the vehicles. So OVRP can be designed as a problem of finding the least distance Hamiltonian path for all the vehicles used where there will be only one central depot from where the vehicles start (Aksen, Özuyurt, & Aras, 2007). This problem is NP hard as any type of the Hamiltonian path problem is just a modified version of the TSP problem that is basically a NP hard problem (Reinelt, 1994). So like TSP, the Open Vehicle Routing Problem is also not an easy problem to solve. In terms of the motive of the OVRP, all the researchers make an assumption that the price of hiring an extra vehicle increases the transportation cost due to this extra route (Fu, Eglese, & Li, 2005). At the duration of 1980 and 1990, very little work has been published on OVRP in the field of operation research and computer science. But after that period and still now many researchers are working in this area and several variety of VRP is developed.

The Vehicle Routing Problem (VRP) is in its simple form can be represented as a problem of finding the shortest sub routes for all the vehicles started from a central location called depot and visit a set of customers assigned to them to provide the service. The VRP in its simple form is also known as the Capacitated Vehicle Routing Problem (CVRP). Dantzig and Ramser (1959) introduced first time the concept of CVRP. After that several types of CVRP has been designed by considering several constraints depending on the real life scenario like time windows, uncertainty in demands, multi depot, dynamic demand, heterogeneous vehicles. Ali et al. (2016) have developed a new method to solve VRP by reducing the uncertainty. Afshar-Nadjafi and Afshar-Nadjafi (2016) have published a paper on time dependent multi depot VRP with other constraints. They have used simulated annealing method. Kim et al. (2016) have proposed a dynamic VRP considering the constraint of traffic congestion. Wang et al. (2016) have proposed a multi objective VRP with several constraints. Here they have taken five objectives and applied multi objective memetic algorithm. Kritzinger et al. (2017) have designed a unified framework for generalized VRP. Yi et al. (2017) have introduced a new vehicle routing problem having some new constraints of one dimension. This is applicable in automotive industries. Şevkli and Güler (2017) have published a paper on solving methodology to the newspaper delivery optimization. This is a real-life example of VRP. Montoya et al. (2017) have extended the
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