An Application of GA Algorithm on Vehicle Routing Problem in a Case Study of a Bakery Company in Thailand

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Abstract

This research considers the vehicle routing problem in a specific bakery making company where is located in Bangkok. This company has to produce and deliver the bakeries to its customers everyday. Until now, this mentioned company generates the delivery's route by using the experience taken from the company's truck driver. The company has to daily use the route with unnecessary long distances. According to the given statement, this research aims to develop algorithm to generate the delivery route for this company by using the Genetic Algorithm in order to minimize the transportation distances.

Key words: VRP, Vehicle Routing Problem, GA, Genetic Algorithm, Optimization

1. Introduction

The classical Vehicle Routing Problem (VRP) [1] consists of a single depot and a predefined number of customers. The single depot mentioned above has a predefined number of vehicles in order to deliver its products. Each customer in VRP requires a specific number of products which will be delivered from the depot through a vehicle. The capacity of each vehicle is limited, and, as a consequence, one vehicle can serve only a limited number of customers within one single route. The objective of the VRP problem is to find the delivery's route that minimizes the total distances.

Later on, corresponding to the real world applications, many variants of VRP problem have been introduced such as the VRP with pickups-first and deliveries-second [2, 3], the VRP with mixed pickups and deliveries [4, 5], and VRP with simultaneous deliveries and pickups [6, 7].

This paper considers a real application of the VRP problem taken from a specific bakery making company located in Bangkok. Similar to the classical VRP, the VRP problem of this bakery company consists of a single depot with a large number of vehicles and 32 customers. The demand of each customer may or may not be the same with the demand of the other customer. Although there are various types of bakeries in this problem, the bakeries from different types can be packed in a same package, called break case, before delivery. Hence, the VRP considered in this paper will define a break case as a single unit of product in order to simplify the problem. Each vehicle can loads 90 break cases as the maximum capacity. Each vehicle starts and ends its route at the depot, passing the subset of all customers.

In current situation, the company uses the nearest neighbor heuristic [8], based on the experience of vehicle's driver, which generate the route with unnecessarily long total distances. Therefore this paper's objective is to develop the algorithm which generates better route for the company. The algorithm developed in this research is based on Genetic Algorithm (GA). The reason behind the selection of GA in this research is that GA has been successful in many real applications [9, 10].

This paper is organized as follows: Section 2 describes the VRP problem in the specific bakery making company. Section 3 presents the GA algorithm proposed in this research for the VRP problem of the bakery making company. Section 4 presents the numerical comparison between the nearest neighbor heuristic and the proposed GA on the considered VRP problem. Eventually, Section 5 presents the conclusions of the findings from this paper.

2. VRP in the Specific Bakery Making Company

As mentioned before, the VRP problem of the bakery making company is a classical VRP problem that uses the real data from the company. The detail of this specific problem is described as follows. The problem has one depot which is located at Soi. Chockchairuammit in the coordinate (13.796146N, 100.567185E). There are 32 customers which are located in Bangkok Metropolitan as follows:

1. Suppavut Bangna (13.67311, 100.6055)
2. Jarunsanitwong (13.77878, 100.4867)
3. Pratanporn (14.00889, 100.61493)
4. Sukhumvit 107 (13.65853, 100.60104)
5. Ramkhamhaeng 34 (13.7614, 100.63657)
6. Petkasem 33 (13.71329, 100.43946)

7. Petburi 39 (13.7500, 100.5566)
8. Rangsit1 (14.07567, 100.61741)
9. Tait (13.88064, 100.45882)
10. Lido (13.74556, 100.53254)
11. Tharakorn (13.79738, 100.71173)
12. Nanajaruen (13.97072, 100.6449)
13. Pongeum (13.61768, 100.74333)
14. Rangsit 2 (13.98789, 100.61602)
15. Sintong (13.86516, 100.48235)
16. Teparuk (13.61834, 100.64922)
17. Talad Nikom (13.561, 100.67187)
18. Ladkrabang (13.72169, 100.78391)
19. Wattananan (13.91315, 100.59043)
20. Piboonwit (13.68692, 100.44407)
21. Kingkueng (13.63455, 100.71107)
22. Kaha 9 (13.57378, 100.79309)
23. Salaya (13.79363, 100.32026)
24. Hualampong (13.73752, 100.51736)
25. Ramkhamhaeng65(13.7661,100.623)
26. Saitaimai 2 (13.79346, 100.42583)
27. Saitaimai 3 (13.79346, 100.42583)
28. Khao San (13.75958, 100.49571)
29.Rangsit Pirom (14.04007,100.61607)
30. Jangwattana (13.88251, 100.58497)
31.Sriboonrueng (13.72784, 100.53335)
32. Tepleela (13.75757, 100.61528)

In order to find the distance from the depot to a customer or the distance from a customer to one another customer, it can be found by inserting the coordinates into Google Earth, and then Google Earth will return the distance.

The depot of this specific problem has very high capacities; thus, it can be assumed that the depot has unlimited capacities. In addition, this depot has a large number of vehicles; thus this research will assume the number of vehicles to be unlimited. Each vehicle is able to contain 90 break cases as its maximum capacities.

In this problem, the following condition must be satisfied: (1) Each vehicle has to start its route from the depot and end its route at the depot; (2) Each customer must be visited by exactly one vehicle; (3) The demand of each customer must be satisfied. The objective of this problem is to find the routes of all vehicles, which minimize the total distances.

3. Proposed GA Algorithm

This research proposes a GA algorithm for solving the specific VRP problem of the bakery making company mentioned in Section 2. The flow chart of the proposed GA is shown in Figure 1.

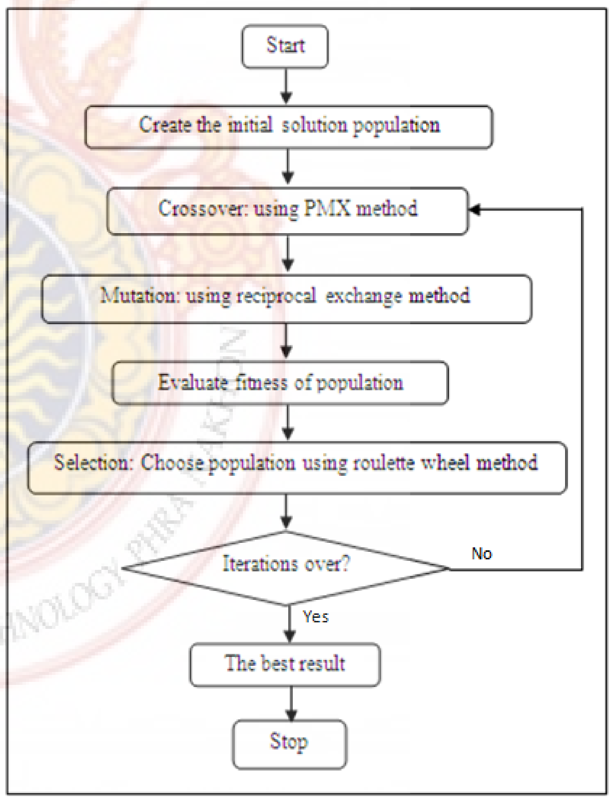

Fig. 1 Flowchart of the proposed GA

The steps shown in Figure 1 are described in the sub-sections below. Section 3.1 presents the solution representation. Section 3.2 presents population initialization. Section 3.3 presents genetic operators used in the proposed GA algorithm.

3.1 Solution representation

In this proposed GA, a chromosome consists of several routes, each of which contains a subset of customers that should be visited in the same order as they appear. Every customer has to be a member of exactly one route. Figure 2 illustrates the solution representation described above.

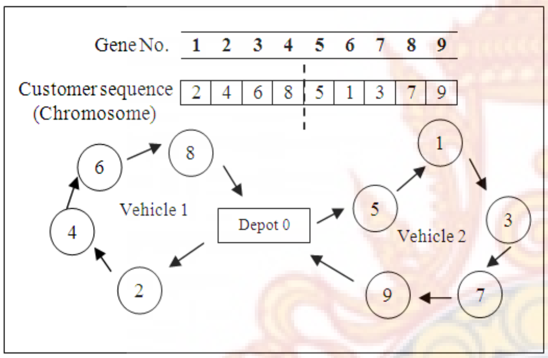

Fig. 2 An illustration of the solution representation.

3.2 Population initialization

This GA proposed in this paper randomly generates the initial population by using nearest neighbor heuristic [8]. In addition, the number of chromosomes in the initial population is equal to the number of customers so that the population size equals to 32 chromosomes.

3.3 Genetic operators

The operators used in the proposed GA algorithm include crossover, mutation and selection. The details of these three operators are described as follows.

- *Crossover*

The partial-mapped crossover (PMX) [12] is applied in the proposed GA. The procedure of PMX given in [13] is as follows: (1) Uniform-randomly select two positions, i.e. genes, along with the string, i.e. chromosome. The sub-strings defined by the two positions are called the mapping sections; (2) Exchange two strings between parents to produce proto-children; (3) Determine the mapping relationship between two sections; (4) Legalize offspring with the mapping relationship. An illustration of this crossover is given in Figure 3.

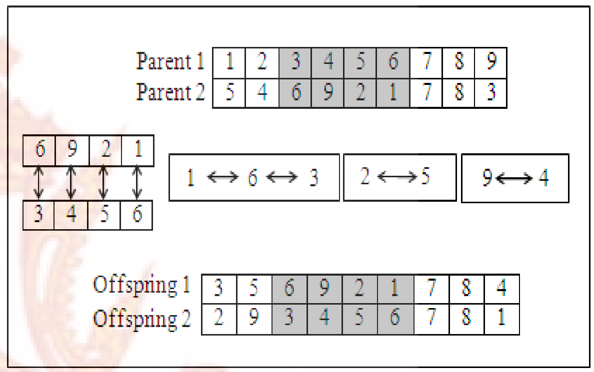

Fig. 3 An Illustration of PMX

- *Mutation*

The mutation operator used in this proposed GA is the reciprocal exchange method. In reciprocal exchange, two genes are selected randomly, and these two genes selected will be replaced by each other. An illustration is given in Figure 4.

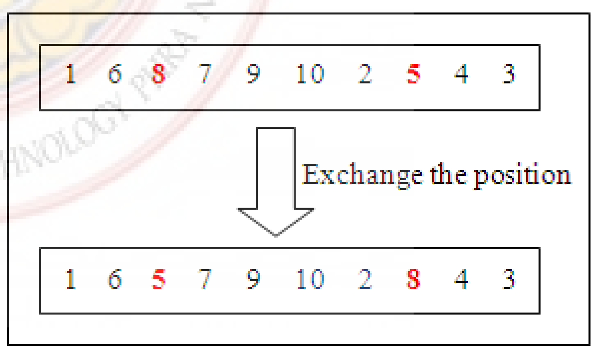

Fig. 4 Illustration of Reciprocal Exchange Mutation

- *Selection*

The proposed GA uses the roulette wheel selection [14] to create the next generation via crossover and mutation. The probability of choosing an individual is directly proportional to its fitness value. As a consequence, the chromosome with the largest fitness value becomes more likely to be selected as a parent than one with a small fitness value. An example of the roulette wheel selection is shown in Figure 5.

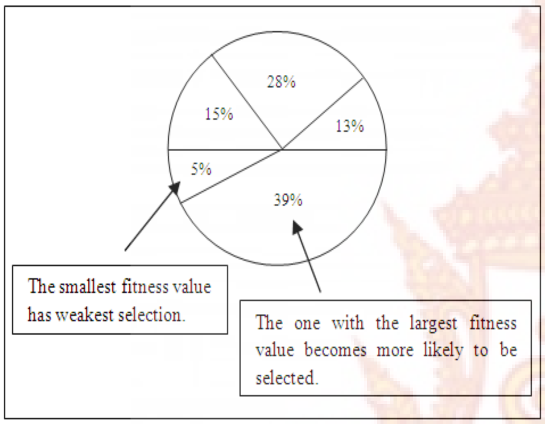

Fig. 5 An Illustration of roulette wheel selection

4. Numerical Experiment

In this research, the parameter values of the proposed GA are given below:

- Number of genes = 32.
- Number of chromosomes = 32.
- Crossover rate = 100%.
- Mutation rate = 100%.
- Population size = 96, including the number of original chromosomes, the number of chromosome taken from crossover, and the number of chromosome taken from mutations.
- The probability of choosing an individual in the roulette wheel selection is directly proportional to its fitness value. For chromosome k with total distance f_k, with its selection probability p_k is calculated as in equation (1).

$$p_k = 1 - \left(\frac{f_k}{\sum_{j=1}^{96} f_j} \right) \qquad (1)$$

- Stopping criterion = 10,000 generations.

This GA will be evaluated on many instances. These instances can be classified, based on level of customer demand, into three categories — Low, Medium and High. Each category contains 30 instances. In Low category, the demand of each customer is randomly given within the range of three through nine break cases. In Medium category, the demand of each customer is randomly assigned within the range of 10 through 15 break cases. In High category, the demand of each customer is randomly given within the range of 16 through 22 break cases. The proposed GA algorithm is coded by using Visual Basic Application (VBA) on Intel Core 2 duo 1.80 GHz CPU speeds and 1 GB of RAM.

In order to evaluate the algorithm's performance, the experimental result taken from the proposed GA will be compared to those taken from the nearest neighbor heuristic as shown in Table 1.

Table 1 average total distance in kilometers from 30 runs

Category	Nearest Neighbor	Proposed GA
Low	559.00	514.93
Medium	574.63	553.13
High	741.10	680.67

5. Conclusions

As shown in Table 1, the results of the proposed GA algorithm are better than those of the nearest neighbor heuristic in all the three categories. In Low category, the improvement given by GA is 7.88%; in Medium category, the improvement given by GA is 3.74%: and in Low category, the improvement given by GA is 8.15%. Thus, based on the information given above, the proposed GA algorithm outperforms the nearest neighbor heuristic on the VRP problem of the specific bakery making company.

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