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Optimization Of J&T Express Manado Courier Distribution Route Using Coordinate-Based Travelling Salesman Problem Method

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Abstract: In the package delivery industry, exemplified by J&T Express Manado, optimizing courier distribution routes is essential for customer satisfaction, cost reduction, and on-time deliveries. The Traveling Salesman Problem (TSP) is a valuable tool for finding efficient routes to visit all delivery points once. This study employed the Genetic Algorithm and Nearest Neighbor Algorithm to tackle the TSP, aiming to identify the shortest routes and minimize distribution distances for J&T Express Manado's couriers using geographical coordinates.
The Genetic Algorithm resulted in a distribution route of 41.20678 km, while the Nearest Neighbor Algorithm achieved a shorter route of 38.10361 km. For J&T Express Manado, our findings indicate that the Nearest Neighbor Algorithm excels in identifying the shortest courier distribution route and requires significantly less computational time. This study offers insights for J&T Express Manado and similar courier services, enabling them to enhance distribution operations, potentially reducing costs and improving efficiency. It also underscores the practical advantages of the Nearest Neighbor Algorithm in addressing TSP challenges within the industry.

Keywords: TSP, Genetic Algorithm, Nearest Neighbor Algorithm

1. Background

Manado City is the capital city of North Sulawesi Province which is the center of development and progress in many sectors, one of which is the shipping and logistics sector. Delivery and logistics service companies are increasing along with the increase in the number of online shops or remote shopping.

J&T Express is a freight forwarding and expedition service provider company in Indonesia. The process of distributing J&T Express goods has become an influential thing along with the increasing public interest in buying and selling online. J&T Express uses a centralized system for distributing and receiving packages. This system is known as Drop Point.

The activity of delivering goods ordered by customers as above can be categorized into the Traveling Salesman Problem (TSP). The actual TSP case model is that there is a salesman who will visit a number of n cities. However, all cities must be visited and each city can only be visited exactly once. The problem is how the salesman can determine the shortest route that will be traveled in visiting all cities and returning to the starting city.

Several methods can be used to solve the TSP problem, including Genetic Algorithm and Nearest Neighbor Algorithm.

Many studies on TSP have been conducted, such as research conducted by Madona and Irmansyah, 2013, to find the shortest evacuation route in disaster-prone areas using the nearest neighbor algorithm. The same research has also been conducted by Zahro and Wahyuni, 2020, to optimize package delivery routes using genetic algorithm.

The limitation of this research lies in the distribution process, which starts from J&T Express Manado Head Office, passes through several J&T Express Drop Points, and finally returns to the head office. This process involves one courier. Travel costs are determined using the indrive application, taking into account the cost of the vehicle (car) and considering the shortest route based on two different algorithms.

The purpose of this research is to Determining the shortest route and minimum distribution with the

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Traveling Salesman Problem in the distribution of J&T Express Manado couriers with coordinates and to knowing the performance of Genetic Algorithm and Nearest Neighbor Algorithm in the case of J&T Express Manado. To obtain distance data, the Google Maps application is used to record the coordinates of each location.

2. Literature Review

2.1. J&T Express

J&T Express is a goods delivery service company, both in the form of documents and packages. J&T Express is a new company that also uses IT in offering its services, they offer the advantage of picking up goods. [1]

2.2. Spatial Data

Spatial data is data about geographic objects or elements that can be identified and have a reference location based on certain coordinates. [2]

2.3. TSP

Traveling Salesman Problem (TSP) is one of the optimization problems that seeks a cycle tour to visit all cities exactly once. [3]

The Hitchcock distribution problem is to find a set of values of the *mn* real variables x_{ij} subject to the following conditions in the equation below: [4]

$$\sum_{i=1}^{m} x_{ij} = c_j, \sum_{j=1}^{n} x_{ij} = r_i, x_{ij} \geq 0, \sum_{i,j} x_{ij} d_{ij} = minimum, \quad (1)$$

Where:

m,n : the number of cities to be visited.
i,j : indices of stops that can take integer values from 1 to n.
c_j : represents the total number of carriers to be routed to new station j from all the m old stations
r_i : represents the number of carriers initially at old station i
x_{ij} : displacement from point i to point j. Values 1 if there is a displacement, 0 if no displacement occurs displacement.
d_{ij} : distance between point i and point j

In determining the closest distance, latitude and longitude are used to compute the distance between two coordinates. Haversine is one of the equations used to find the distance between two coordinates using latitude and longitude parameters. The representation of the location point of the shortest route search uses coordinate points in the form of latitude and longitude by calculating the distance between location points using the Haversine formula : [5]

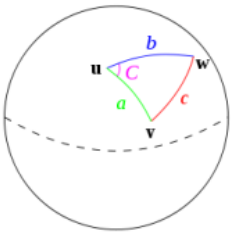

Fig. 1. Haversine Formula

The Haversine formula serves to find the distance between the user's location and the destination location by performing calculations with this following [6]

$$long = (long2 + long\ 1) cos\left(\frac{lat1+lat2}{2}\right) =$$
$$\cos a \cos b = \sin a \sin b$$
$$lat = (lat2 - lat1)$$
$$a = sin^2\left(\frac{lat}{2}\right) + \cos(lat1)\cos(lat2)\, sin^2\left(\frac{long}{2}\right)$$
$$d = \sqrt{(a)R} \quad (2)$$

Information:
R : the radius of the earth is 6371 (km)
Lat : amount of change in latitude (km)
Long : magnitude of change in longitude (km)
d : distance (km)

2.4. Genetic Algorithm

Genetic algorithms search the solutions space of a function through the use of simulated evolution. In general, the fittest individuals of any population tend to reproduce and survive to the next generation, thus improving successive generations. Genetic algorithms have been shown to solve linear and nonlinear problems by exploring all regions of the state space and exponentially exploiting promising are as through mutation, crossover, and selection operation applied to individuals in the population. [7]

2.5. Nearest Neighbor Algorithm

The nearest neighbor (NN) algorithm for determining a traveling salesman tour is as follows. The salesman starts at a city, then visits the city nearest to the starting city. Afterwards, he visits the nearest unvisited city, and repeats this process until he has visited all the cities, in the end, he returns to the starting city. [8] This algorithm works as follows:

1. The salesman starts traveling from one city (usually the first city in the list).
2. Then, he visits the city closest to the selected starting city.
3. After visiting that city, he will go to the nearest city that he has not visited before.
4. This process is repeated over and over again until it has visited all the cities on the list.
5. Finally, after visiting all the cities, it returns to the initial city (home city).

3. Research Methodology

This research uses the Traveling Salesman Problem (TSP) method by utilizing Genetic Algorithms and Nearest Neighbor Algorithms. By using this method, the shortest route for the distribution of goods from the J&T

Express Manado Head Office to the J&T Express Manado Drop Point based on coordinates can be obtain.

The data in this research is secondary data which will be taken from the coordinate points of the J&T Express Manado courier distribution route using google maps.

The steps in this research are:

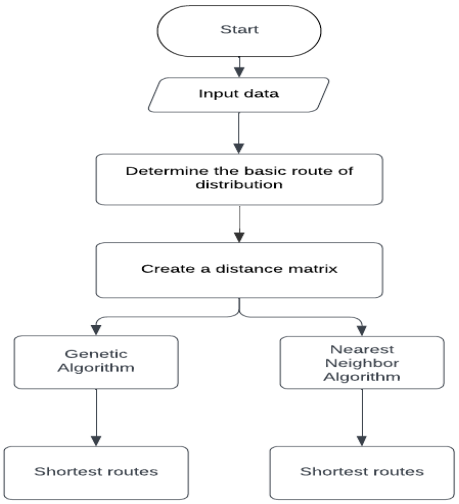

Fig. 2. Flowchart

4. Result and Discussion

4.1. Research Area and Symbolization

The distribution process by J&T Express Manado couriers starts from the J&T Express Manado Head Office. Furthermore, it moves to 11 J&T Express Manado drop points. To facilitate the work area in the process of distributing goods carried out by couriers, google maps are used to record the coordinates of the point. Then, the points are modeled using leaflet maps symbolized by red numbers in R as shown below:

Fig. 3. Research Point

1 : J&T Express Manado Head Office
2 : J&T Express Tanjung Batu
3 : J&T Express Malalayang
4 : J&T Express Tuminting
5 : J&T Express Sea
6 : J&T Express Paal
7 : J&T Express Komo Luar
8 : J&T Express Bahu
9 : J&T Express Winangun
10 : J&T Express Teling
11 : J&T Express Wonasa
12 : J&T Express Tateli

4.2. Distance Between Point

Table 1. Distance Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	0.00000000	1,9800029	6,6086644	2,2392263	5,9595211	2,7713173	0,2916172	4,0224481	5,4357743	2,6260683	0,8325122	11,634688
2	1,9800028 6	0,0000000	5,2665685	4,1688888	4,1715559	4,1690888	2,1002960	2,2437554	3,6048001	1,1295530	2,7203614	10.277105
3	6,6086643	5,2656685	0,0000000	8,0130017	2,2352276	9,2881111	6,8659547	3,2311.7798	5,9826248	5,9484887	7,4334011	5,0398997
4	2,2392628	4,1688888	8,0130177	0,0000000	7,8323007	3,1126144	2,2439854	5,9696677	7,6749393	4,8594008	1,8203781	12,875863
5	5,9595207	4,1715559	2,2352276	7,8323007	0,0000000	8,3364556	6,1568251	1,9444885	3,8337757	4,4788898	6,7778343	6,5088838
6	2,7713731	4,1690888	9,2881111	3,1126144	8,3364564	0,0000000	2,4859715	6,4125311	6,6640035	4,0850550	2,0551006	14,327900
7	0,2916172	2,1002096	6,8655595	2,2439854	6,1568225	2,4859571	0,0000000	4,2140277	5,4566626	2,6276338	0,6253318	11,896643
8	4,0224812	2,2437554	3,2317988	5,9696677	1,9448885	6,4125331	4,2140269	0,0000000	3,2823357	2,7335494	4,8363140	8,1307799
9	5,4357431	3,6048001	5,9826483	7,6749393	3,8337757	6,6640035	5,4566260	3,2823557	0,0000000	2,8325548	6,0019232	10,182214
10	2,6260825	1,1295530	5,9484887	4,8594008	4,4788898	4,0850550	2,6276381	2,7335594	2,8325548	0,0000000	3,1703146	10,857809
11	0,8325122	2,7203561	7,4334011	1,8203778	6,7778834	2,0551001	0,6253318	4,8363144	6,0019223	3,1703315	0,0000000	12,453542
12	11,634685	10,277105	5,0398997	12,875863	6,5088838	14,327900	11,896643	8,1307799	10,182214	10,857809	12,453542 4	0,0000000

Based on Table 1, point 1, that is the J&T Express Manado Head Office is the starting point and end point of the courier distribution in distributing goods. The distance from point 1 to point 2 is 1.980029 km. Likewise, the distance from point 2 to 1 is 1.980029 km, the distance from point to point itself is 0 km.

4.3. Route Determination Using Genetic Algorithm Method

4.3.1. Determining Genetic Algorithm Parameters

Table 2. Genetic Algorithm Parameters

Population Size	Number of Generations	Mutations Probability
20	20	0.1

4.3.2. Defining Genes

The gene in this case is a representation of the J&T Express Manado Head Office which is the starting place for distribution and drop points which are places that must be visited by couriers. The gene representation is as follows:

Gene 1 = J&T Express Manado Head Office .
Gene 12 = J&T Express Tateli

4.3.3. Generating The Initial Population

Table 3. Initial Population

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6	12	3	2	3	3	12	8	11	3	5	6	6	5	10	4	6	12	5	10
11	4	5	4	12	4	5	11	9	10	9	2	11	2	3	9	12	10	7	12
9	6	4	11	6	7	10	4	5	9	4	7	10	3	12	6	7	7	10	7
5	9	6	5	9	9	11	7	7	7	3	5	7	9	6	11	4	4	8	2
10	2	8	10	8	10	8	10	10	5	11	4	8	6	5	5	5	2	11	5
4	7	11	7	10	5	2	6	6	4	7	12	4	11	8	7	2	9	6	4
2	8	9	6	11	8	3	3	3	12	12	3	9	7	9	3	3	3	9	9
3	3	12	8	4	6	9	2	8	8	2	10	3	8	11	10	10	5	12	8
8	11	7	3	5	11	7	12	4	2	6	9	5	10	2	8	11	6	4	3
7	5	2	12	7	2	4	9	12	11	10	11	2	4	4	12	8	8	3	6
12	10	10	9	2	12	6	5	2	6	8	8	12	12	7	2	9	11	2	11

The initial population is generated using a random number technique, where each gene's value is determined according to the chromosome representation. Chromosomes contain information regarding potential solutions to the problem. To improve the solution, each generation produces new chromosomes using crossover and mutation operators. Each chromosome represents a sequence of locations to visit, with each number signifying the start and visitation points.

4.3.4. Determining Fitness Value

Then each chromosome undergoes an evaluation process to get the fitness value of each chromosome Calculate the distance of chromosomes based on the distance matrix table, for example:

Chromosome 1 = [6 > 11] + [11 > 9] + [9 >5] + [5 > 10] + [10 > 4] + [4 > 2] + [2 > 3] + [3 > 8] + [8 > 7] + [7 > 12] = 4.085050 + 2.832548 + 3.833757 + 4.478898 + 4.859408 + 4.168888 + 5.265685 + 3.231798 + 4.2140269 + 11.896643 = 50.0053701.

As for calculating the Fitness Value on chromosome 1, is Fitness Chromosome1= 1/50.0053701 = 0.01999755. By performing the same calculation steps, Fitness Value of the other chromosomes will be obtained. Fitness Value on other chromosomes at Table 4.

Tabel 4. Fitness Value

0.01999755	0.01646308
0.01835079	0.01730297
0.01794055	0.02067041
0.02117475	0.02022357
0.01882250	0.01851333
0.02153545	0.01580169
0.02309486	0.01587918
0.01836202	0.01949077
0.01554056	0.01628392
0.01777693	0.01602796

Based on the Table 4, the best fitness value of the initial population is the 7th chromosome with a fitness value of 0.02309486. Chromosomes with the best fitness value of this generation population will be retained and carried over to the next generation.

4.3.5. Selection

After the generation of the initial population and the fitness value has been calculated, selection is performed on the population. In this process, the selection method used is elite selection. Elitism selection method is a method by retaining individuals that have a high fitness value to become the next generation. Individuals that have been retained will be compared with the the result of the regeneration process.

Table 5. Selection

p1	p2	p3	p4	p5	p6	p7	p8	p9	p10
12	**3**	2	6	5	6	12	3	10	8
5	**4**	4	11	2	11	10	12	3	11
10	**7**	11	10	3	9	7	6	12	4
11	**9**	5	7	9	5	4	9	6	7
8	**10**	10	8	6	10	2	8	5	10
2	**5**	7	4	11	4	9	10	8	6
3	**8**	6	9	7	2	3	11	9	3
9	**6**	8	3	8	3	5	4	11	2
7	**11**	3	5	10	8	6	5	2	12
4	**2**	12	2	4	7	8	7	4	9
6	**12**	9	12	12	12	11	2	7	5

Based on Table 5, p1until p10 is the chromosome that has the highest fitness value at the previous fitness calculation stage.

4.3.6. Crossover

Based on the results, P1 until P10 were selected from the best population (parents). At each iteration of repetition for each pair of parents, the crossover point is generated at the 4th point between the two chromosome genes. Then, the child chromosomes (Offspring) are formed by swapping the parts after the crossover point between the two parent chromosomes.

Crossover 1:

Parent 1 = 12-5-10-11-8-2-3-9-7-4-6

><

Parent 2 = 3-4-7-9-10-5-8-6-11-2-12

The result of crossover 1 is as follows:

Offspring 1 = 12-5-10-11-8-5-8-6-11-2-12

The offspring resulting from the cross-moving process above will then be mutated. The mutation process is carried out on the cross-moving offspring with the aim of obtaining new individuals as solution candidates in the next generation with better fitness, and gradually towards the desired optimum solution. In the results above, it can be seen that there are duplicates in the crossover results, this is because when the crossover point is chosen randomly there is a possibility that the same genes will be exchanged between the 2 parent chromosomes.

4.3.7. Mutation

Mutation occurs with a 10% probability. If a randomly generated number between [0,1] falls below this threshold, a gene value is swapped with another random gene value. Duplicates discovered during the previous crossover are removed using the Mutation process in R. This ensures the new population's chromosomes are free from duplicates. Swapping mutation is employed, where a randomly selected gene is exchanged with the gene that follows it.

Before duplicate removal and swapping mutation:

Mutation 1: 6-3-5-4-5-11-10-6-6-6-10

After duplicate removal and swapping mutation:

Mutation 1: 6-3-5-4-12-11-10-9-7-8-2

4.3.8. Formulation New Population and Final Solution Genetic Algorithm

Table 6. New Population and Final Solution Genetic Algorithm

Pop. Size	Mutation Probability	Number of Generation	Shortest Routes	Shortest Distance	Opt. Generation	Fitness Value
20	0.1	20	1-12-5-10-11-8-2-3-9-7-4-6-1	57.70574 km	10	0.02309486
20	0.1	20	1-6-3-5-4-12-11-10-9-7-8-2-1	67.35377 km	10	0.01597384
20	0.1	20	1-9-3-4-7-10-2-12-5-11-6-8-1	61.48645 km	10	0.01922034
20	0.1	20	1-2-6-3-5-10-11-4-8-9-12-7-1	58.76459 km	10	0.01770132
20	0.1	20	1-2-12-4-8-9-10-5-6-7-11-3-1	67.18629 km	10	0.01706555
20	0.1	20	1-9-8-2-7-4-3-5-12-10-11-6-1	50.91787 km	10	0.02341331
20	**0.1**	**20**	**1-6-2-10-3-12-5-8-9-4-11-7-1**	**41.20678 km**	**10**	**0.02621659**
20	0.1	20	1-2-4-9-5-12-6-10-7-3-11-8-1	68.36488 km	10	0.01603531
20	0.1	20	1-4-5-8-11-10-2-9-7-3-6-12-1	72.33033 km	10	0.01710677
20	0.1	20	1-3-7-2-5-6-11-12-10-8-9-4-1	69.37923 km	10	0.01652038
20	0.1	20	1-9-7-6-5-11-3-4-12-8-2-10-1	70.94508 km	10	0.01590249

The best chromosome with the highest fitness value in the initial population is carried over to the new population. The procedures of determining fitness value, selection, crossover and mutation are performed in the second generation to determine the population in the next generation. Iteration is carried out until the optimum fitness value is obtained in a particular generation. Based on the results of the study, the optimum generation was obtained in the 10th generation.

Based on Table 6, the shortest distance of 41.20678 km is obtained with the shortest route 1-6-2-10-3-12-5-8-9-4-11-7-1 because it has the highest fitness value of 0.02621659.

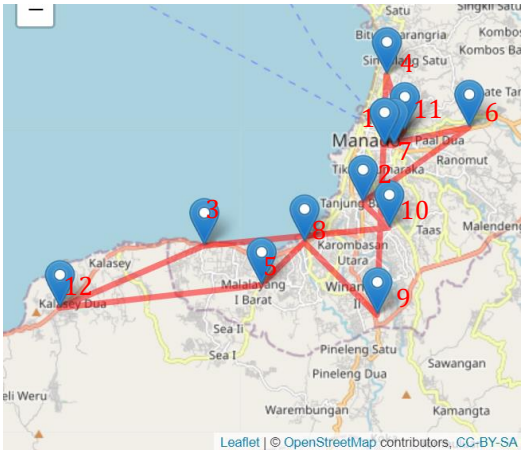

Fig. 4. Travel Route Map

4.3.9. Minimum Distribution

Table 7. Shortest Route Travel Cost Genetic Algorithm

Origin Address	Destination Address	Travel Cost
J&T Express Manado Head Office	J&T Express Paal 2	IDR 35.000
J&T Express Paal 2	J&T Express Tanjung Batu	IDR 29.000
J&T Express Tanjung Batu	J&T Express Teling	IDR 14.000
J&T Express Teling	J&T Express Malalayang	IDR 31.000
J&T Express Malalayang	J&T Express Tateli	IDR 20.000
J&T Express Tateli	J&T Express Sea	IDR 33.000
J&T Express Sea	J&T Express Bahu	IDR 15.000
J&T Express Bahu	J&T Express Winangun	IDR 29.000
J&T Express Winangun	J&T Express Tuminting	IDR 47.000
J&T Express Tuminting	J&T Express Wonasa	IDR 15.000
J&T Express Wonasa	J&T Express Komo Luar	IDR 14.000
J&T Express Komo Luar	J&T Express Manado Head Office	IDR 19.000

Based on the results of research using genetic algorithms, the shortest route is obtained, that is J&T Express Manado Head Office - J&T Express Paal 2 - J&T Express Tanjung Batu - J&T Express Teling - J&T Express Malalayang - J&T Express Tateli- J&T Express Sea - J&T Express Bahu- J&T Express Winangun - J&T Express Tuminting - J&T Express Wonasa - J&T Express Komo Luar- J&T Express Manado Head Office. Furthermore, travel costs are calculated, in this study travel costs are taken from the indrive application according to the route that has been obtained. Based on the total cost obtained as a minimum distribution result is IDR 301.000 for the vehicle used by the J&T Express Manado courier in one trip to distribute goods.

4.4. Route Determination Using the Nearest Neighbor Algorithm

Table 8. Nearest Neighbor Iteration Results

Iteration	Routes	Distance
1	1 – 7	0.2912909
2	1 – 7 – 11	0.6246320
3	1 – 7 – 11 – 4	1.8183411
4	1 – 7 – 11 – 4 – 6	3.1091313
5	1 – 7 – 11 – 4 – 6 – 10	4.0804787
6	1 – 7 – 11 – 4 – 6 – 10 – 2	1.1282665
7	1 – 7 – 11 – 4 – 6 – 10 – 2 – 8	2.2412438
8	1 – 7 – 11 – 4 – 6 – 10 – 2 – 8 – 5	1.9427087
9	1 – 7 – 11 – 4 – 6 – 10 – 2 – 8 – 5 – 3	2.2327751
10	1 – 7 – 11 – 4 – 6 – 10 – 2 – 8 – 5 – 3 – 12	5.0342577
11	1 – 7 – 11 – 4 – 6 – 10 – 2 – 8 – 5 – 3 – 12 – 9	10.1708202

In this step, we begin at J&T Express Manado Head Office and calculate the distances to all J&T Express Manado drop points. Using the Nearest Neighbor algorithm, we select the drop point closest to "J&T Express Manado Head Office," which is "J&T Express Komo Luar" at a distance of 0.2912909 km. "J&T Express Komo Luar" is then chosen as the first stop on the route.

After visiting "J&T Express Komo Luar," the next iteration identifies the nearest drop point from "J&T Express Komo Luar" that hasn't been visited, and this process continues until all drop points are visited. Finally, the route returns to "J&T Express Manado Head Office," serving as the endpoint of the journey.

Using the same method following the Nearest Neighbor method algorithm, the distribution route obtained at the J&T Express Manado Head Office is 1 - 7 - 11 - 4 - 6 - 10 - 2 - 8 - 5 - 3 - 12 - 9 - 1 with a total distance is 0. 2912909 + 0.624632 + 1.818341 + 3.109131 + 4.080479 + 1.128267 + 2.241244 + 1.942709 + 2.232775 + 5.034258 + 10.17082 km = 38.10361 km.

Fig. 5. Travel Route Map

4.4.1. Minimum Distribution

Based on the results of research using the Nearest Neighbor algorithm method, the shortest route is obtained from J&T Express Manado Head Office, J&T Express Komo Luar, J&T Express Wonasa, J&T Express Tuminting, J&T Express Paal 2, J&T Express Teling, J&T Express Tanjung Batu, J&T Express Bahu, J&T Express Sea, J&T Express Malalayang, J&T Express Tateli, J&T Express Winangun back to J&T Express Manado Head Office. Then the travel costs are calculated using the indrive application to obtain the total cost as a minimum distribution.

Table 9. Shortest Route Travel Cost Algorithm Nearest Neighbor

Origin Address	Destination Address	Travel Cost
J&T Express Manado Head Office	J&T Express Komo Luar	IDR 25.000
J&T Express Komo Luar	J&T Express Wonasa	IDR 14.000
J&T Express Wonasa	J&T Express Tuminting	IDR 15.000
J&T Express Tuminting	J&T Express Paal 2	IDR 20.000
J&T Express Paal 2	J&T Express Teling	IDR 22.000
J&T Express Teling	J&T Express Tanjung Batu	IDR 14.000
J&T Express Tanjung Batu	J&T Express Bahu	IDR 16.000
J&T Express Bahu	J&T Express Sea	IDR 23.000
J&T Express Sea	J&T Express Malalayang	IDR 17.000
J&T Express Malalayang	J&T Express Tateli	IDR 20.000
J&T Express Tateli	J&T Express Winangun	IDR 43.000
J&T Express Winangun	Kantor Pusat J&T Express Manado	IDR 15.000

Based on Table 9, the total cost obtained as a minimum distribution result is IDR 224.000 for the vehicle used by the J&T Express Manado courier in one trip to distribute goods.

4.5. Performance of Genetic Algorithm and Nearest Neighbor Algorithm

Tabel 10. Performance of Genetic Algorithm and Nearest Neighbor Algorithm

Method	Route	Distance	Distribution Cost
Genetic Algorithm	1-6-2-10-3-12-5-8-9-4-11-7-1	41.20678 km	IDR 301.000
Nearest Neighbor Algorithm	1 -7 – 11 -4 – 6 – 10 -2 – 8 -5 – 3 -12	38.10361 km	IDR 224.000

According toTable 10, it becomes evident that the Genetic Algorithm and the Nearest Neighbor Algorithm exhibit distinct strengths and weaknesses in the context of J&T Express Manado's distribution process.

The Genetic Algorithm's ability to yield the shortest route with a distance of 41.20678 km is a testament to its capacity for extensive search space exploration. By doing so, it can successfully navigate complex routes, potentially bypassing local minimums, and thereby, inching closer to the optimal solution. This outcome suggests that the Genetic Algorithm is well-suited for scenarios where finding the absolute shortest route is of paramount importance. However, it is imperative to note that this advantage comes at the cost of a significantly longer computation time. Therefore, its feasibility in real-world applications may be limited, particularly in cases where time efficiency is crucial.

On the other hand, the Nearest Neighbor Algorithm's result of a 38.10361 km shortest route showcases its simplicity and efficiency. By prioritizing the closest distance between unvisited points, it offers a more straightforward and easily comprehensible approach to route optimization. The lower distribution cost of Rp 224,000 further underscores its cost-efficiency. This algorithm is particularly well-suited for situations where computational speed is a priority, and where the exact shortest route may not be the primary concern.

Referring to research conducted by Zahro and Wahyuni (2020), the use of mutation probability 10% can produce more genes that have similarities with their parents than using mutation probabilities smaller than 10%.

It is important to recognize that the choice between these algorithms should be made in alignment with the specific requirements and constraints of the distribution process. Factors such as time sensitivity, computational resources, and the acceptable degree of route optimization must be carefully considered. Moreover, it is worth noting that these results may serve as a foundation for further research and optimization strategies in the field of distribution logistics.

5. Conclusion

Genetic Algorithm: route 41.20678 km, cost Rp 301,000. Nearest Neighbor Algorithm: route 38.10361 km, cost Rp 224,000.

In conclusion, the Nearest Neighbor Algorithm is simpler and more economical than the Genetic Algorithm, suitable for J&T Express Manado. Nearest Neighbor involves distance calculation and nearest neighbor search, while Genetic Algorithm requires deeper understanding due to more complex concepts.

References

[1] Murningsih, S and Parini, "Pengembangan Aplikasi Pendataan Paket Gagal Kirim Pada J&T Express CP Arvino Hessa Berbasis WEB," *JUTSIJurnal Teknol. dan Sist. Inf.*, vol. 2, no. 3, pp. 185–194, 2022.

[2] Cressie. N. A, *Statistics for Spatial Data.*, vol. 156, no. 1. 1993.

[3] Mahmudy, W. F, "Optimasi Multi Travelling Salesman Problem (M-TSP) Menggunakan Algoritma Genetika," *Semin. Nas. Basic Sci.*, vol. 1, no. 2, pp. 1–6, 2008.

[4] Flood. M. M., "The Traveling-Salesman Problem," *Oper. Res.*, vol. 4, no. 1, pp. 61–75, 1956.

[5] Utomo. D. W, Kurniawan. D, and Ningrum, N. K, "Implementasi Traveling Salesman Problem pada Pemilihan Jalur ATM Locator Menggunakan Ant Colony Optimization," *J. Pengemb. IT*, vol. 20, no. 20, pp. 20–25, 2017.
[6] Dauni. P, Firdaus. M. P, Asfariani. R, Saputra M. I. N,Hidayat A. A, and Zulfikar. W. B., "Implementation of Haversine formula for school location tracking," *J. Phys. Conf. Ser.*, vol. 1402, no. 7, pp. 1–6, 2019.
[7] Michalewicz. W, "Genetic algorithms + data structures = evolution programs," *Artificial Intelligence in Medicine*, vol. 9, no. 3. pp. 283–286, 1994.
[8] Kizilateş. G, and Nuriyeva. F, "On the Nearest Neighbor Algorithms for the Traveling Salesman Problem," *Adv. Intell. Syst. Comput.*, vol. 225, no. 1, pp. 111–118, 2013.