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The Optimization of Semi Finished Garment Distribution of Forboys SME in Pandeglang Area Using Genetic Algorithm

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Abstract. Distribution is one of crucial activities for a company because it will benefit the company from the sales of its distributed products. One way to facilitate distribution is determining an optimal route. Determining an optimal route is an important issue to solve since it can affect vehicle operating cost and time. Moreover, it is required to obtain an efficient route. This research deals with the optimization of distribution route of a garment SME located in Pandeglang, namely Forboys (FBS), who produces children's clothing. This research attempts to seek which route is best for distributing semi-finished goods from FBS Warehouse to each CMT in Pandeglang, so as to minimize the cost incurred. In order to distribute semi-finished goods quickly, an efficient distribution route from FBS Warehouse to each CMT is required. This research is conducted uses Genetic Algorithm method. Genetic algorithm which is reliable in producing optimal output that can be used to solve the most appropriate for this type of problem. Based on the results of the research, the optimum route is found to be the one starting the delivery from FBS Warehouse - CMT 3 - CMT 2 - CMT 1 and back to FBS Warehouse, with a total distance of 205.5 km and the cost incurred for each distribution of IDR 386,500.
Keywords: distribution, genetic algorithm, optimal route

1. Introduction

Each company must be good at cost management, as well as at its distribution, by spending outcome as little as possible but still getting income as optimal as possible. Distribution is an activity of moving goods or service from producer to the final customer through distribution channels on time [1]. Companies must distribute their products to the customers quickly with minimal cost. Point depot and the determination of the route is the problems that commonly encountered in distribution [2].

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In this case, a matter that can be considered is the determination of the distance or route taken during the distribution.

The determination of the optimal route is one of the problems encountered by Forboys (FBS) SME that has a depot or distribution centre located in Pandeglang. Currently, FBS SME distributes semi-finished goods to Pandeglang (Petir and Baros area). Each collector of each CMT (Cut, Make and Trim or tailor) pick up the goods to be sewn and subsequent to sewing, each CMT will send back the goods to depot 1 or FBS Warehouse. The distribution is carried out every Friday, including sending finished goods and semi-finished goods to sew for a week ahead. Thus, FBS SME wants to have an optimal route and count its distribution cost if it is done from FBS Warehouse to each CMT located in Pandeglang. In this research, it is necessary to solve the problem of the optimization of the distribution route to each CMT in Pandeglang. Therefore, the determination of the optimal route for FBS SME is performed using Genetic Algorithm method.

2. Methods

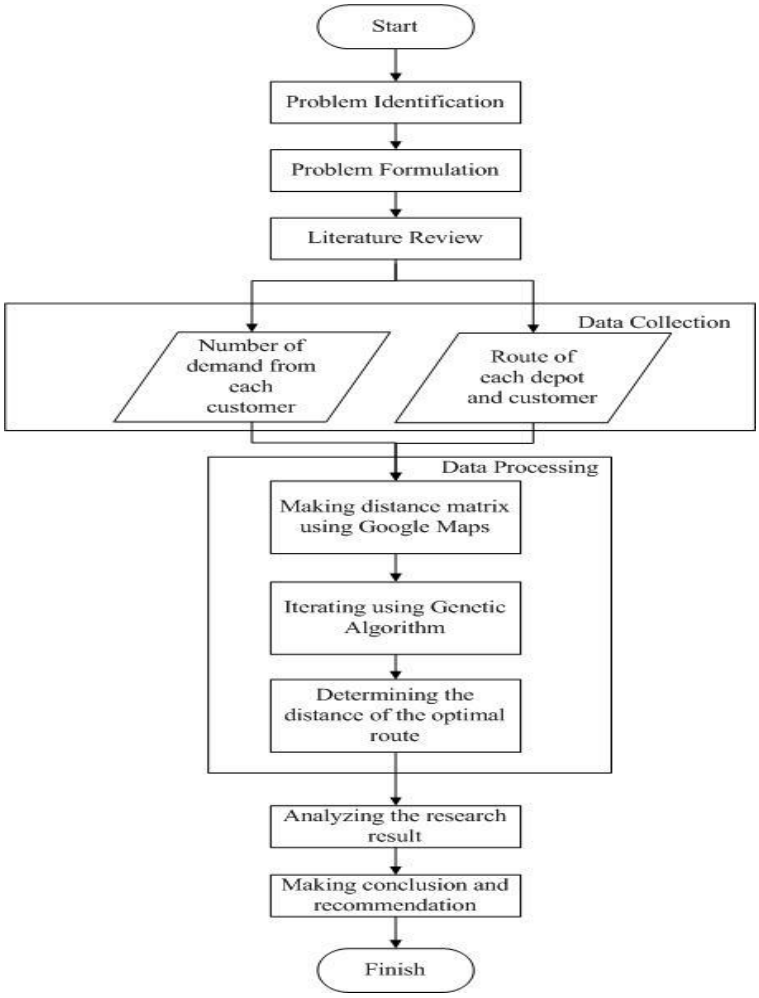

Figure 1. Research Metodology

The first stage performed in this research is identifying the problem by synthesizing ones occurring in the distribution of Forboys' semi-finished goods to every CMT in Pandeglang. Afterwards, we formulate the

problems and determine how the literature review shall be conducted. Furthermore, all data concerning the number of demands from each customer and the route of each depot are collected to determine customer demand. The next stage is forecasting routes for a month (March) as many as 20 PO and collecting data of route for each depot and customer by finding out the location of each depot and CMT. The data collection stage includes making distance-matrix using Google Maps by means of inputting the distance travelled from each depot to the customer and between customers. After collecting the entire data, calculation is made using Genetic Algorithm. This Genetic Algorithm stage includes making initial population, objective function evaluation, adjusting the criteria of the optimization, selection, crossover and mutation, determining new population, and determining the best individual to find the optimal route of the depot. The analysis of the results of the calculation of the optimum route distance for the distribution of semi-finished goods from the depot to each CMT of Forboys SME in Pandeglang is done in this research using Genetic Algorithm. At the end of the research, the best route for the distribution from the depot to each CMT can be concluded.

3. Results and Discussion

3.1 Forecasting

At this stage, forecasting is done using Exponential Smoothing method. It is done by collecting data six month earlier, from September to February 2018. Forecasting is done to determine how many orders will be made in March 2018. Here are the forecasting results of each CMT:

Table 1. Forecasting of CMT 1

Month (2018)	Time Index	Actual Demand	Forecasting
September	1	1767	5040
October	2	1131	2094
November	3	2592	1227
December	4	11907	2456
January	5	8388	10962
February	6	4452	8645
March	7		4871
Total		30237	

Table 2. Forecasting of CMT 2

Month (2018)	Time Index	Actual Demand	Forecasting
September	1	0	2477
October	2	0	248
November	3	0	25
December	4	1440	2
January	5	9504	1296
February	6	6396	8683
March	7		6625
Total		17340	

Table 3. Forecasting of CMT 3

Month (2018)	Time Index	Actual Demand	Forecasting
September	1	0	2793
October	2	0	279
November	3	1548	28
December	4	7542	1396
January	5	3600	6927
February	6	4068	3933

March	7		4054
Total		16758	

Table 4. Number of Customer Demands for each CMT

The name of CMT	Demand			Total maximum capacity
	PO	DZ	PCS	PO
CMT 1	6,00	405,92	4871	20
CMT 2	8,00	552,08	6625	
CMT 3	5,00	337,83	4054	
Total	19,00			

3.2 Genetic Algorithm

At this stage, the calculation using Genetic Algorithm requires the data of the distance-matrix from the depot to the customer and between customers. The distance matrix in Table 5 is obtained using Google Maps app. Here is the distance matrix for each route:

Table 5. Distance Matrix from FBS Warehouse to each Customer

Distances Matrix	Depot 1 (FBS Warehouse)	CMT 1	CMT 2	CMT 3
From/To	**1**	**2**	**3**	**4**
1	0	84,7	102	98,4
2	84,7	0	10,8	22,4
3	102	10,8	0	11,6
4	98,4	22,4	11,6	0

3.2.1 Initial Population

At this stage, the determination of initial population is conducted using encoding technique. Encoding technique used in this research includes permutation encoding and value encoding. In permutation encoding, there is a chromosome consisting of a set of numbers representing the sequence of the route's position. While in value encoding, each depot and CMT is represented by a number; the number is a gene contained in each chromosome. The following is the value encoding in this research:

Table 6. Value encoding of depot and CMT in Pandeglang

Encoding	
FBS Warehouses	1
CMT 1	2
CMT 2	3
CMT 3	4

After determining encoding as shown in Table 6, the chromosome of each number or location is determined for the route formation. FBS warehouse is not included in the genes, assuming that the initial town is also the final town of the distribution. The following is Table 7, showing the initial population of Genetic Algorithm completion:

Table 7. The Formation of Initial Population

Chromosome -	Chromosome form		
1	2	3	4

2	3	2	4
3	3	4	2
4	2	4	3
5	4	2	3
6	4	3	2

3.2.2 Selection

At selection stage, the first thing to do is to calculate fitness value. Fitness value in Table 8 is obtained from the total distance traveled according to the chromosomes in the initial population. Here are the Fitness values for the initial population:

Table 8. Fitness values of the Initial Population

Fitness Value	
Chromosome [1]	205,5
Chromosome [2]	230
Chromosome [3]	220,7
Chromosome [4]	220,7
Chromosome [5]	233,6
Chromosome [6]	205,5

The calculation to get the population inverse values from the values in Table 9 is as follows [3]:

$$Q(i) = \frac{1}{Fitness\ (i)} \quad (1)$$

Table 9. Inverse Values of the Initial Population

Q [1]	0,005
Q [2]	0,004
Q [3]	0,005
Q [4]	0,005
Q [5]	0,004
Q [6]	0,005
Total Q	0,027

Further more, the calculation to get Probability values of Fitness Values is as follows:

$$P(i) = \frac{Qi}{Total\ Q} \quad (2)$$

Table 10. Probability of Fitness Values

Probability	
P [1]	0,177
P [2]	0,159
P [3]	0,165
P [4]	0,165
P [5]	0,156
P [6]	0,177

3.2.3 Cross Over

At this crossover stage, the first thing to do is to accumulate the probability value of the fitness values from chromosome [1] to chromosome [6]. The following is Table 11 showing the results of the accumulation of probability values:

Table 11. Cumulative Values of Fitness Probability

Cumulative value	
C [1]	0,177
C [2]	0,336
C [3]	0,501
C [4]	0,666
C [5]	0,823
C [6]	1,000

After obtaining cumulative values, random numbers are generated for all existing chromosomes. The following are the results of the random numbers:

Table 12. Random Values

Random values	
R [1]	0,861
R [2]	0,170
R [3]	0,641
R [4]	0,484
R [5]	0,543
R [6]	0,141

The first stage to determine the chromosome required for the crossover is comparing the cumulative probability values and random values. The chromosome will be crossed if the random number is smaller than the cumulative probability number. Subsequent to determining the pair, the determination of the crossing site or the part to be crossed is performed by generating random numbers from 1 to m-1 in which m is the length of the sub chromosome, with a crossover probability value of 0.5. The value of the probability of crossover that good is ranged from 0.85% to 95% [4]. After determining these, the next thing to do is to cross. The following is the process after each chromosome is crossed:

Table 13. The Crossover Process

The crossover process																
Chromosome [1]	=	Chromosome [1]	><	Chromosome [2]	=	**4**	3	2	><	3	2	4	=	**4**	2	3
Chromosome [2]	=	Chromosome [2]	><	Chromosome [6]	=	**3**	2	4	><	2	3	4	=	**3**	4	2
Chromosome [6]	=	Chromosome [6]	><	Chromosome [1]	=	**2**	3	4	><	4	3	2	=	**2**	4	3

The results of the crossover performed in Table 13 shall produce new chromosomes called offspring chromosomes. The following is the result of the crossover that has been conducted:

Table 14. New Population After Crossover

Population after crossover			
Chromosome [1]	4	2	3
Chromosome [2]	3	4	2
Chromosome [3]	2	4	3

Chromosome [4]	3	4	2
Chromosome [5]	4	2	3
Chromosome [6]	2	4	3

3.2.4 Mutation

At this stage, mutation is conducted by generating random numbers for each existing chromosome. These random numbers are obtained by limiting random numbers to the number of genes of all chromosomes. The process of mutation is done by exchanging the mutated part with the location on the right. The following are the results after the mutation:

Table 15. Initial chromosome that has been mutated

The mutation process			
Chromosome [1]	3	2	4
Chromosome [2]	3	4	2
Chromosome [3]	3	4	2
Chromosome [4]	4	3	2
Chromosome [5]	4	2	3
Chromosome [6]	4	2	3

3.2.5 The Distance of the Optimal Route

At the Genetic Algorithm stage, the distance of the optimal route is the final stage for determining which chromosome is strongest in surviving in each iteration performed. In this research, the optimum route result is obtained after 8 iterations. The following is the iteration values obtained:

Table 16. Iteration 1

Fitness value					
Chromosome [1]	3	2	4	=	233,6
Chromosome [2]	3	4	2	=	234,4
Chromosome [3]	3	4	2	=	220,7
Chromosome [4]	4	3	2	=	205,5
Chromosome [5]	4	2	3	=	233,6
Chromosome [6]	4	2	3	=	233,6

Table 17. Iteration 2

Fitness value					
Chromosome [1]	4	2	3	=	233,6
Chromosome [2]	4	2	3	=	233,6
Chromosome [3]	3	2	4	=	233,6
Chromosome [4]	3	2	4	=	233,6
Chromosome [5]	3	4	2	=	220,7
Chromosome [6]	4	3	2	=	205,5

Table 18. Iteration 3

Fitness value					
Chromosome [1]	4	2	3	=	233,6
Chromosome [2]	4	3	2	=	205,5
Chromosome [3]	4	2	3	=	233,6
Chromosome [4]	3	2	4	=	233,6
Chromosome [5]	4	2	3	=	233,6
Chromosome [6]	4	2	3	=	233,6

Table 19. Iteration 4

Fitness value					
Chromosome [1]	2	4	3	=	220,7
Chromosome [2]	2	4	3	=	220,7
Chromosome [3]	3	4	2	=	220,7
Chromosome [4]	3	2	4	=	233,6
Chromosome [5]	4	3	2	=	205,5
Chromosome [6]	3	2	4	=	233,6

Table 20. Iteration 5

Fitness value					
Chromosome [1]	2	4	3	=	220,7
Chromosome [2]	4	2	3	=	233,6
Chromosome [3]	4	3	2	=	205,5
Chromosome [4]	3	4	2	=	220,7
Chromosome [5]	2	4	3	=	220,7

Table 21. Iteration 6

Fitness value					
Chromosome [1]	4	2	3	=	233,6
Chromosome [2]	3	4	2	=	220,7
Chromosome [3]	4	3	2	=	205,5
Chromosome [4]	3	4	2	=	220,7
Chromosome [5]	2	3	4	=	205,5

Chromosome [6]	4	3	2	=	205,5

Table 22. Iteration 7

Fitness value					
Chromosome [1]	2	4	3	=	220,7
Chromosome [2]	2	3	4	=	205,5
Chromosome [3]	4	3	2	=	205,5
Chromosome [4]	2	3	4	=	205,5
Chromosome [5]	3	4	2	=	220,7
Chromosome [6]	4	2	3	=	233,6

Chromosome [6]	4	2	3	=	233,6

Table 23. Iteration 8

Fitness value					
Chromosome [1]	3	2	4	=	230
Chromosome [2]	3	4	2	=	220,7
Chromosome [3]	4	3	2	=	205,5
Chromosome [4]	4	2	3	=	233,6
Chromosome [5]	3	4	2	=	220,7
Chromosome [6]	3	4	2	=	220,7

After performing iterations, it is found that chromosome [3], with 1-4-3-2-1 route, is the best chromosome with a distance of 205.5 km since the location of its optimum route, from iteration 5 to iteration 8, does not change.

After obtaining the optimal route for the distribution of semi-finished goods, the cost needed for each distribution can be calculated. The following is the cost incurred for the delivery from FBS Warehouse to Pandeglang:

Table 24. Distribution Operating Cost

The type of car	Box truck "Colt Diesel 110ps Mitshubisi"	
Gasoline	IDR	154.500
Toll	IDR	82.000
Driver	IDR	150.000
Total	IDR	386.500

4. Conclusion

According to the results of the calculation using Genetic Algorithm, the shortest and the most optimal route for distributing FBS's semi-finished goods to three CMTs, spread in Pandeglang, can be concluded as follows:

1. The shortest optimal route obtained from the results of the calculation is 1-4-3-2-1 with a total distance of 205.5 km, starting from Depot 1 (FBS Warehouse) - CMT 3 - CMT 2 - CMT 1 - back to Depot 1 (FBS Warehouse).
2. The distribution cost incurred by FBS SME for the distribution from FBS Warehouse to all CMTs and back to FBS Warehouse is IDR. 386,500.

5. Acknowledgement

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