A Hybrid Meta-heuristic Algorithm for the Vehicle Routing Problem with Simultaneous Delivery and Pick-up

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ABSTRACT

Vehicle routing problem (VRP) is an important issue that has much used for productivity and efficiency of transportation systems in recent decades. One of the most popular and widely used developments VRP is the vehicle routing problem with simultaneous delivery and pick-up (VRPSPD). In other words, each customer simultaneously receives and sends goods. The proposed procedure is a combination of the three heuristic: nearest neighbor algorithm, cheapest insertions, genetic algorithm. The first two algorithms with a random method provided the initial solution for the third algorithm. A probability function has been developed in the nearest neighbors and cheapest insertions to construct better solutions as well as operations proposed for the genetic algorithm to increase the search space and avoiding local optimizations. The proposed algorithms have implemented on forty different standard examples. By comparing, the results obtained from the best available solutions than other algorithms, improvement observed in some examples.

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1- Intruduction

Vehicle routing problem with simultaneous pick-up and delivery (VRPSPD) has a similar fleet of vehicles, a specific set of customers, each with two requests: one for collection and for delivery and one for warehouse. To find routes with the shortest distance covered by the vehicle so that the following conditions are true:

1) Every vehicle is exactly travel one path.

2) Each customer fully serviced only by one of the vehicles (receiving and delivery).

3) Total demand is received and collected in any direction must not exceed the vehicle's capacity.

Vehicle routing problem with simultaneous pick-up and delivery introduced first time by Dantzig and Ramser in 1959 [1]. Min defined a new limit for vehicle routing problem in 1989 [2]. After a long period of time, Salhi and Nagi solved vehicle routing problem with simultaneous pick-up and delivery uses a heuristic method in 1999 [3]. In 2002, Angelelli and Mansini introduced time limit for vehicle routing problem with simultaneous pick-up and delivery. Their research is the first and only study to use an exact algorithm to solve the original problem [5].

Another method of solving vehicle routing problem with simultaneous pick-up and delivery was an algorithm presented by Tang and Galva (2006) [6]. They proposed tabu-search meta-heuristic algorithm with double fine.

In 2009, Gajpal et al. used an improved ant colony system for solving vehicle routing problem with simultaneous pick-up and delivery [7].

In 2011, Zachariadis presented a meta-heuristic algorithm for solving vehicle routing problem with simultaneous pick-up and delivery [8]. In this algorithm, he used local search meta-heuristic algorithm to find neighborhood's answers.

This paper presents a hybrid meta-heuristic algorithm to solve vehicle routing problem with simultaneous pick-up and delivery. This method is a combination of meta-heuristic algorithm and has not been seen in previous studies.

2- Methodology

Vehicle routing problem can be expressed by a graph $G=(V,E)$ where $V=\{0,...,n\}$ is set of nodes and E is the set of links between nodes. Target's function of this problem is to minimize the distance traveled by the vehicle. An algorithm used in this paper for solving vehicle routing problem with simultaneous pick-up and delivery is based on the genetic method in which is using meta-heuristic method for build the first generation. Three algorithms used in this paper:

1) Randomized algorithm

2) Nearest neighbor algorithm

3) Cheapest insertions algorithm

In this study, a function which used to control chromosomes were changed by the operator. This function defined control limits for vehicle routing problem with simultaneous pick-up and delivery which recognize justified or non-justified chromosomes, if unjustified chromosome is detected, the operator can produce another chromosome. This chromosome was controlled again. This process continues until justified chromosome has to be created.

In this study, to evaluate the proposed algorithm, the Dethloff standard examples (2001) [4] are used. These examples have fifty customers with two different scenarios are based on geographic location. In SCA scenario, costumer's coordination is distributed steadily in the range (0 to 100). In CON scenario, half of customers in the same way of SCA and the other half is distributed steadily in the range (100.3 to 200.3). To run algorithms, MATLAB software was used.

3- Discussion and results

The results from the proposed algorithm (Rahimi and Rajabi, 2013) on Dethloff examples [4], compare with best method in the world until 2012. Graphs shown in Figs. 1 and 2 indicated that results from the proposed algorithm are close compared with results from other algorithms. Comparing the results with previous studies, indicate that proposed algorithm in CON 8-1, CON 8-5 and CON 8-6 was 0.55, 0.44 and 0.55 percent respectively and the obtained answer is better than the best solutions available in the world. 1.18 unit mean improvements achieved in the answers, showing the quality of results obtained in this paper.

4- Conclusions

In this paper, the hybrid meta-heuristic method for solving vehicle routing problem with simultaneous pick-up and delivery was presented. In this method, three algorithms randomized, nearest neighbor and cheapest insertions were used for generate answers. The results obtained were used for the
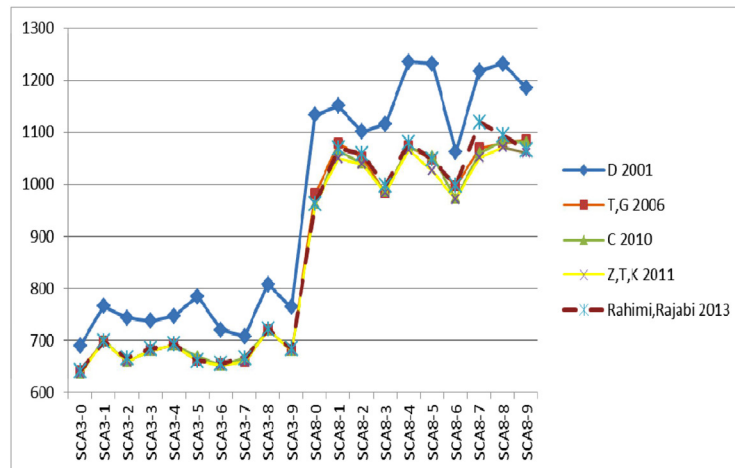
Fig. 1. Comparison of results obtained from proposed algorithm with other algorithms in SCA scenario
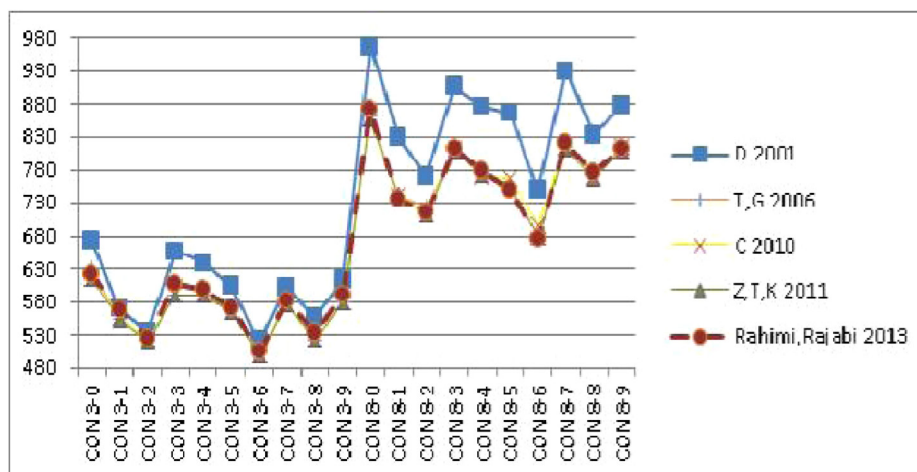

Fig. 2. Comparison of results obtained from proposed algorithm with other algorithms in CON scenario

initial population of the genetic algorithm. In each algorithm, the initiative was done to achieve a better answer. Then the answers were improved using a genetic algorithm. The proposed method has gained good answers for this problem's standard examples. This method improved the best answers available in the world for three standard examples and has close competition with other algorithms.

5- Refrences

[1] Dantzig, G. B. and Ramser, R. H.; "The Truck Dispatching Problem," *Management Science*, Vol. 6, No. 1, pp. 80–91, 1958.

[2] Min, H.; "The Multiple the Vehicle Routing Problem with Simultaneous Delivery and Pick-up Points," *Transportation Research-Part A*, Vol. 23, No. 5, pp. 377–386, 1989.

[3] Salhi, S. and Nagy, G. "A Cluster Insertion Heuristic for Single and Multiple Depot Vehicle Routing Problems with Backhauling," *Journal of the Operational Research Society*, Vol. 50, No. 10, pp. 1034–1042, 1999

[4] Dethloff, J.; "Vehicle Routing and Reverse Logistics: The Vehicle Routing Problem with Simultaneous Delivery and Pick-up," *OR Spektrum*, Vol. 23, No. 1, pp. 79–96, 2001.

[5] Angelelli, E. and Mansini, R.; "The Vehicle Routing Problem with Time Windows and Simultaneous Pick-up and Delivery," *Quantitative Approaches to Distribution Logistics and Supply Chain Management, Lecture Notes in Economics and Mathematical Systems*, Springer-Verlag, pp. 249–267, 2002.

[6] Tang-Montane, F. A. and Galvao, R. D.; "A Tabu Search Algorithm for the Vehicle Routing Problem with Simultaneous Pick-up and Delivery Service,"

Computers and Operations Research, Vol. 33, No. 3, pp. 595–619, 2006.

[7] Gajpal, Y. and Abad, P.; "An Ant Colony System (ACS) for Vehicle Routing Problem with Simultaneous Delivery and Pick-up," *Computers and Operations Research*, Vol. 36, No. 12, pp. 3215–3223, 2009.

[8] Zachariadis, E. E. and Kiranoudis, C. T.; "A Local Search Meta-heuristic Algorithm for the Vehicle Routing Problem with Simultaneous Pick-ups and Deliveries," *Expert Systems with Applications*, Vol. 38, No. 3, pp. 2717–2726, 2011.