INTERNATIONAL JOURNAL OF ADVANCED
STUDIES IN COMPUTER SCIENCE & ENGINEERING
IJASCSE VOLUME 9 ISSUE 9, 2020
09/30/2020

Optimization of Courier Travel Routes Using Genetic Algorithms

Wirawan Istiono
Universitas Multimedia Nusantara
Jl. Scientia Boulevard Gading Serpong
Tangerang, Indonesia
wirawan.istiono@umn.ac.id

***Abstract*—Efficiency and effectiveness are two things needed to save time and energy. One example is the optimization of route selection for courier services in delivering goods. The calculation of the best route order selection plays an important role, so the courier can deliver the goods to the customer with optimal time. The more dense and complicated the sequence of travel routes traveled, the time spent becomes less optimal. This study aims to examine the application of genetic algorithms to solve problems in optimizing the route selection, by considering the estimated time. A genetic algorithm is a search method that is inspired by the process of completing natural and genetic selection. Combine the solutions to produce new solutions, using several combinations of crossover and mutation probabilities, as well as population size and generation size. In this research get resulted in an optimization of travel routes for couriers in Tangerang using Genetic Algorithms on 5th chromosome, with an objective function value of 1023.115773 and fitness function 0.000976452 from 50 generations was formed. This value is obtained from a solution that allows the courier to deliver the goods at the optimal time.**

Keywords-component; route optimization, courier, genetic algorithm, Route Optimization

I. INTRODUCTION

The rapid development of technology makes it easy for someone to achieve certain goals, one of them is an online transaction. Online transactions are now rife with users, due to its ease in making long-distance transactions between sellers and buyers [1]. With the increase of online transaction users, it is also possible for the rise of various expeditionary businesses to provide delivery services. When delivery of goods, couriers often experience difficulty in determining the route to be traversed, because the number of the address. Therefore, we need a solution that can help the courier in determining the order of the route traversed, so that the courier can deliver goods with optimal time [2][3].

The problem of optimization is a problem that has many solutions and must be able to determine which solution is optimal. One technique used to optimize travel routes uses genetic algorithms [4]. A genetic algorithms solve problems in evolutionary ways. Genetic algorithms mimic the natural evolutionary process and look for excellent solutions [5]. A solution contained in a genetic algorithm is called a chromosome. A collection of chromosomes produced randomly, called a population. The chromosomes formed will evolve in a continuous iteration process, and are called generations. In each generation, chromosomes are evaluated to find chromosomes that have high quality [6][7]. The selection of chromosomes that will be retained for the next generation, is carried out a process called selection. After several generations, genetic algorithms will produce chromosomes whose genes converge, and are expected to be the optimal solution [8].

Based on the description above, this study examines the application of genetic algorithms in terms of optimizing the route of courier travel in the Tangerang. The goal is to obtain travel route optimization in courier service transactions, which is the condition where the best combination occurs for the path traveled and fast travel times, so that the courier can deliver goods to all customers with optimal time.

II. PROBLEM FORMULATION

A. Research Object

Route and travel times are interrelated and affect each other. The more crowded and complicated the route traveled, the more time and energy spent by courier. Accuracy in choosing the optimal travel route, results in optimal time for the courier to deliver the goods. The aim is the optimum route as fast as possible to get the travel time from point of origin to destination. So to determine the optimum route in addition to seeing mileage, also must consider other components such as the level of congestion [9]. For example, there are two routes, the first route that has a short distance but there is a traffic jam so that it takes an hour, and the second route has a longer distance but there is no traffic so it takes only half an hour. Then the optimum route is the second route because the overall travel time is faster than the first route. By getting the shortest travel time means that fuel consumption will also be less than the route that has a longer travel time [1]. This research will find the optimum route using the genetic algorithm, so that later it

will produce a solution which produces the most optimum route, and has the fastest distance and travel time.

Optimization of travel routes using genetic algorithms is expected to help in finding solutions. One application of genetic algorithms is the combination optimization problem, which is getting an optimal solution value for a problem that has many possible solutions [8]. Various possible solutions found, the best solution will appear. Google Maps is a map application service from major Google companies, which can be accessed online. The site contains geographical information. Google Maps is created by using a combination of map images, databases, and interactive objects created with the HTML, JavaScript and AJAX programming languages, as well as several other programming languages [10]. This research uses the help of Google Maps to find out the coordinates of the location, distance between locations, road density, and estimated time taken. There are five addresses of research objects. All of these addresses are domiciled in Tangerang. Courier travel route starts from JNE Kelapa Dua, then goes to the location of the next addresses. Table I below is shown a list of addresses and coordinate positions of each address and Table II below is shown the weight of road congestion used, based on Google Maps features.

TABLE I. ADDRESS LIST AND CUSTOMER POSITION

No	Name	Address	Coordinate	
			Latitude	***Longitude***
1	JNE Kelapa Dua	Jl. Kelapa Dua Raya	-6.235221	106.625878
2	Sinta	Jl. Dukuh 5, Cibodasari	-6.213254	106.609223
3	Alex	Jl. Garuda Raya, Legok	-6.311879	106.583375
4	Linda	Jl. Dawai 2, Cikupa	-6.236226	106.521104
5	Sony	Jl. Pd. Hijau Golf Raya, Klp. Dua	-6.25174	106.628167

TABLE II. ROAD TRAFFIC WEIGHT LIST

Road Congestion	Weight
Normal	1.0
Crowd	1.5
Traffic Jam	2.0

B. Concepts of Genetic Algorithms

A genetic algorithm is a search algorithm that uses the principle of natural selection in genetic science to develop solutions to problems [11]. Genetic Algorithms are a class of heuristic search algorithms based on biological evolution [6]. In general, genetic algorithms have five basic components: (1) Genetic representation of problem solutions; (2) How to form an initial population of solutions; (3) An evaluation function that rates solutions based on their fitness; (4) Genetic operators that change the genetic composition of offspring during reproduction; (5) Values for genetic algorithm parameters [12].

III. METHODOLOGY

A genetic algorithms are used to find a solution of all possible solutions that meet the criteria without the need to examine the whole of the existing solutions [7]. The first stage determines the starting point where the courier is located and determines the destination point of the customer's address. With Google Maps, each location point is given coordinates (latitude and longitude) to clearly know the position of the address. Location points are five. The courier starts at the starting point, then goes to various destination points. After all the destination points have been passed, the courier must return to the starting point.

The second stage, makes the structure of chromosomes starting from the initial position to the destination position, then back again to the starting point with the length of chromosome 5 (the end point does not count). Coding the contents of genes obtained from the first stage, distance, time, and congestion index, and building a match function. Coding is a technique for expressing the initial population as a potential solution of a problem to a chromosome as a key issue when using genetic algorithms [13].

The third stage is the process of generating a random initial population of 10 chromosomes. Each chromosome has five genes that contain the attributes of distance, time, congestion index, latitude and longitude. After that, the compatibility of the chromosome structure is calculated using the objective function that is made, then carried out an evaluation and selection. The selection process is carried out by making chromosomes that have a small objective function have a high probability of being selected or have a high probability value [8]. Then enter the stage of the crossing process, the crossing that is used is the permutation crossing in which each chromosome cannot have the same crossing point [7]. Then the mutation process is carried out on certain chromosomes, and then, again, an evaluation is made for new populations. The flow chart of the genetic algorithm to solve the problem of optimization of the courier route can be seen in Figure 1.

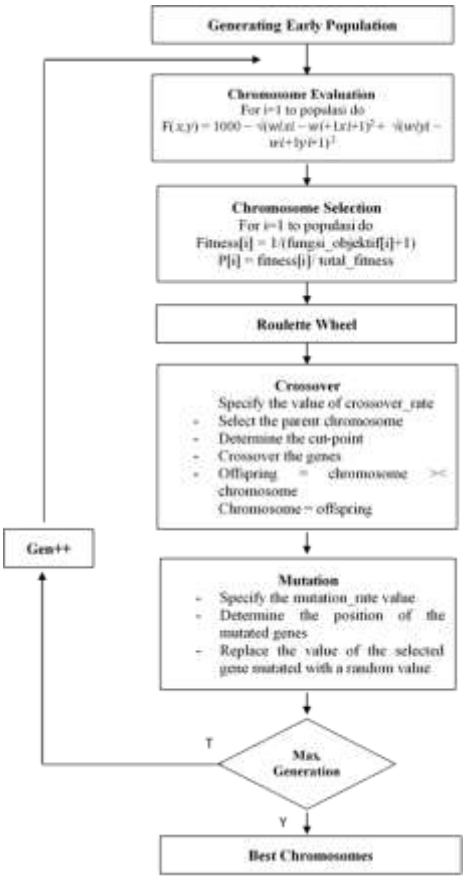

Figure 1. Flowchart Genetic Algorithms

IV. RESULT

The chromosomes in this study contain 5 generations. Each gene represents the starting point to the destination point used as a route, starting from gene 1 stating the position or starting point, gene 2 to gene 5 expressing the destination point used as a route and gene 6 is the starting point of the courier to return. Each gene has a list of attributes or a list of contents. The list of contents of genes used on chromosomes is in Table 3.

TABLE III. TABLE OF CONTENTS GENES ADDRESS

Point			Time (m)	Distance (km)	Congestion Weight
1	-	2	18	5	1.5
1	-	3	29	12	1.5
1	-	4	44	17	1
1	-	5	7	3	1
2	-	3	40	14	1.5
2	-	4	39	17	1
2	-	5	25	8	2
3	-	4	37	15	1
3	-	5	24	10	1
4	-	5	39	16	1

The initial population is raised by taking several chromosomes into one population in each generation. The arrangement in the chromosome is a different series on each chromosome, with the contents of genes in the form of values taken at random [7].

Determined individuals stating the sequence of courier routes in Tangerang stated in the value of 1 to 5 as many as 6 genes with the provisions of 5 place sequence genes and the last 1 gene are duplicates of the first gene because the courier travel route starts from JNE Kelapa Dua, then goes to the addresses customers and return to JNE Kelapa Dua. Therefore, gene 1 (JNE Kelapa Dua) will be called back at the end. The initial population can be seen in Table IV.

TABLE IV. INITIAL POPULATION

Chromosome 1	1	2	4	3	5	1
Chromosome 2	1	3	4	2	5	1
Chromosome 3	1	2	5	4	3	1
Chromosome 4	1	4	3	2	5	1
Chromosome 5	1	5	2	4	3	1
Chromosome 6	1	4	5	3	2	1
Chromosome 7	1	3	4	5	2	1
Chromosome 8	1	2	3	5	4	1
Chromosome 9	1	4	5	2	3	1
Chromosome 10	1	2	3	4	5	1

The evaluation process is a process for calculating fitness values that states the level of chromosome quality as a representation of problem solving. The fitness function must be mapped from its objective function [4]. The selected travel route is the route with the closest distance, fast travel time, and taking into account the index of congestion. These criteria are then made into mathematical functions as

objective functions and the gene is a representation of the point of intersection location as a route, as in equation 1 [7].

$$F(x,y) = 1000 - \sqrt{(wixi - wi{+}1xi{+}1)^2} + \sqrt{(wiyi - wi{+}1yi{+}1)^2}$$

Explanation:
F : declare an objective function,
n : states the number of points for each gene,
x : express the distance between points,
y : express time between points, and
w : states the weight of road congestion for each gene.

The results of calculating the objective function with the equation above, are shown in Table V.

TABLE V. OBJECTIVE FUNCTIONS FOR FIRST POPULATIONS

	Objective Function
1	1028.115773
2	1023.115773
3	1064.577064
4	1027.615773
5	1081.077064
6	1079.022313
7	1042.522313
8	1087.669906
9	1066.077064
10	1030.115773

The selection process is carried out by making chromosomes that have a small objective function, have a high probability of being selected or have a high probability value. For this reason the fitness function can be used = (1 / (1 + objective function)), the objective function needs to be added 1 to avoid program errors due to division by 0 [8]. The result can be seen in Table VI.

TABLE VI. FITNESS FUNCTION FOR THE FIRST POPULATION

	Fitness function
1	0.000971708
2	0.000976452
3	0.000938459
4	0.00097218
5	0.000924149
6	0.000925907
7	0.000958293
8	0.000918552
9	0.000937139
10	0.000969823
Total	0.009492662

After calculate the fitness, the next step is to calculate the probability with the formula: P [i] = fitness [i] / total fitness**,** and the result are shown in Table VII

TABLE VII. PROBABILITY VALUE

	Probability Value
1	0.102364118
2	0.102863886
3	0.098861482
4	0.102413876
5	0.097353998
6	0.097539215
7	0.100950911
8	0.096764435
9	0.098722512
10	0.102165568

From the probabilities above we can see that the 2nd chromosome has the greatest fitness. Then the chromosome has a greater probability of being selected in the next generation than the other chromosomes. For the selection process using the roulette wheel. Therefore the cumulative probability value (C) must be sought first:

C[1] = P[1],
C[2] = P[1] + P[2],
C[3] = P[1] + P[2] + P[3]
…
C[10] = P[1] + … + P[10]

After calculating the cumulative probability, the selection process using the roulette-wheel can be carried out. The process is by generating random numbers R in the range 0-1. If R [k] <C [1] then select chromosome 1 as the parent, otherwise choose the k-chromosome as the parent with the condition C [k-1] <R <C [k]. Turn the roulette wheel as many times as the population that is 5 times (generate random numbers R) and at each spin, we choose one chromosome for the new population, ant the result are shown in Table VIII.

TABLE VIII. SELECTION PROCESS WITH THE ROULETTE WHEEL METHOD

Chromosome	C	R	Results of Selection
1	0.102364118	0.73	7
2	0.205228004	0.59	6
3	0.304089486	0.92	10
4	0.406503362	0.13	2
5	0.50385736	0.21	2
6	0.601396575	0.99	10
7	0.702347486	0.08	1
8	0.799111921	0.54	6
9	0.799111921	0.05	1
10	0.901277488	0.38	4

The new population resulting from the selection process that has been carried out can be seen in Table IX. The position of the chromosome changes according to the results of the selection that has been done.

TABLE IX. RESULTS OF POPULATION SELECTION PROCESS IN FIRST POPULATION

Chromosome 1	1	3	4	5	2	1
Chromosome 2	1	4	5	3	2	1
Chromosome 3	1	2	3	4	5	1
Chromosome 4	1	3	4	2	5	1
Chromosome 5	1	3	4	2	5	1
Chromosome 6	1	2	3	4	5	1
Chromosome 7	1	2	4	3	5	1
Chromosome 8	1	4	5	3	2	1
Chromosome 9	1	2	4	3	5	1
Chromosome 10	1	4	3	2	5	1

The results of the selection are then carried out crossover. The method used is a one-cut point, which randomly selects a position on the parent chromosome, then exchanges genes. The parent of the chromosome chosen randomly, as well as the number of chromosomes undergoing crossover is affected by the crossover_rate parameter. For example, determine the probability crossover of 25%. Generate as many random numbers R as the population first, and the result are shown in the Table X.

TABLE X. CROSSOVER PROCESS

Crossover		
Chromosome	***R***	***Position***
1	0.82	No
2	0.93	No
3	0.19	Parent
4	0.37	No
5	0.29	No
6	0.14	Parent
7	0.18	Parent
8	0.79	No
9	0.89	No
10	0.31	No

The chromosome to k will be chosen as the parent if R [k]<probability crossover (0.25), from the random number R above. So the parent is chromosome-3, chromosome-6 and chromosome-7.

After making the parent selection the next process is to determine the position of the crossover. This is done by generating random numbers with a limit of 1 to (length of chromosome-1), in this case the random number generated is 1-3. Suppose that the crossover position is 1, the parent chromosome will be cut from the 1st gene then the gene pieces are exchanged between the parent [8].

Chromosome [3] >< Chromosome [6]
Chromosome [6] >< Chromosome [7]
Chromosome [7] >< Chromosome [3]

Determine the cut-point position using random numbers 1-3, as many as the number of crossovers that occur. For example the results of random numbers: C[1] = 1, C[2] = 2, C[3] = 1. And the result are shown in Table XI.

TABLE XI. CUT-POINT CROSSOVER

Offspring [3]	Chromosome [3]	1	2	3	4	5	1
	Chromosome [6]	1	2	3	4	5	1
	Result	1	2	3	4	5	1
Offspring [6]	Chromosome [6]	1	2	3	4	5	1
	Chromosome [7]	1	2	4	3	5	1
	Result	1	2	4	3	5	1
Offspring [7]	Chromosome [7]	1	2	4	3	5	1
	Chromosome [3]	1	2	3	4	5	1
	Result	1	2	3	4	5	1

The population conducted by the crossover is the new population that has been selected. Then the new population that has been subjected to crossing operators can be seen in the table below. And the result are shown in Table XII.

TABLE XII. POPULATION RESULTS FROM CROSSING THE FIRST POPULATION

Chromosome 1	1	3	4	5	2	1
Chromosome 2	1	4	5	3	2	1
Chromosome 3	1	2	3	4	5	1
Chromosome 4	1	3	4	2	5	1
Chromosome 5	1	3	4	2	5	1
Chromosome 6	1	2	4	3	5	1
Chromosome 7	1	2	3	4	5	1
Chromosome 8	1	4	5	3	2	1
Chromosome 9	1	2	4	3	5	1
Chromosome 10	1	4	3	2	5	1

The chromosomes which have been crossed will be mutated. Genes will be randomly selected for mutation. The total length of genes in this population is 50, derived from 5 genes multiplied by 10 chromosomes. Determine the probability of mutation (pm). The selected pm is 10%. Then the gene to be mutated is 0.1 * 50 = 5 times. Next generate random numbers with a range of 1 to 50, 5 times. For example getting positions for genes 22, 17, 40, 9, and 35 that have mutations. Then the location of these genes is exchanged with other genes, which are located on the same chromosome. The results of the mutation are in Table XIII.

TABLE XIII. POPULATION RESULTS OF MOVEMENTS IN THE FIRST POPULATION

Chromosome 1	1	3	4	5	2	1
Chromosome 2	1	4	5	3	2	1
Chromosome 3	1	5	3	4	2	1
Chromosome 4	1	3	5	4	2	1
Chromosome 5	1	3	4	2	5	1
Chromosome 6	1	5	4	3	2	1
Chromosome 7	1	2	4	3	5	1
Chromosome 8	1	4	5	3	2	1
Chromosome 9	1	2	4	3	5	1
Chromosome 10	1	4	3	2	5	1

After the mutation process is complete, the objective function and fitness function for the new population will be formed, and the result are shown in Table XIV.

TABLE XIV. OBJECTIVE FUNCTIONS AND FITNESS FUNCTIONS FOR SECOND POPULATIONS

Chromosome	Objective Function	Fitness Function
1	1042.522313	0.000958293
2	1079.022313	0.000925907
3	1042.022313	0.000958752
4	1040.522313	0.000960133
5	1023.115773	0.000976452
6	1076.022313	0.000928486
7	1028.115773	0.000971708
8	1079.022313	0.000925907
9	1028.115773	0.000971708
10	1027.615773	0.00097218

Based on the table above, generated in the second population, the value that is considered the most optimal is the 5th chromosome with an objective function value of 1023.115773, and a fitness function value of 0.000976452. The second population is more optimal than the first population, the initial population value is 1081.077064.

V. CONCLUSION

This research resulted in an optimization of travel routes for couriers in Tangerang using Genetic Algorithms. The resulting route is on the 5th chromosome, 1-3-3-2-5-1 (JNE Kelapa Dua - Alex - Linda - Sinta - Sony - JNE Kelapa Dua), with an objective function value of 1023.115773, and a fitness function value of 0.000976452. The order of travel routes is the most optimal route to be traversed. Genetic

Algorithms can be implemented in the case of optimal route search. However, a lot of steps that must be done to obtain a solution of Genetic Algorithms.

VI. FUTURE WORK

To improve route accuracy, can adding some input weather conditions that can sometimes affect the traveling situation, beside from Road Congestion and location distances.

ACKNOWLEDGMENT

This research and manuscript is funded and supported by Universitas Multimedia Nusantara, Tangerang, Indonesia.

REFERENCES

[1] R. Adipranata, A. Handojo, and H. Setiawan, "Aplikasi Pencari Rute Optimum Pada Peta Guna Meningkatkan Efisiensi Waktu Tempuh Pengguna Jalan Dengan Metode a* Dan Best First Search," *Jurnal Informatika*, vol. 8, no. 2, pp. 108–108, 2007.

[2] A. Faza and F. Natalia, "Modelling of Traffic Flow on West Jakarta Highways," *International Journal of Engineering and Technology*, vol. 10, no. 3, pp. 658–666, 2018.

[3] N. P. Afifah, P. S. Informatika, U. M. Nusantara, A. O. Penelitian, A. Genetika, and I. Pendahuluan, "Optimasi Rute Perjalanan Kurir Menggunakan Algoritma Genetika."

[4] D. Silvi and P. Dwiza, "Promosi Marketing Menggunakan Algoritma Genetika Dan," *Informatika*, vol. 3, no. September, pp. 299–313, 2016.

[5] J. E. A. Efraim Turban, *Decision Support Systems and Intelligent Systems*, Indiana Un. Pearson/Prentice Hall, 2010.

[6] S. Khan *et al.*, *Observation of π-hole interactions in the solid state structures of three new copper(II) complexes with a tetradentate N4donor Schiff base: Exploration of their cytotoxicity against MDA-MB 468 cells*, vol. 123. 2017.

[7] N. M. Hasyim, E. C. Djamal, and A. Komarudin, "Optimalisasi Rute Obyek Wisata Di Bandung Raya Menggunakan Algoritma Genetika," *Seminar Nasional Aplikasi Teknologi Informasi (SNATi)*, pp. 6–10, 2017.

[8] D. Hermawanto *et al.*, "Algoritma Genetika dan Contoh Aplikasinya," *Universitas Brawijaya*, vol. 5, no. 4, pp. 1–8, 2012.

[9] D. D. Sinaga and S. Hansun, "Indonesian text document similarity detection system using rabin-karp and confix-stripping algorithms," *International Journal of Innovative Computing, Information and Control*, vol. 14, no. 5, pp. 1893–1903, 2018.

[10] S. Hu and T. Dai, "Online Map Application Development Using Google Maps API , SQL Database , and ASP . NET," *International Journal of Information and Communication Technology Research ISSN*, vol. 3, no. 3, pp. 102–110, 2013.

[11] R. L. Haupt and S. E. Haupt, "practical genetic algorithms second edition, 2004 by John Wiley & Sons," *Inc. All rights reserved*, 2004.

[12] A. E. Eiben, "Genetic algorithms + data structures = evolution programs," *Artificial Intelligence in Medicine*, vol. 9, no. 3. pp. 283–286, 1997.

[13] M. Gen, *Network Models and Optimization : Multiobjective GA Approach*. 2009.