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Application for Determining Shipping Routes at Cargo Companies with Genetic Algorithms

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A R T I C L E I N F O

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A B S T R A C T

Consumer needs for speed of delivery of goods and retrieval of goods are very important in the world of cargo. One of them is TAM CARGO BALI where couriers have difficulty in delivering goods during the process of determining the shipping route route. This makes the need for an information system to determine accuracy in the selection of the initial and subsequent paths to facilitate couriers, with the Traveling Salesman Problem (TSP) genetic algorithm with optimization problems, namely visiting every place from a set of specified places once and only once. then return to the starting place at the end of the travel route with the distance, the minimum time and cost and the results of distance optimization by generating chromosomes from the specified route make a sequence of the shortest path from the starting point of TAM CARGO BALI back to the end point at TAM CARGO BALI. Traveling Salesman Problem TSP is the search for the shortest route or minimum distance by a salesman from a city to n-city exactly once and back to the initial city of departure where the weight on the side is the distance. This TSP route contains all the vertices on the graph exactly one turn. After the generation of chromosomes, the generation selection process, crossover and mutation are carried out to get the best fitness value for each generation. The generation process will be repeated until the maximum generation is the 10th generation. The application that has been successfully built can determine the best route visualized on the map. Application testing is carried out by testing the system's functional and manual calculations according to the route output generated by the system.

1. Introduction

A logistics distribution company is one of the companies that is growing in line with the development of digital technology in the trading industry. The progress of ordering digitally and widely has resulted in the movement of goods transport being increased. Many industries and individuals entrust expedition delivery services as an alternative to sending their goods. Expedition delivery services have several advantages, one of which is that they are not bound by time where delivery can be made at any time if the delivery quota has been reached. In addition to promising the best service, the industry also strives to present a variety of innovative products for shipping goods and document packages. But in reality, the company not only aims to minimize transportation costs,

CV. Tunas Antarnusa Muda Kargo (TAM) is a company engaged in shipping services via land transportation to the destinations of Sumatra, Java, Bali, and NTB. Timely delivery is TAM's top priority in delivering goods to customers. From the results of observations of the courier's performance in making deliveries, there is often a delay in the arrival of consignments to customers, because so far according to the courier, they do not know the arrangement or order of the delivery line from the closest location to the next location. Not infrequently, the courier does not know the intended address well so that he cannot take into account the distance to the address and may pass the same point over and over again. due to the difficulty of

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determining which shipping route should be delivered first or picked up first. Due to the irregular delivery of goods by couriers, the delivery time will be long, and sometimes the goods will be sent the next day.

The problem in the background is one example of a problem in the traveling salesman problem. The Traveling Salesman Problem is one of the most important transportation problems in logistics operations[1]The main problem of TSP is how a salesman can arrange his travel route to visit a number of cities with a minimum distance. The genetic algorithm can be applied to the traveling salesman problem in determining the route of travel[2].Genetic algorithms are often used as an approach to solving TSP[3]. Several studies have succeeded in applying genetic algorithms in finding the optimal route in the TSP. This article proposes the application of genetic algorithms to the application of determining the best route by visualizing directly on the map. Maps that will be used in google map-based applications. The application is built based on a website so that it can be accessed by couriers when delivering goods.

2. Methods

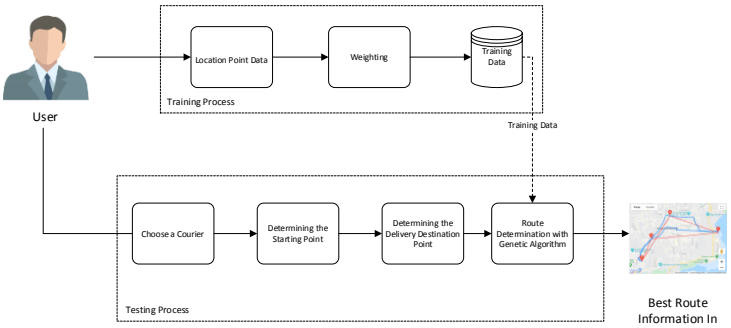

Fig. 1. Overview of the Application System for Determining Shipping Routes With Genetic Algorithms

In general, the route determination system consists of two systems, namely the training system and the testing system shown in Fig. 1. The training system is a collection of processes in determining the weight value for each location point. The weight of the specified point affects the suitability in determining the route. The testing system is the main system in determining the best route for couriers. In the testing process, the user selects the name of the courier, then determines the starting location point and the delivery destination point. The system will display route information on a map with a genetic algorithm based on the calculation of the weighted points that have been entered.

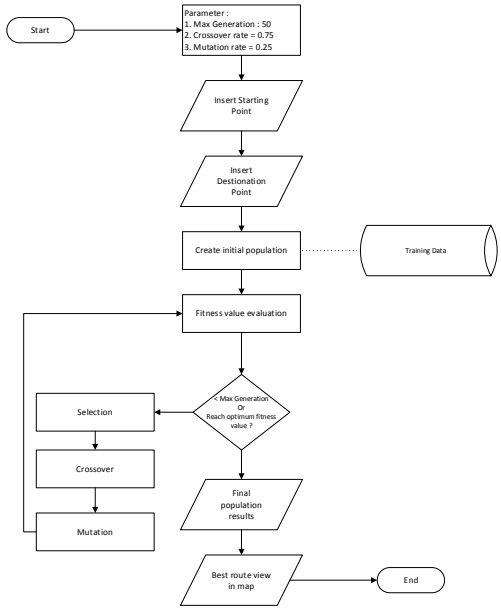

Fig. 2. Flowchart of Application of Genetic Algorithm in Shipping Routing Determination System.

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Fig 2 is the application of genetic algorithms to the cargo delivery route determination system. A genetic algorithm is applied to find a sequence of starting location points to the destination point of delivery which determines the route of the trip. At the beginning of the process, data initiation is required including determining the maximum generation parameters, crossover rate, mutation rate, starting point, and end point location. The initial stage of calculating the algorithm is done by generating the initial population based on the weight data that has been entered during training. The selection system includes encoding for each member of the population, the method used in the selection process is roulette wheel selection. In the selection process, the probability value of each chromosome produced in the roulette wheel process is calculated. After calculating the probability value, then a crossover process is carried out, namely crossing two chromosomes to form a new chromosome that is expected to be better than the parent. Crossover works to generate new offspring by replacing some of the information from the parents[4]. The process after the crossover is then carried out a mutation process with the scheme used in this system is swapping mutation. The mutation process is carried out by exchanging randomly selected genes with the following genes. If the gene is at the end of the chromosome, it is exchanged for the first gene[5]. The iterative process of selection, crossover, and mutation forms a generation with a set of chromosomes. The loop will stop if the stopping condition has been met, namely the lowest fitness value is still the same as the previous iteration or reaches the maximum number of iterations that have been determined at the beginning.

Each menu in the application generated in this article is tested for functionality by the blackbox testing method. Blackbox testing is a software testing technique that focuses on the functional specifications of the system. Blackbox testing allows developers to develop scenarios for system input conditions and see if the results match the expected ones[6].

The steps to find the shortest path using the genetic algorithm, the traveling salesman problem method, can be seen as follows: :

TABLE 1
COORDINATES OF LOCATION POINTS ON MAP

Route	Street Name	Latitude	Longitude
1	Jln pura mertasari no 4d	-87098582	115.184191
2	Tangkuban Perahu Gang III street no 33	-8.6582738	115.1721397
3	Jln Gunung Karang 2 housing primaloka block 17	-8.6647764	115.1948703
4	Jln Ahmad Yani Utara no.178	-8.6285698	115.2001563
5	Perum padang block b10 padang sabian	-8.6983199	115.1249996
6	Jln Tukad Banyusari XV No. 88	-8.6827083	115.2176911

Based on the routes in Table 1, then the distance between routes is searched, described in Table 2

TABLE 2
ROUTE DISTANCE

No	A	B	C	D	E	F
A	0	7.3	3.9	10.8	7	10.5
B	7.3	0	5.3	6.7	1.9	7.8
C	3.9	5.3	0	5.5	4.9	4.6
D	10.8	6.7	5.5	0	4.8	5.9
E	7	1.9	4.9	4.8	0	5.9
F	10.5	7.8	4.6	5.9	5.9	0

2.1 Selection Process

For example, the distribution route to be taken is Jalan Pura Mertasari - Jalan Tangkuban Perahu - Jalan Gunung Karang - Jalan Ahmad Yani - Padang Sambian Housing - Jalan Tukad Banyusari. Then the endcoding technique is carried out by initializing these goals with numbers, namely Jalan Pura Mertasari (1) - Jalan Tangkuban Perahu (2) - Jalan Gunung Karang (3) - Jalan Ahmad Yani (4) - Padang Sambian Housing (5) - Jalan Tukad Banyusari (6), Jalan Pura Mertasari (1) was not included in the gene because the assumption is that the city of origin is the final city for the distribution of goods.

Chromosome [1]: [t. boat - ahmad yani - perum sabian - banyusari - g. coral] [BDEF]

Chromosome [2]: [Ahmad yani – t. boat – perum [DBECF]

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	sambian – g. coral – banyusari]	
Chromosome [3]:	[g. coral – banyusari – perum sambian – ahmad yani – t. boat]	[CFEDB]
Chromosome [4]:	[banyusari – perum sambian – t. boat – g. coral – ahmad yani]	[FEBCD]
Chromosome [5]:	[perum sambian – banyusari – ahmad yani – g. coral – t. boat]	[EFDCB]
Chromosome [6]:	[g. coral – ahmad yani – banyuasari – t. boat – perum sambian]	[CDFBE]

After that look for the fitness value with the formula below:

Fitness 1 = BD+DE+EF+FC = 6,7+4,8+5,9+4,6 = 22
Fitness 2 = DB+BE+EF+CF = 6.7+1.9+5.9+4.6 = 19.1
Fitness 3 = CF+FE+ED+DB = 4.6+5.9+4.8+6.7 = 22
Fitness 4 = FE+EB+BC+CD = 5.9+1.9+5.3+6.7 = 19.8
Fitness 5 = EF+FD+DC+CB = 5.9+5.9+5.5+5.3 = 22.6
Fitness 6 = CD+DF+FB+BE = 5.5+5.9+7.8+1.9 = 21.1

From the results above, we look for chromosomes with a smaller fitness and the chromosomes will have a greater probability of being re-elected, so inverse is used. With the formula:

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

Q[1]=1 / 22 =0.045454545
Q[2]=1 / 19.1 =0.052356021
Q[3]=1 / 22 =0.045454545
Q[4]=1 / 19.8 =0.050505051
Q[5]=1 / 22.6 =0.044247788
Q[6]=1 / 21.1 =0.047393365
ΣTotal Q[]= 0.285411315

Then after finding the Q value, it is continued by looking for the probability, to find out which chromosome is selected as the new generation. The probability formula is:

$$P[i] = \frac{Q[i]}{Total\ Q} (2)$$

P[1]=0.045454545/0.285411315 = 0.159259788
P[2]=0.052356021 /0.285411315 = 0.183440593
P[3]=0.045454545 /0.285411315 = 0.159259788
P[4]=0.050505051 /0.285411315 = 0.17695532
P[5]=0.044247788 /0.285411315 = 0.155031652
P[6]=0.047393365 /0.285411315 = 0.166052859

It can be seen that chromosome 1 has the smallest fitness so that the probability of being selected in the next generation is greater than that of the other chromosomes. The selection process using the Roulette Wheel Selection has the following stages:

a. [Sum] : Add up all probability values C
b. [Select] : Generate random number with interval (0-C) R
c. [Loop] : Compares the values of R and C, if R[k]<C[k] then the kth chromosome is the parent, in addition, select the kth chromosome as the parent with the condition that C[k-1] < R[k] < C[k

The process of turning the Roulette Wheel is carried out as many as the number of chromosomes (six) to get a random value.

Find the cumulative value of the probability (C).

C[1]=0.159259788 =0.159259788
C[2]=0.159259788 +0.183440593 =0.342700381
C[3]=0.342700381 +0.159259788 =0.501960169
C[4]=0.501960169 +0.17695532 =0.678915489
C[5]=0.678915489 +0.155031652 =0.833947141
C[6]=0.833947141 +0.166052859 =1

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Then the random value (R) is:

R[1] = 0.114
R[2] = 0.112
R[3] = 0.411
R[4] = 0.642
R[5] = 0.783
R[6] = 0.556

After the comparison is made, the latest population is obtained:

Chromosome [1]:[2]	[Ahmad yani – t. boat – perum sambian – g. coral – banyusari]	[DBECF]
Chromosome [2]:[1]	[t. boat - ahmad yani - perum sabian - banyusari - g. coral]	[BDEF]
Chromosome [3]:[3]	[g. coral – banyusari – perum sambian – ahmad yani – t. boat]	[CFEDB]
Chromosome [4]:[4]	[banyusari – perum sambian – t. boat – g. coral – ahmad yani]	[FEBCD]
Chromosome [5]:[5]	[perum sambian – banyusari – ahmad yani – g. coral – t. boat]	[EFDCB]
Chromosome [6]:[6]	[g. coral – ahmad yani – banyuasari – t. boat – perum sambian]	[CDFBE]

2.2 Recombination or Crossover Process

The recombination process or better known as the crossover process is the crossing of two chromosomes to form a new chromosome that is expected to be better than the parent. Not all chromosomes in a population will undergo the recombination process.

The probability of a chromosome undergoing a recombination process is based on a predetermined crossover probability (PC). The crossover probability is the probability that a chromosome will have a crossover. There are several recombination techniques that can be used to solve problems like this, including partially mapped crossover (PMX), order crossover and cycle crossover.

The recombination technique used is the order crossover technique. Order crossover (OX) was introduced by Davis. This technique begins by generating two random numbers. Then the gene that is between the two random numbers will be copied to the offspring in the same position. The next step to get the first offspring is to sequence the genes that are in the second parent with the sequence of genes that are in the position after the second random number, followed by the genes that are in the position before the first random number and ending with the genes that are in the position between the two random numbers. Then the sequenced genes are compared with the first offspring. If the gene is in the second offspring then ignore the gene from the sequence. Then enter the sequence that has just been obtained in the offspring by entering the gene sequence at the position after the second random number first and the rest is entered in the position before the first random number. Likewise to produce a second offspring. For example, if we determine PC = 50%, it is expected that in 1 generation there will be 50% * 6 chromosomes = 3 chromosomes from the population experiencing crossover. Previously, generate a random number R as many as the total population that is 6 times.

R[1] = 0.672131921
R[2] = 0.900945616
R[3] = 0.228508006
R[4] = 0.675761115
R[5] = 0.266848355
R[6] = 0.770144326

Then search for the category of the kth chromosome which is selected as the parent if R[k] < pc. Then what will be used as parents are chromosomes[2], chromosomes[3], and chromosomes[6]. The next process is to determine the crossover position. This is done by generating random numbers from 1 to the length of chromosome-1. (4-1 = 3). Suppose a random number for 3 parent chromosomes to be crossed:

C[2] = 3

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C[4] = 3
C[6] = 1

For example, if the random number is 3, then the second gene on the first parent chromosome is taken and then exchanged for a gene on the second parent chromosome that does not exist in the first parent while still paying attention to the order.

Crossover process:

Chromosome [2]: Chromosome [2]x Chromosome [4]= [DBECF] X [FEBCD]
Chromosome [4]: Chromosome [4]x Chromosome [6]= [FEBCD]X [CDFBE]
Chromosome [6]: Chromosome [6]x Chromosome [2]= [CDFBE]X [DBECF]
Results : [FEBCD]
[CDFBE]
[DBECF]

So that the population after the crossover is obtained:

Chromosome [1]= [BDEFC]
Chromosome [2]= [CFDBE]
Chromosome [3]= [CFEDB]
Chromosome [4]= [ECDFB]
Chromosome [5]= [EFDCB]
Chromosome [6]= [BFECD]

2.3 Mutation Process

This mutation process is carried out after the recombination process by choosing the chromosome to be mutated at random, and then determining the mutation point on the chromosome randomly as well. The number of chromosomes that will undergo mutation is calculated based on the mutation probability that has been determined in advance. If the probability of mutation is 100% then all the chromosomes in the population will experience mutations. On the other hand, if the mutation probability used is 0%, then there are no chromosomes that have mutations in that population. The number of chromosomes that experience mutations in one population is determined by the mutation rate (PM) parameter. The mutation process is carried out by exchanging randomly selected genes with subsequent genes. If the gene is at the end of the chromosome, it is exchanged for the first gene.

First, calculate the total length of the genes in a population: Total Gene Length = number of genes in 1 chromosome * number of chromosomes

Total Length of Gen= 5x630
Total Length Gen30

To select the position of the mutated gene, it is done by generating a random number between 1 – The total length of the gene is 1-30. For example, PM = 20% is determined. Then the number of genes to be mutated is = 0.2 * 30 = 6. Then 6 gene positions to be mutated, after being randomized are positions 3, 7, 10, 20, 24,30.

Chromosome Crossover Results:

Chromosome[1]= [BDEFC]
Chromosome [2]= [CFDBE]
Chromosome [3]= [CFEDB]
Chromosome [4]= [ECDFB]
Chromosome [5]= [EFDCB]
Chromosome [6]= [BFECD]

Mutation Process:

Chromosome [1]= [BDECF]
Chromosome [2]= [CFDEB]
Chromosome [3]= [CEFDB]
Chromosome [4]= [EFDBC]
Chromosome [5]= [BCDFE]
Chromosome [6]= [BFCED]

After this process is complete, one generation has been completed and also generated with a genetic algorithm. Previously it was determined when the genetic algorithm process would stop. There are several conditions to check, namely if the lowest fitness value is obtained which does not change or we specify it will

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be generated until the Nth generation. Then look for the Fitness value again. The fitness value after 1 generation is:

Fitness[1]= BD+DE+EC+CF = 6.7+4.8+4.9+4.6 = 21
Fitness [2]= CF+FD+DE+EB = 4,6+5,9+4,8+1,9 =17.2
Fitness [3]= DE+EF+FD+DB = 4,6+5,9+5,9+6,7 =23.1
Fitness [4]= EF+FD+DB+BC = 5,9+5,9+6,7+5,3 =23.8
Fitness [5]= BC+CD+DF+FE = 5,3+5,5+5,9+5,9 =22,6
Fitness [6]= BF+FC+CE+ED = 7,8+4,6+4,9+4,8 =22.1

Furthermore, it is repeated or looped according to the population of the generation that is raised so that it will get the final result with the first chromosome value with the fitness value and can produce delivery and retrieval routes. From the calculation example, it can be seen that Fitness 4 has the highest value and is used as a route in the order of BCDFE [Jln pura mertasari no 4d - Jln tangkuban boat gang iii no 33 - Jlngunung coral 2 housing primaloka block 17 - Jln ahmad yani Utara no.178 - Jln tukad banyusari xv no.88 - Perum padang block b10 padang sabian - Jln pura mertasari no 4d]

3. Results and Discussion

This research produces a website-based application that has the main feature of recommending the best route in shipping goods. The system in the application can calculate the best route determination with the genetic algorithm in accordance with the general description of the system and the flow diagram of the implementation of the genetic algorithm. In this system, it can process group data, point data, courier data weight data, user data, and travel salesman problem (TSP) route data. There are 2 access rights in the system, namely admin and courier. Admin has access to manage location points, location point weights, location groups, and courier data. Couriers have access to the TSP route finding feature.

3.1 Login Page

The login page is the first page that appears when the system is opened. On this page the user must enter a username and password. After the username and password are filled use the login button to enter the system. The login view can be seen in Figure 3.

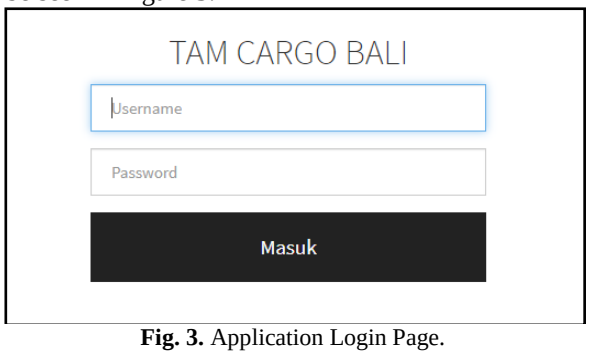

Fig. 3. Application Login Page.

3.2 Admin Main Page

Admin Main Page is a login display as admin, on this page there are several menus contained in it such as group menu, point, topic, weight, courier, user, TSP route, password, logout to exit the system. The main view can be seen in Fig 4.

Fig. 4. User Main Page.

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3.3 Courier Data Manage Page

The Manage Courier Data page is used to display courier data that has been stored in the database, add, change, and deactivate courier data. The display of the courier data management page can be seen in Figure 5.

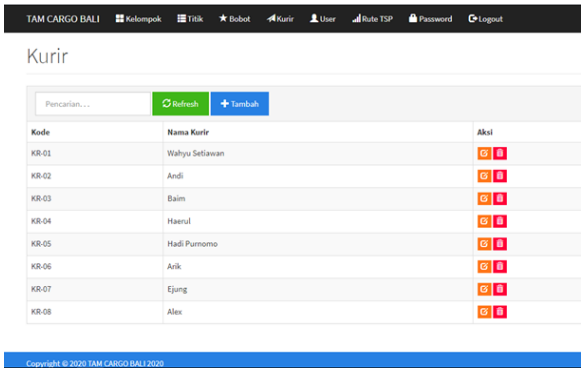

Fig. 5. Manage Courier Data page.

3.4 Manage Location Point Data Halaman page

On this Location Point Data Management page, there is the name of the group that will be searched for the destination point, delete point data, search for point data and also add point data. The main view of the point data menu can be seen in Figure 6

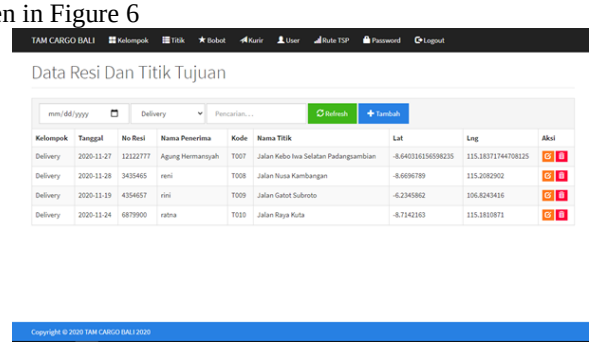

Fig. 6. The Manage Location Point Data page.

Location point data can be added by pressing the blue plus button in Fig 6. The display for adding location point data is shown in Fig 7. Users can add location points by selecting a location on the map. Latiude and longitude coordinates will be automatically filled according to the selected location on the map. When all the fields have been filled in by the user, then the save button is pressed.

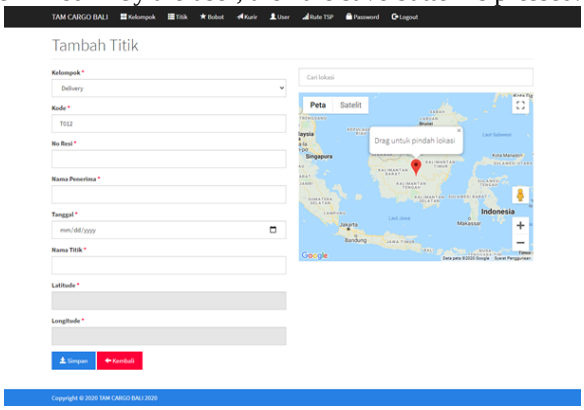

Fig. 7. Add Location Point Data page.

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3.5 Genetic Algorithm Calculation Page

The initial process of calculating the genetic algorithm in this application is determining the weight of the location points that have been added. The comparison weight between the points becomes the training data in the calculation of determining the route with the genetic algorithm. The point weight data management page is shown in Figure 8.

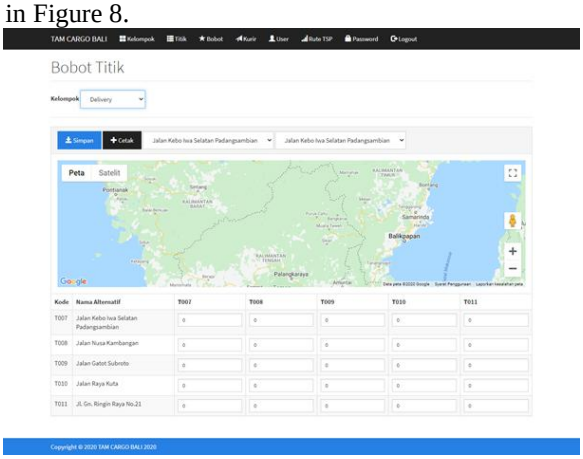

Fig. 8. Manage Location Point Data.

Figure 9 is the page that is used for the process of determining the route of delivery and retrieval of goods using the Genetic Algorithm method. In this view, the selection of which route points will be addressed by the courier determined by the admin is carried out. As test data determined 4 route points where Jl. Mertasari Temple as the starting point and Jl. Imam Bonjol, Jalan Gajah Mada, Jalan Sanur Beach Street Walk as destination route points.

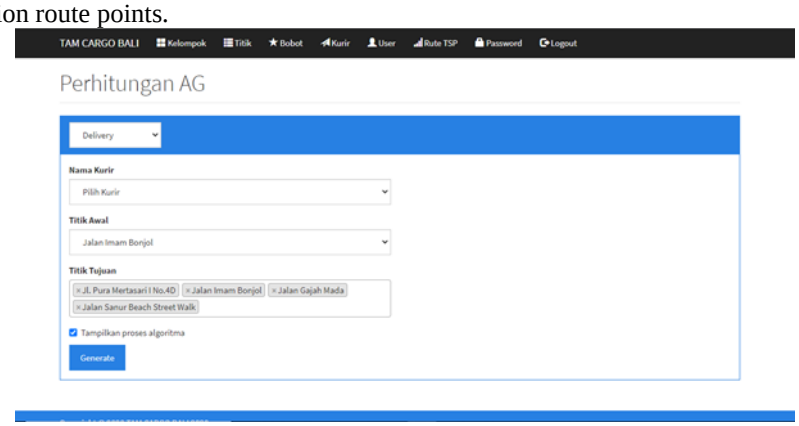

Fig. 9. Initiation of Routing Determination Process With Genetic Algorithm.

After selecting the route, the admin presses the generate button and the search for the best route will be carried out by the TSP genetic algorithm where the TSP genetic algorithm generates chromosomes and will be repeated until it reaches the maximum generation. The chromosome generation process is shown in Figure 10.

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Fig. 10. Chromosomal Generation Process and Finding the Best Fitness Value.

It can be seen in Figure 10 that in each generation, the generation of chromosomes is carried out after which the generation selection, crossover and mutation processes are carried out to get the best fitness value for each generation. the generation process will be repeated until the maximum generation is the 10th generation. From each generation will be compared which generation has the best fitness value. In this test data, the best fitness is 27,107 which is found in the 9th generation. The fitness results in Fig. chromosomes that form the best route, namely Jl. Mertasari Temple -> Jl. Gajah Mada -> Jl. Imam Bonjol -> Jl. Sanur Beach Walk and Back to Jl. Mertasari Temple. The results of the route are translated into google maps which provides information on the route sequence and the total distance traveled. google maps route results which can be seen in Figure 11

3.6 Best Shipping Route Page On Map

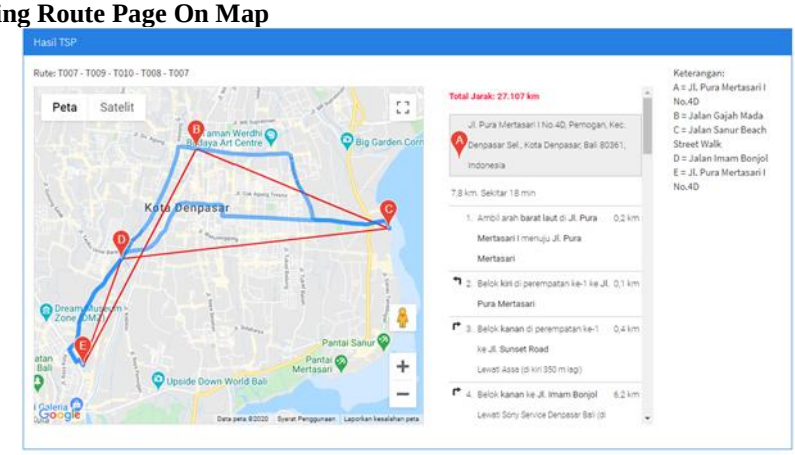

Fig. 11. Results of Determining the Best Route With Genetic Algorithm on a Map Based on Google Map.

3.7 Application Testing

Application testing is done by blackbox testing method. There are 9 scenarios of functional system testing. Based on the test results, of the 9 specified test scenarios, the system's functions run according to expectations in the 9 scenarios. This states that the system that has been built has carried out the functions that have been designed previously. The results of the functional testing of the system are presented in the table

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TABLE 3
SYSTEM FUNCTIONAL TESTING

No	Module	Test	Expected results	Test result
1	Invalid login	Entered the wrong username and password	Login failed message appears	Corresponding
2	Login Valid	Enter the correct username and password	When the login is successful, it will directly enter the system.	Corresponding
3	Add group data	One field is empty	A message appears, there cannot be an empty field	Corresponding
4	Add success group data	Enter all fields correctly	The data entered will appear on the group data display	Corresponding
5	Add point data	One field is empty	There can be no empty fields	Corresponding
6	Add success point data	Enter all fields correctly	The inputted data will appear on the point data display	Corresponding
7	Add courier data	One field is empty	There can be no empty fields	Corresponding
8	Add user data	Enter all fields correctly	The data entered will appear on the user data display	Corresponding
9	Determination of the Best Route	Choose a courier name	The system displays the best route on the map	Corresponding

4. Conclusion

The route determination application generated in this study can be used as a tool for courier delivery processes. The application system can show route suggestions from the starting point and destination that have been entered by the user. The genetic algorithm in the optimization process for determining the best route in this article has been successfully applied. The results of determining the route by the genetic algorithm in this application are presented in the form of a map. The application runs according to the functions that have been designed, this is shown from the results of functional system testing. The test results show that from the 9 specified trial scenarios, the 9 trials state that the system functions are appropriate.

5. References

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