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Take out route optimization based on optimized immune algorithm

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ABSTRACT. *With the development of the Internet age, take out service is also popular. How to effectively shorten the delivery time of take out, complete the service in a shorter time, and improve the time satisfaction of customers has become one of the most urgent problems to be solved. Aiming at the shortest delivery route, this paper constructs a targeted delivery route optimization model, and uses the optimization immune algorithm to solve it. The results of the example are compared with the current actual data to verify the rationality and effectiveness of the algorithm and provide decision support for the delivery route.*

KEYWORDS: *Take out distribution, Shortest take out distribution path, Optimized immune algorithm*

1. Introduction

In recent years, the continuous improvement of living standards the rapid development of Internet, people are increasingly inclined to use mobile payment outside selling point meal service, according to Chinese take-out published hungry? Large, according to data delivery market have had a present state of rapid development in recent years, is expected to 2020 Chinese take-out market scale can be reached 5 trillion, has 600 million users, take-away will gradually become an indispensable part of national life.

Delivery is the core of takeout service. Customers place orders online through the ordering platform, and then the merchants receive and make the orders, and finally the delivery personnel carry out offline delivery. Reasonable and efficient distribution path planning can effectively shorten the delivery journey and delivery time, deliver takeout to customers within the time specified by customers, and enable merchants to obtain more profits by using the same resources. How to arrange the optimal distribution path for the deliverer before delivery becomes one of the most important problems to improve the delivery service.

ISSN 2616-5775 Vol. 3, Issue 3: 18-26, DOI: 10.25236/AJCIS.030303

TSP is the NP problem in the field of path planning and optimization. The problem is roughly described as follows: a businessman wants to visit n cities, each city can only visit once, and after visiting the last city, he needs to go back to the original city, the goal is to plan the shortest tour route for the businessman.A large number of scientists and literatures have studied the TSP problem: Wang Di and Jin Hui studied the path optimization of university campus canteen takeout delivery by using the improved genetic algorithm, and established a mathematical model with the shortest delivery path as the optimization goal [1]. Wang Shuai, Zhao Laijun et al. successfully described the distribution of random travel time by using simulation method after analyzing the characteristics of distribution of external sales, and established a mathematical model of random travel time with customer demand time window by comprehensively considering the maximization of customer satisfaction and various constraints in delivery [2]. Xu Zhaoyuan used two-stage heuristic algorithm to optimize the delivery route, and established a multi-objective delivery route optimization model aiming at maximizing customer satisfaction and shortest delivery route, so as to obtain the optimal delivery route optimization scheme [3]. Zhao, south XingLei to operating costs such as settlement of robustness for optimizing goal, considering the uncertain time problem in the process of delivery and distribution, using non dominated sorting genetic algorithm with elitist strategy and mixed integer programming model is established, and the optimal delivery distribution for take-out platform and business planning path to provide decision-making basis [4].

2. Problem description and mathematical model

2.1 Problem description

This paper studies the optimization problem of delivery route, which can be described as: customers order food online, merchants receive orders, arrange a delivery Courier to carry out offline distribution, send the delivery to multiple designated locations of customers, and return to the distribution center, aiming at the shortest delivery route. The standard of optimal path is to make the distribution distance shortest.

Constraints and Assumptions:

(1) Only consider a single distribution center to accept and distribute multiple orders;

(2) Only consider a single deliverer to deliver takeout for multiple customers;

(3) Each deliverer only serves one customer once;

(4) The order quantity of each delivery is within the bearing capacity of distribution personnel and distribution vehicles.

ISSN 2616-5775 Vol. 3, Issue 3: 18-26, DOI: 10.25236/AJCIS.030303

2.2 The objective function

The take-away distribution distance calculation, from businesses to receive many customers order online, and completed to take-out marki calculation of distribution to marki sets out until marki, accurate to complete the delivery of all orders, until finally return to merchant, with a path for take-out delivery path optimization, take-away distribution shortest path are obtained. To sum up, the delivery route optimization model is as follows:

$$\min Z = \sum_{i=0}^{n}\sum_{j=0}^{n} d_{ij} x_{ij} \tag{1}$$

s.*t*.

$$\sum_{i=0}^{n}\sum_{j=0}^{n} h_i x_{ij} \le Q \tag{2}$$

$$\sum_{i=0}^{n} x_{i0} = 1, i = 0,1,\cdots,n \tag{3}$$

$$\sum_{j=0}^{n} x_{0j} = 1, j = 0,1,\cdots,n \tag{4}$$

$$\sum_{i=0}^{n}\sum_{j=0}^{n} x_{ij} = 1, i, j = 0,1,\cdots,n \tag{5}$$

$$\sum_{i\in n} x_{ij} - \sum_{i\in n} x_{ji} = 0, i, j = 0,1,\cdots,n \tag{6}$$

$$x_{ij} = \begin{cases} 1, \text{distribution vehicles drive on the section of (i, j)} \\ 0, \text{ otherwise} \end{cases} \tag{7}$$

In the above model, Z represents the total delivery distance, dij represents the distance between the ith customer and the J customer, X_{ij} represents the decision variable of the research problem,hi represents the weight of a single delivery, and Q represents the maximum load of the delivery vehicle.

Formula (1) represents the objective function; S.t. stands for constraint;

Formula (2) indicates that the total weight of a single delivery shall not exceed the maximum carrying capacity of the vehicle.

Formula (3) indicates that the deliverer must return to the merchant after all the delivery.

Formula (4) indicates that the deliverer must start from the merchant;

Formula (5) indicates that there is only one distribution path between two customers;

Formula (6) indicates that each customer can only be served once for each delivery;

Formula (7) is the decision variable of the research problem

ISSN 2616-5775 Vol. 3, Issue 3: 18-26, DOI: 10.25236/AJCIS.030303

3. Immune Algorithm Design

3.1 Idea of immune algorithm

After a long time of evolution and improvement, the biological immune system has become an important link in the biological system. The immune system is composed of antigen recognition system, memory system, acceleration and control mechanism of antibody, etc. Its main function is to accurately distinguish harmful antigens from the external environment and protect its own tissues and system, so as to ensure the stable operation of biological system. Immune optimization algorithm is a new intelligent algorithm based on biological immune system. Because the immune system can maintain population diversity, immune optimization algorithm can play an important role in solving the "premature" problem in the process of solving the optimal solution, so as to obtain the global optimal solution.

3.2 The specific operation process of immune algorithm

1) Antigen input and antibody coding

Antigens: objective functions and constraints.

Antibody coding: Use natural integer coding to form antibody sequence code. When n clients are coded, the route can form an antibody of length N. If n=5, then the antibody is (3,5,2,1,4). The antibody sequence code indicates that, starting from distribution center 0, a delivery to customer 3-5-2-1-4 is delivered once and then returned to distribution center 0 to form a distribution path.

2) Production of initial antibody groups

At the first selection, antibodies were randomly generated. Some of the antibodies are then selected from the memory bank, and the rest are randomly generated by the system. The higher fitness of the antibodies selected from the memory bank can accelerate the convergence.

3) Affinity evaluation

Each feasible solution in the population requires an affinity evaluation. The antigen-affinity antibody added to the memory unit was used instead of the original antibody with high affinity.

4)

Determine whether the operation satisfies the condition of the end of the algorithm. If satisfied, the calculation is terminated and the optimal result is output; otherwise, the calculation is terminated.

5) Calculate antibody concentration and excitation degree

ISSN 2616-5775 Vol. 3, Issue 3: 18-26, DOI: 10.25236/AJCIS.030303

The antibody whose expected value is lower than the threshold value is calculated by inhibition calculation. As the affinity between antibody and antigen increases, the number of clone's increases and the mutation rate decreases.

6) Immune treatment

Immunological treatment, including selection, cloning, mutation, and clonal inhibition.

7) Population refresh

Randomly generated new antibodies are used to replace the lower excitation degree antibodies in the population to form a new generation of antibodies. Step 3.

4. The example analysis

The calculation example is based on the actual case setting of a KFC takeaway in Huai 'an city. In the case, data was collected on one delivery of KFC on a given day, including delivery address and delivery time. The collected data is processed and calculated by the program written by MATLAB software to obtain the optimal delivery distance of the take-out, and calculate the delivery time, compared with the actual delivery distance time.

4.1 The data processing

After getting the delivery data of a KFC takeout order, I sorted out the data and screened out the data I needed. For example, if there are multiple duplicate addresses in the order, I will process them according to one place. The longitude and latitude of the restaurant and the delivery address of all orders at one time are arranged in table 1 according to the delivery order of the deliverer.

Table 1 Latitude and longitude of each point

Serial number	The name of the place	Longitude	Llatitude
1	KFC	119.27141	33.771164
2	Wenzhou garden	119.26984	33.77013
3	Ripple in the garden	119.2644	33.773094
4	Top housing estate	119.257835	33.78646
5	The sun housing estate	119.26629	33.785156
6	Vanda one city	119.2722	33.7815778
7	Like fuhua court	119.27759	33.77951

The addresses in the above table are in the form of latitude and longitude, which is inconvenient for calculation and processing. In this paper, Excel software will be used for Gaussian projection conversion to convert latitude and longitude coordinates to rectangular coordinates in the Gaussian plane. For example, the longitude and latitude coordinates of "KFC" numbered 1 are (119.27141,

ISSN 2616-5775 Vol. 3, Issue 3: 18-26, DOI: 10.25236/AJCIS.030303

33.771164), and the plane rectangular coordinates obtained after conversion are (3798243.137, 225969.6835). Because the scope of this paper is relatively small, and the difference of latitude and longitude coordinates of all numbered points is small, the difference of the converted plane rectangular coordinates mainly starts from thousands. Therefore, in order to facilitate calculation, the coordinate values are processed to obtain (8243, 5969). Table 2 shows the processed plane rectangular coordinates of each point.

Table 2 Rectangular coordinates of each point

Serial number	The name of the place	X coordinate	Y coordinate
1	KFC	8243	5969
2	Wenzhou garden	7939	6599
3	Ripple in the garden	8819	5185
4	Top housing estate	11690	4459
5	The sun housing estate	11316	5608
6	Vanda one city	10225	6124
7	Like fuhua court	10854	7488

Establish coordinate system and draw scatter diagram with MATLAB, as shown in the following figure.

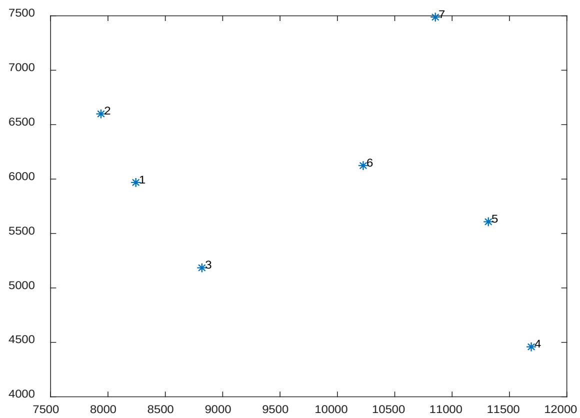

Figure. 1 Scatter diagram of each point distribution

4.2 Simulation and result analysis

Parameter values were set according to the actual situation, the crossover and mutation probabilities were 0.04 and 0.004 respectively, and the number of iterations was 100. Program simulation was carried out by MATLAB to obtain the optimal fitness trend chart and the optimal take-out delivery path chart.

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Figure 2 shows the trend of optimal fitness change, and Figure 3 shows the optimal path. It can be concluded from Figure 3 that the optimal path for this delivery is 1-2-7-6-5-4-3-1with a total distance of 11598m.

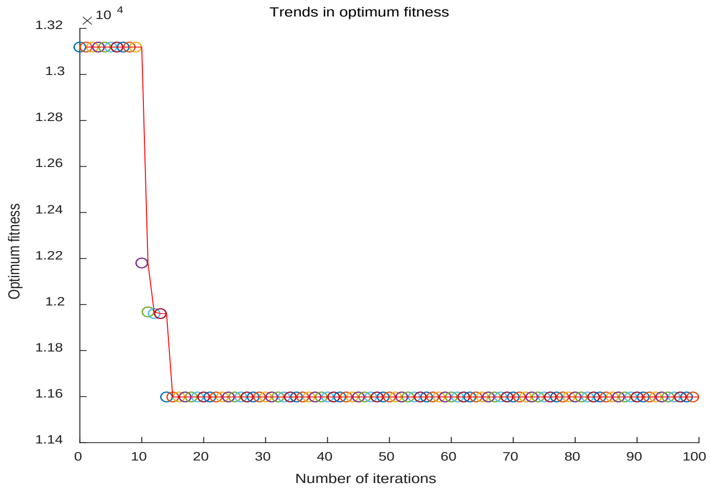

Figure. 2 Trend chart of optimal fitness variation

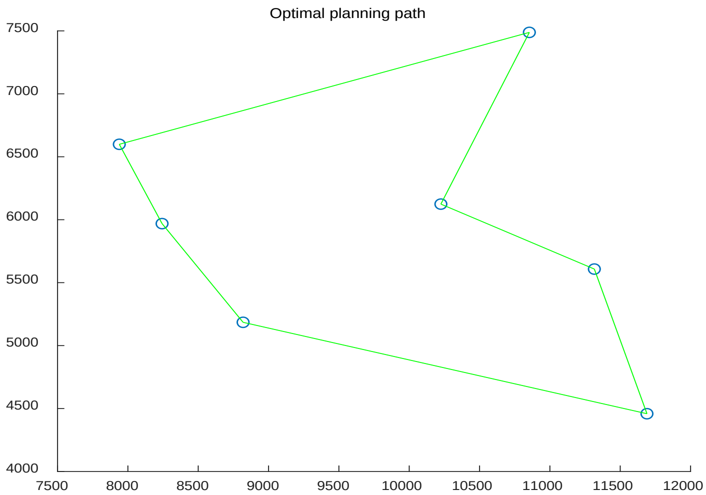

Figure. 3 Optimal takeout distribution path diagram

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The original distribution path was 1-2- 3- 4-5-6- 7-1 and the total distance was 12,264m. By comparing before and after optimization, the total length of optimized path shortens by 666m, greatly reducing the delivery distance and delivery time.

4.3 The results discussed

The above study is about the distribution route optimization of KFC takeout. After using immune optimization algorithm, the delivery route can indeed be effectively shortened, but there are few factors considered in this paper. Due to the different types of delivery, delivery requirements and the way will be different, this has involved distribution time, the speed of delivery, delivery order, delivery delivery temperature, distribution the damage of the delivery, etc., these factors will influence foreign selling and distribution of the optimal path planning, so as to produce different optimal path. Due to the limitation of the work energy and the length of this paper, all the factors cannot be taken into account, but it also provides the direction and goal for the future research.

5. Conclusion

The research in this paper proves that the immune optimization algorithm can effectively reduce the delivery distance of takeout, so as to shorten the corresponding delivery time, which is conducive to improving customer satisfaction.

(1) The optimized distribution method greatly reduces the distribution distance. Compared with the route before optimization, it reduces the driving of repeated sections, so that the delivery vehicles complete the delivery task in the most direct and short route, and deliver the takeout to the ordering customers in a shorter time.

(2) This paper only calculates the shortest distance without taking into account such factors as time, road conditions and weather, which will influence the time and speed of distribution and make the optimal path change. In the study of distribution service, we can not only consider the length of the journey, but also plan the path based on the cost of distribution. All the above aspects are missing in this paper and can be considered in the follow-up research.

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