Research on the Optimization of the Distribution Path at the End of the Last Mile Logistics

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Abstract. This paper models the path selection in the logistics distribution process, obtains different paths in the process of vehicle transportation through genetic algorithm, and analyzes the shortest choice of different paths
The distance of the path, the selection of the path should fully consider the customer and other factors, and then through MATLAB simulation to select the distribution path, the experimental results show that the use of the legacy
The transmission algorithm selects the transportation path, which can reduce the corresponding carbon emissions and realize the greening of transportation.

Keywords: path optimization; logistics and distribution; green logistics; Genetic algorithms

1 INTRODUCTION

In the process of logistics distribution, the "last 1000 meters" of logistics terminal distribution mainly refers to the stage when the goods are handed over by the delivery person from the distribution point to the consumer for signing, which is also[1]. The last step in the entire logistics distribution[2]. At present, the "last 1000 meters" of China's logistics takes about 5 hours, accounting for 45% of the express business market[3]. The transportation distance is less than 5% of the entire transportation distance[4]. It can be seen that how to improve the transportation efficiency of the "last 1000 meters" is an important problem for current logistics transportation[5]. Fast. The distribution efficiency of the end of the delivery is affected by many factors, the most important of which is the selection of the delivery path of the express vehicle, which is selected in the increasingly fierce market competition. Choosing a reasonable distribution path can enable enterprises to achieve the maximum distribution range at the minimum cost. Cost savings while improving service quality and customer satisfaction, needed: Achieved through path optimization[6]. Therefore, it is an important way to reasonably choose the distribution path to improve the competitiveness of enterprises and save costs[7].

This paper investigates the express delivery situation of many express company outlets in Jinzhou City, and finds that customer satisfaction and work efficiency are not ideal[8]. The delivery situation and service quality are not the same, so this article selected one of the courier companies for research[9]. Many factors can lead to high

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operating costs, such as the method of using manual experience and manual arrangement for vehicle scheduling is still applied in most logistics and distribution centers, but with the enhancement of logistics information, customers the requirements for time are getting higher and higher, and the express companies take reducing costs and improving the quality of customer service as important goals, and the realization of these goals is mainly reflected[10]. In the rational planning of express delivery routes[11]. In this paper, the minimum total route is taken as the objective function and the optimal delivery is completed according to the genetic algorithm based on the combination of customer differences and distances[12]. Exploration of the scheme It can improve transportation efficiency, effectively protect the natural environment, and help the express industry improve its market competitiveness, which is very important for the development of the express delivery industry practical significance[13].

2 ESTABLISHMENT OF THE MATHEMATICAL MODEL OF VRP

2.1 Problem Description

VRP refers to the distribution of goods from the logistics distribution center (express outlet) to each customer node, in which the needs of each customer node are distributed

The quantity is known, the number and location of each outlet and customer point are known, and the express delivery vehicle can be made to start from the outlet through the reasonable design of the express delivery route. Dispatch of goods to each known customer location in an orderly manner, while satisfying many linear constraints such as the demand at each customer point, the customer can accept the goods time, the full load factor of the vehicle, the distance of the driving route during delivery, etc., and then return to the express network (distribution center) to achieve the least amount of fuel and the most efficient transportation high, the lowest cost, the highest customer satisfaction, etc.. Through the investigation and data collection of the logistics company (SF Express), the data shows that the distribution efficiency is affected. Many factors are affected, the important of which is the path selection of the express vehicle, in the process of the formulation of the distribution task and the execution of the distribution task, the express vehicle is delivered by the delivery. The heart is set out, for the delivery of customers who know the location coordinates and the amount of demand, and stipulates that a car is essentially only for one customer, and the vehicle driving path is reasonably planned. At the same time, it is necessary to ensure that the carrying capacity of the goods cannot exceed the load limited by the vehicle, so as to ensure that the total emissions are minimized and the time consumption is less at the macro level, so as to improve delivery efficiency of vehicles.

2.2 Explanation of Basic Assumptions and Symbols

The path optimization problem of logistics and distribution vehicles is modeled, and the final optimization goal of the route problem is to calculate a group of vehicles with the shortest total distribution distance. The following assumptions need to be followed when finding a vehicle route that meets the constraints and needs at the minimum cost:

(1) There is a linear relationship between vehicle distance traveled and cost;

(2) The coordinates of each customer's shipping address are known

(3) For each customer node, the target vehicle will make the delivery

(4) There is no limit to the maximum load capacity of a delivery vehicle

(5) The driving distance of the logistics and distribution vehicle shall not be greater than the specified maximum driving distance of the vehicle

(6) All customer requirements for delivery need to be met

(7) A customer can and can only be visited once

P_0: Represents the distribution center, i.e., the express outlet

P_i: Represents each customer node （i = 1， 2， …， N）

N: Represents the number of customers who need logistics and delivery services within the scope of this article's survey.

X_{ij}: As a decision variable, the number of deliveries that the delivery vehicle needs to make from customer i to customer j is indicated

a_{ij}: Represents the distance gap from customer i to customer j

d_{10}: Represents the distance between the transport vehicle from the delivery location to the first customer node

d_{n0}: It indicates the distance of the express transport vehicle back to the express outlet after delivery

L: Indicates the maximum distance that the delivery vehicle has traveled

2.3 Build a Model

After the above specific description and assumptions of the conditions, the required mathematical model is established for the distribution route optimization problem, and the cut-off transportation distance is the objective function. On the premise of ensuring green logistics, the optimal distribution path is designed, as follows, as follows, as follows, the objective function and constraints.

$$S = min \sum_{i=0}^{N} \sum_{j=0}^{N} d_{ij} x_{ij} + d_{10} + d_{n0} \tag{1}$$

$$\sum_{i=o}^{N} x_{ij} = 1 \quad (\mathrm{i} \neq \mathrm{j}\ \mathrm{j} = 1,2, \ldots, \mathrm{N}) \tag{2}$$

$$\sum_{j=0}^{N} x_{ij} = 1 \quad (\mathrm{j} \neq \mathrm{i}, \mathrm{i} = 1,2, \ldots \mathrm{N}) \tag{3}$$

$$\mathrm{S} \ 〈 \ \mathrm{L} \tag{4}$$

$$\boldsymbol{X_{ij}} \begin{cases} 1 & \mathit{The\ delivery\ vehicle\ travels\ from\ point}\ \mathrm{i}\ \mathit{to\ point}\ \mathrm{j} \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

Constraints:

Objective function (1): Represents a function that calculates the shortest route that a vehicle can travel

Constraints (2)、(3)：Represents that each customer has been visited only once; And ensure that the transport vehicle departs and returns to the distribution center.

Constraints（4）：It means that the distance traveled by the delivery vehicle on the way to the delivery should be less than the vehicle distance L specified in this article.

Constraints (5):X_{ij} is the decision variable of the model established in this paper

3 VRP BASED ON GENETIC ALGORITHMS

Genetic algorithms randomly generate first-generation initial solutions (called "populations") that search each of the first-generation chromosomes. bodies are an initial solution to the vehicle routing problem. As for the quality of chromosomes in subsequent generations, the "fitness function" is generally used to calculate

The chromosomes of the later generation are crossed and mutated to form new offspring. According to Darwin's theory of natural selection for the survival of the strong, in the process of forming offspring, adaptation Individuals with higher degrees survived, while individuals with lower fitness were eliminated. If the chromosome has a high adaptation value, it has a higher probability of being selected. Many generations later, heredity

In the end, the algorithm will converge to the chromosome with the best fitness, which is most likely the optimal solution to the genetic problem.

The genetic algorithm can be solved through the following steps:

3.1 Encode

The determination of chromosomes and their recombinant coding is the most critical problem to solve the genetic algorithm, and the sequence of each customer point is to solve the problem of vehicle path. The core of the question. In the coding operation, each customer point is regarded as a chromosome gene, and n customer points are arranged and processed, and then encoded to make it. Become chromosomes. In this paper, the coding method used for the genetic algorithm problem is to encode the chromosome by serial number, and randomly select 8 customer points for express matching I send it, and the code is (1 2 3 4 5 6 7 8), When the encoding string is (1 2 3 4 5 6 7 8) time Representatives: The delivery vehicle departs from the courier outlet 0 and follows the order described above .Passing through these 8 customer points in sequence, and finally returning to a driving route at delivery outlet 0.

3.2 Fitness Function

When studying the vehicle path problem (VRP), the fitness function can be used to accurately calculate the distance between the two customer points, and the total distance can be passed by the customer. The order in which the points are arranged is calculated accurately. In this paper, the reciprocal of the total distance randomly arranged by the customer points is regarded as the fitness function, and the shorter the total distance, the more the fitness function, Good.

3.3 Select an Action

In this paper, we choose to use genetic algorithm to solve the VRP problem, and make the corresponding choice according to the proportion of fitness, that is, the longer the driving path of the logistics and distribution vehicle, the lower the probability of being selected to enter the next generation, the shorter the driving path of the logistics distribution vehicle, and the higher the probability of being selected to enter the next generation.

3.4 Cross-Manipulation

In order to achieve the optimal delivery route for all customer points, this paper chooses to use the Partial Matching Crossover (PMX) algorithm. Start by randomly generating two crossovers point, the area in the two intersections is defined as the matching region, and then the two randomly generated matching regions of the parent are exchanged, and finally the original individual is removed in turn. The same gene fragment as the crossed gene can be obtained after the crossing. For example, now we randomly select 8 customer points and perform on these 8 customer points. Logistics distribution (where 0 indicates express outlets):

Randomly select a crossover region in the parent individual, as follows, the two crossover regions and the parent individual can be set as A, as shown in B:

A（1 2 5 | 8 3 7 0 | 4 6）

B（3 0 8 | 5 1 4 2 | 6 7）

(The " | | " above represents the intersection area)

The mating regions of A and B are added in front of B and A, respectively, to give two intermediate individuals.

A_1（5 1 4 2 | 1 2 5 8 3 7 0 4 6）

B_1（8 3 7 0 | 3 0 8 5 1 4 2 6 7）

In A1 and B1, delete those genes one by one (the same as the intersection region), and the final result is two individuals as:

A_2（8 3 7 0 5 1 4 2 6）

B_2（5 1 4 2 8 3 7 0 6）

In order to achieve the crossover of two identical individuals and obtain a new individual, it is necessary to avoid precocious puberty as much as possible in this process. The aim is to reduce the probability of the local optimal solution.

3.5 Mutation Operations

By changing the position of the gene code, changing the existing individual to obtain a new individual requires a mutation operation, which is aimed at making evolution more possible. Ability. The inverted mutation operator is the operation method about the mutation type used in this paper, and the mutation operation refers to the chromosomes when solving the routing optimization problem of delivery vehicles The two client points on are considered as mutation points, and finally the inverted processing of the variant regions on the chromosomes can obtain new individuals. Inverted mutation can be prevented in the evolutionary process and can enhance the global optimization performance in the process of genetic manipulation. For example, 8 customer points are randomly selected and delivered by express Service (where 0 is the distribution center):

(1) For any new individual, such as: M(2 8 1 0 3 6 4 7 5), its mutation points are 1 and 7, i.e., M_1 (2 8 | 0 3 6 4 | 5), where" | | " indicates the area where the mutation is taking place.

(2) The genes in the mutated region are arranged in reverse order and placed in the original position, so that a new individual is obtained:m^2（2 8 | 4 6 3 0 | 5）

3.6 Decode Operations

For any individual, for example, (0 1 2 3 4 5 6 7 8 0), sum the distances of every two adjacent genes, and the result is the car. The total distance of the travel path. Through the process of chromosome crossing and mutation of the previous generation, new populations with good convergence are obtained, and then the optimal individuals are selected under the premise of ensuring the best individual choose the shortest driving path.

With the goal of minimizing the distribution cost and maximizing the quality of the distribution service, the genetic algorithm is used to solve the path optimization problem, and the basic process is shown in Figure 1.

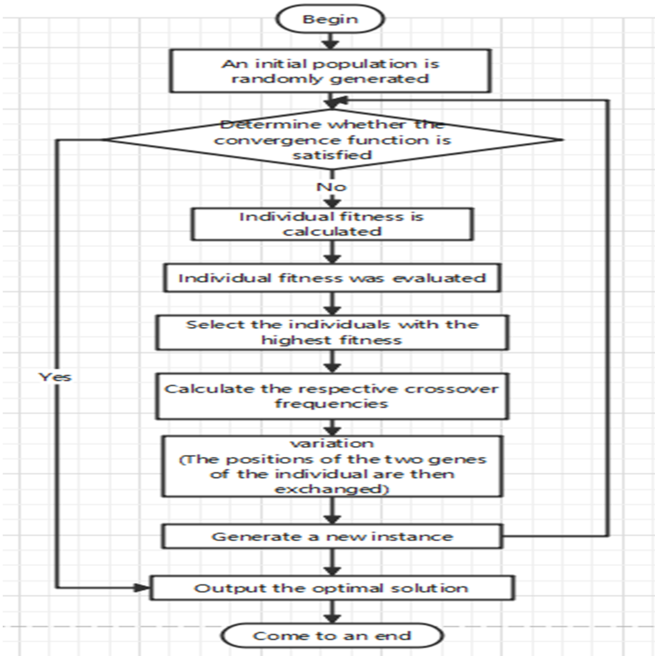

Fig. 1. Schematic diagram of genetic algorithm solving vehicle routing problem

4 ANALYSIS OF EXPERIMENTAL RESULTS

4.1 Background and Data Sources

This paper investigates the express delivery situation of many express companies in Jinzhou City, but customer satisfaction and work efficiency are not ideal, and the distribution situation of each express company. The situation and service quality are not the same, so this article chooses SF Express for research. Through the investigation of the distribution center of SF Express, it was found that it was reasonable and prudent Careful arrangement of logistics distribution methods and transportation routes can effectively improve distribution efficiency. According to the results of the case analysis of Jinzhou Wannianli, it can be obtained, based on customer satisfaction .

The express delivery method can not only effectively improve the quality of service, increase market competitiveness, improve the efficiency of logistics and customer satisfaction, but also reduce carbon emissions. Put. The data in this article are all based on field research, by collecting the number of business operations of delivery vehicles driven by regional couriers in their area of responsibility for a week in 10,000 years. occupy. Due to the sheer volume of data in the survey, this paper selected 34 customer points delivered in a single day by a vehicle driven by one courier Object.

4.2 Data Processing

According to the location information of the 34 customer points surveyed, the longitude and latitude information of each customer location node can be found out by using Baidu Maps, and then Gauss can be used

The standard converter inputs the latitude and longitude of 34 customer points, and the latitude and longitude information of the customer points is converted by the Gaussian projection method, and finally the latitude and longitude of the 34 customer locations are converted the degree information is converted into the x,y coordinates of 34 customer points in the Gaussian plane in the planar Cartesian coordinate system,

where the ellipsoid parameters use the WGS1984 reference ellipsoid, a=6378137, alfa=298.2572235635

For the x, y coordinates in the plane Cartesian coordinate system obtained by the above process, after appropriate processing and transformation. It is stored as the arithmetic coordinates used in this article. Figure 2 shows a detailed process for data processing.

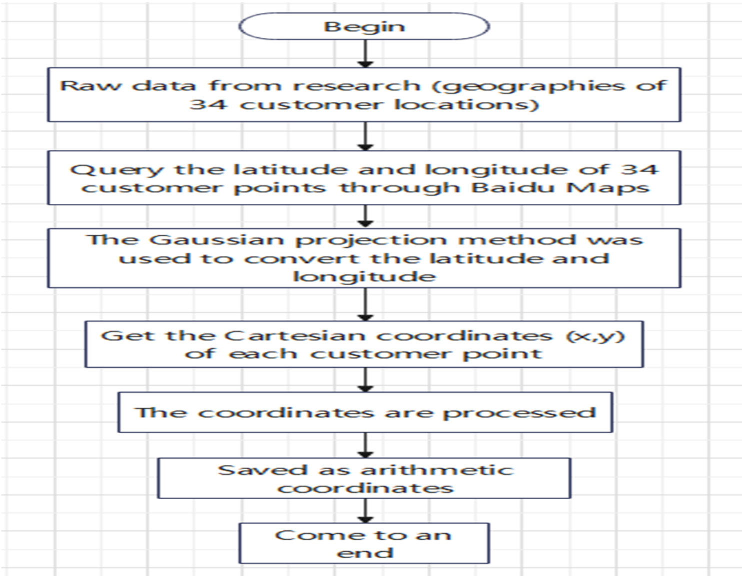

Fig. 2. Data Processing Flow Diagram

After obtaining the original data through the survey, the corresponding longitude and latitude information of each customer point location on the Baidu map was found. For example: Raw numbers according to the No. 1 customer point is Jinzhou Qianjin Cable Factory, look for the No. 1 customer point in the Baidu map API, and determine the longitude and latitude coordinates of the point to be (121.151953,41.14411）.In the Gaussian projection method, the latitude and longitude coordinates of No.1 are converted to plane Cartesian coordinates as (4558224.07872955,21344849.7108733).

Table 1 shows the latitude and longitude coordinates for the 34 customers for which the courier is responsible.

Table 1. Customer latitude and longitude coordinate table

Customer number	Latitude and longitude coordinates	Customer number	Latitude and longitude coordinates
1	(121.151953，41.14411)	18	(121.154356，41.138066)
2	(121.151675，41.145027)	19	(121.153121，121.153121)
3	(121.152065，41.146164)	20	(121.15145，41.140117)
4	(121.152209，41.146439)	21	(121.156157，41.143353)
5	(121.152613，41.146633)	22	(121.155573，41.14285)
6	(121.153655，41.146582)	23	(121.157464，41.141689)
7	(121.153817，41.146168)	24	(121.156211，41.14064)
8	(121.15428，41.145642)	25	(121.153938，41.140558)
9	(121.154226，41.146545)	26	(121.154926，41.138962)
10	(121.156714，41.146884)	27	(121.153067，41.140321)
11	(121.158416，41.145499)	28	(121.151243，41.139224)
12	(121.160123，41.144239)	29	(121.15145，41.138341)
13	(121.159229，41.14301)	30	(121.149972，41.143832)
14	(121.15856，41.141886)	31	(121.155852，41.139696)
15	(121.159988，41.139801)	32	(121.154926，41.138962)
16	(121.158708，41.13881)	33	(121.154113，41.138307)
17	(121.157509，41.137968)	34	(121.155304，41.145051)

4.3 Instance Data

Because the range of delivery addresses is small, the difference in latitude and longitude coordinates between customer points is also small, and the position information obtained by the Gaussian projection method is on the plane The Cartesian coordinate difference mainly starts from the thousands of horizontal and vertical coordinates, so it is necessary to round the processed latitude and longitude coordinates to obtain the new coordinates of the customer point.

Through the above data processing, the position information of 34 customer nodes after conversion can be obtained, and the customer nodes can be seated in the plane Cartesian coordinate system is shown in Table 2 below for the location coordinates of each customer node, assuming that the delivery window is 11:00-12:30 for all of them.

Table 2. Coordinates of each customer location

Customer number	1	2	3	4	5	6	7	8	9	10
	82	83	84	84						
x	24	26	52	82	8503	8495	504	8390	8490	8523
	48	48	48	48						
y	49	42	63	76	4911	4998	5011	5048	5046	8255
Customer number	11	12	13	14	15	16	17	18	19	20
	83	82	80	79						
x	66	23	88	65	7731	7623	7532	7548	7565	7781
	53	55	54	53						
y	95	35	58	99	5514	5404	5301	5037	4933	4978
Customer number	21	22	23	24	25	26	27	28	29	30
	81	80	79	78						
x	32	77	45	31	7826	7647	7801	7682	7182	8167
	52	51	53	51						
y	00	50	06	99	5008	5087	4934	4778	5084	6082
Customer number	31	32	33	34						
	77	76	75	83						
x	26	47	75	22						
	51	50	50	51	The time window requested by each customer is					
y	66	87	17	33	11:00-12:30 delivery					

In order to observe the data more intuitively, the position distribution of the 34 customer nodes in Table 2 was plotted by MATLAB based on the coordinate information. As can be seen from Figure 3, the 34 customers selected in this article have the characteristics of a sub-regional concentration.

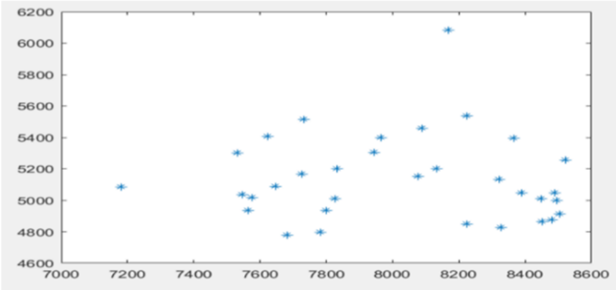

Fig. 3. Scatter plot of customer distribution

4.4 Based on the Results of the Instance Analysis of the VRP with the Shortest Path

In this example, the electric tricycle of SF Express (Wannian Li Dianbu) departs from Dianbu at 11 noon every day, assuming that the electric tricycle is not considered The distance from the point to the first customer and the express service time, that is, the first logistics service point is regarded as the starting point of delivery. Through the genetic algorithm of the above the problem is solved, and the optimal distribution path of the electric tricycle is obtained, as shown in Figure 4

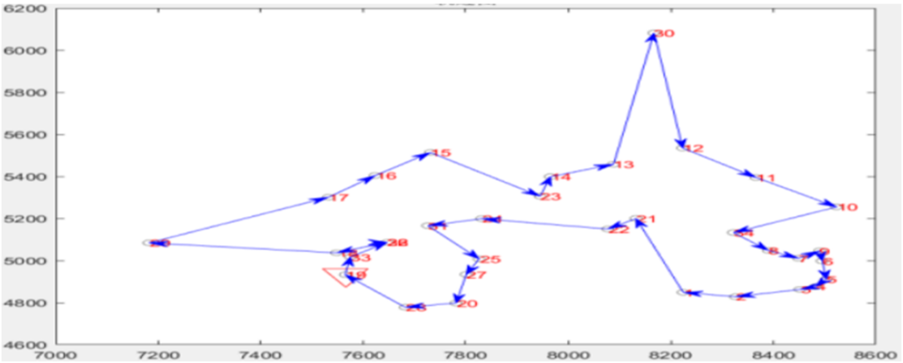

Fig. 4. Driving route diagram of the delivery vehicle

A random value in the initial population:
32—>22—>34—>6—>3—>16—>11—>30—>33—>7—>28—>17—>14—>8—>5—>29—>21—>25—>31—>27—>26—>19—>15—>1—>23—>2—>4—>18—>24—>13—>9—>20—>10—>12—>32

Total distance: 19292.3759

Optimal solution:
19—>33—>26—>32—>18—>29—>17—>16—>15—>23—>14—>13—>30—>12—>11—>10—>34—>8—>7—>9—>6—>5—>4—>3—>2—>1—>21—>22—>24—>31—>25—>27—>20—>28—>19

The total distance of the optimal solution is 5895.0485

The genetic algorithm is used to solve the vehicle routing problem with the shortest path (i.e., route optimization) and the model built by MATLAB simulation software is used to solve it The optimal shortest path for express delivery is obtained, so as to improve the customer satisfaction of express delivery.

5 CONCLUSION

This paper mainly studies a certain section of the distribution area of an SF Express delivery person in Jinzhou, analyzes the path, solves it by MATLAB simulation, and finally obtains one Based on the overall optimal distribution route, so as to improve the efficiency of distribution, in order to achieve the purpose of green transportation. Utilize MATLAB simulations to validate genetic-based derivation The path optimization model of the algorithm is feasible in Jinzhou Wannianli, and the simulation results show that the path optimization model established above is helpful to improve express delivery on the one hand

The company's distribution efficiency and cost savings, improve the competitiveness of express companies; On the other hand, it ensures that customers are more convenient and receive express delivery in a short time, and at the same time reduce the number of cars mileage will help alleviate urban traffic pressure and reduce air pollution, so as to achieve green transportation. However, the factors considered in this article are relatively simple, in the future In the study, we will study more on the issue of mixed route distribution, so that the research can be more in line with the current end users with different varieties and sporadic needs in local areas Requirements for integrated logistics services.

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