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Optimizing Intelligent E-commerce Logistics Path using Shortest Path Algorithm

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Abstract: With the development of information technology, human activities in reality have become more and more convenient. It can conduct various interactions without going out through simple operations on the Internet. Among them, the model of online shopping is generally accepted by the public with the rise of the Internet. The logistics industry has also risen accordingly. In the face of the huge demand for goods distribution, the economic benefits brought by the logistics industry are also huge. Therefore, how to develop effectively in the logistics industry market for a long time while improving its own economic benefits? It is the focus of consideration for the entire industry. Since the demand for distribution is fixed, improving the efficiency of distribution route planning, reducing transportation costs, and choosing the most effective plan are hot topics in the current logistics and distribution industry. Therefore, reasonable route planning is one of the topics worth studying in the entire logistics industry. It is necessary to achieve distribution in the shortest time, improve customer experience, choose the shortest distribution route, reduce distribution costs, and increase economic benefits. Therefore, how to choose the most effective method is to reasonably optimize the distribution link through data comparison and effective algorithms to achieve practical goals.

Keywords: Information Technology; Route Planning; Shortest Distribution Route.

1. Significance of Project Research

With the development of technology and society, the logistics industry has gradually emerged. The control of all links in the entire logistics distribution and the allocation of material resources, the path of vehicles and the requirements for capital costs in various aspects have gradually been paid more attention [4]. Therefore, reasonable planning and design can not only reduce manpower and material resources, as well as all aspects of transportation costs, it also brings huge economic benefits to the logistics industry. With the help of the times, the rise and challenges of the logistics industry have also brought huge competition to this industry. Therefore, on the premise of meeting customer needs, how to reduce more transportation funds and human resource expenditures in logistics distribution has become a more important part of the entire logistics industry. Under the conditions of effective path planning and guaranteed delivery speed, it can also save money for itself and bring more benefits.

2. Main Methods of Research

The solution of Vehicle Routing Problem (VRP) in logistics distribution is a key point to improve logistics efficiency. How to effectively solve path planning while improving the efficiency of path planning? We can describe the problem as follows: When vehicles are in logistics distribution, the shortest travel path is obtained by planning the path of the vehicle. While reducing time costs, we weighed the load of delivery vehicles and the demand for customer service to arrive at the most effective delivery plan to maximize benefits [5-6]. This paper studies VRP, uses Simulated Annealing (SA) for path planning, realizes the design of vehicle path planning and distribution, and obtains the optimal solution for path planning.

3. Problem Description and Mathematical Model

3.1. Description of the Problem

The VRP problem in this study can be described as: a vehicle routing optimization problem under the two constraints of vehicle delivery considering customer needs.

That is: the distribution channel is composed of 1 central distribution point and n customers. The delivery vehicle departs from the distribution center to each customer. The weight required by each customer is a, and each customer can only be delivered once. The upper limit of the limited total amount is b. After each vehicle has been transported, it must return to the distribution center to load the goods and find the minimum route plan, and solve the problem of delivering goods to all customers in the shortest time.

The path planned at this moment is the smallest, which is mapped to complete the delivery to all users in the shortest time, and the cost is the lowest.

3.2. Mathematical Model

Select the first point as the distribution center D, and the rest as the customer's geographic location F_i.

Assuming that the geographic locations of the distribution center and customers are determined, a complete route from the distribution center to the geographic locations of all customers is represented by A_i, then:

$$A_i = \left\{ DF_{\mathrm{i}}, F_i F_{i-1}, F_{i-1} F_{i-2}, F_{i-2} F_{\mathrm{i}\text{-}3}, \ldots, F_{i-n} F_{i-n-1} \ldots, F_0 D \right\}$$

The number of goods delivered by the delivery vehicle each time is the same as the number of customers that need to be served in a single loop, so the number of customers that need to be delivered each time is a fixed value, then the set of each plan after serving all customers can be expressed as:

$$X_i = \{A_0, \ldots, A_i\}$$

The feasible solution of all distribution schemes, that is, the set of schemes for all distribution situations can be expressed as

$$M_i = \{X_1, \ldots, X_i\}$$

Where X_i represents the total route plan of the i -th delivery travel.

The time cost obtained from the optimization cost result is the smallest, that is, the total distance value of the smallest path is the smallest, that is:

$$K = \min M_i$$

Among them: K represents the optimal solution among all feasible solutions in the process of distributing vehicles; therefore, the minimum path obtained is the minimum solution among all the total routes, and also the minimum solution for all loops.

Therefore, the obtained optimal solution can be expressed by K as:

$$K = \min \sum_{i=0}^{n} (DF_i, F_iF_{i-1}, F_{i-1}F_{i-2}, F_{i-2}F_{i-3}, \ldots, F_{i-n}F_{i-n-1} \ldots, F_0 D)$$

In this study, the corresponding ratio of the relationship between time cost and path distance is 1, that is, the total time T in the minimum path value of the current optimal route planning is

$$T = Kt$$

t is the time coefficient within the unit distance.

In the distribution process, there are two constraint conditions, the cargo loading capacity of the distribution vehicle and the customer demand, and the relevant constraint variables are added in the calculation process, namely: the number of customers served by the distribution vehicle is fixed, and each customer must be served and can only be served once after the goods are delivered and the distribution vehicle returns to the distribution center to load the goods. So, the constraints obtained are:

$$p_i \in (0,1)$$

$$na \le b$$

Among them, P_i represents the status of whether the customer is served, when it is 0, it means that the customer is not served, and when it is 1, the customer has been served. n indicates that the number of customers that need to be served in a single vehicle delivery multiplies the customer demand, a should be less than or equal to the upper limit value b of the weight of a single vehicle.

3.3. Analysis of the Problem

According to the above problem description and modeling, a simple summary of the problem is obtained, that is, the transportation process of the distribution vehicle meets the one-time service for each user, and the service that meets the loading limit at the same time, returns to the distribution center for cargo loading [6-8]. Then find the shortest path and carry out the distribution in the process. The distribution process is simplified as shown in Figure 1.

Assumption: where points A, B, C, D, E, F, G, H, I, J, K represent the geographical location of the customer, point 0 represents the distribution center, assuming that the delivery vehicle load is 4, it looks for the shortest path during the delivery process, the multi-loop distribution plan with the minimum time is obtained, so as to achieve the optimization.

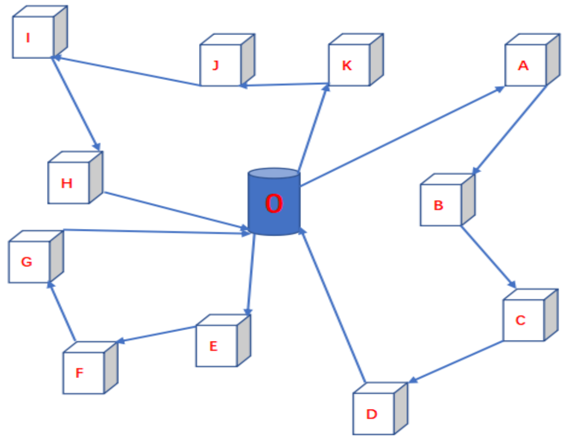

Figure 1. Distribution Process Simplification Diagram

By simplifying the experiment, a small-scale local minimum path is obtained, so that the time cost is the least.

4. Algorithm Implementation Steps

After the data is sorted, the pseudo code is preliminarily written, and the initial use of the data is realized through simple pseudo code writing. At the same time, combined with the annealing simulation algorithm, the pseudo code is improved to obtain the data for analysis.

1) Annealing simulation description [3]

Assume that the single distribution loop of a certain distribution vehicle is:

$$A \to B \to C \to D \to E \to F \to A$$

A	B	C	D	E	F	A

The next solution is obtained by exchanging the positions between two customers. Assuming that customer C and customer D are exchanged, the following results are obtained:

$$A \to B \to D \to C \to E \to F \to A$$

A	D	C	E	F	A

When the path value of the new solution obtained is less than the previous solution, the current solution is accepted, that is

$$f(x_1) < f(x_2)$$

$$K = f(x_2)$$

When the path value of the new solution obtained is greater than the previous solution, and the current temperature is greater than the end temperature, the probability of accepting the current solution is [4]

$$t_{now} > t_{end}$$

$$\exp(-\frac{\Delta f(x)}{t_{now}}) > (0,1]$$

2) Key steps

Step1 Initialize the data required for annealing simulation

Step2 Create objects where all customers are located

Step3 Initialize the vehicle

Step4 Get a solution (the initial solution is set randomly)

Step5 Calculate the distance between all positions from the data

Step6 Exchange the positions of two customers randomly in the path, and get a new solution

Step7 If the new solution is better than the current solution, return to Step5

Step8 If the new solution is inferior to the current solution, according to annealing simulation, once accepted, return to step4

Step9 If it doesn't accept, keep the current solution and return to step4

Step10 If the current temperature is less than or equal to the end temperature, exit the entire cycle.

3) The flowchart of annealing simulation operation is shown in Figure 2.

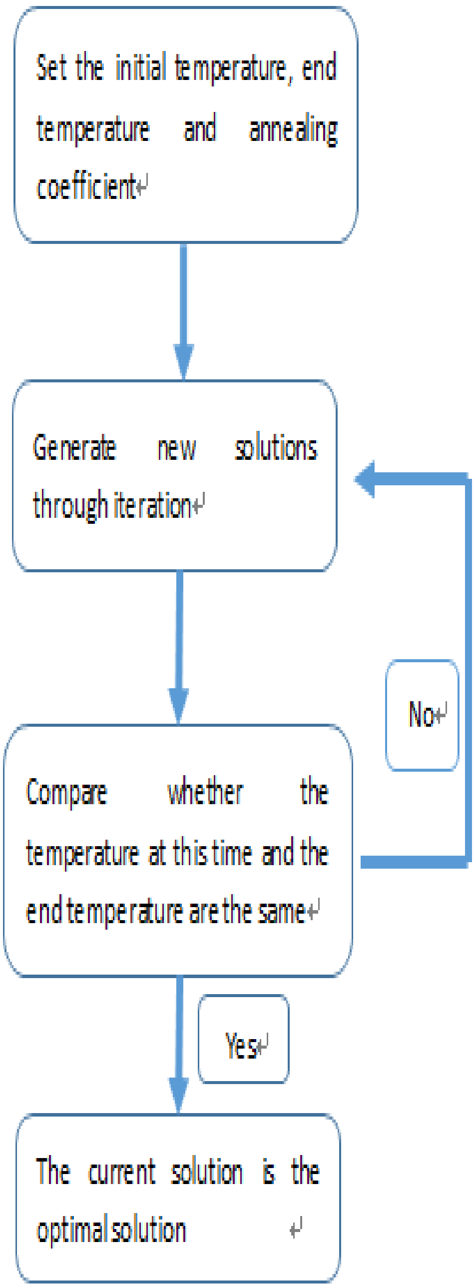

Figure 2. Flow chart of annealing simulation operation

5. Experimental Results and Experimental Comparison

5.1. Experimental Results

In the process of calculating the vehicle distribution path algorithm through the annealing simulation algorithm [5] in the heuristic algorithm, although the heuristic algorithm is easy to fall into the local optimum, the speed of finding a feasible solution is better than the ordinary greedy algorithm, an it converges locally at the same time. The speed of is more intuitive, and through experiments, an effective convergence chart is obtained, as follows in Figure 3.

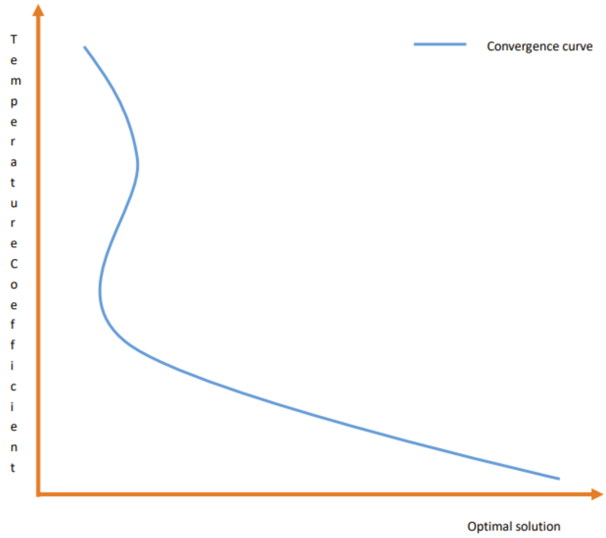

Figure 3. Effective convergence chart

5.2. Experimental Comparison

Through many experiments, we tried to compare the results, and recorded and compared the running time of the results. We drew a table for experimental analysis. The first experiment only compares the annealing simulation parameters, and the second time we choose to show the result of coincidence, the final result is drawn in the table as follows:

Table 1. Experimental Analysis Table

Experiment number	Starting temperature(℃)	Annealing coefficient	End temperature(℃)	End Time(s)	Shortest distance
1	50.00	0.98	1.00	10.35	3902.15
2	100.00	0.98	1.00	16.59	3820.18
3	100.00	0.99	1.00	30.34	3745.20

Table 2. Experimental Analysis Table

Experiment number	Starting temperature(℃)	Annealing coefficient	End temperature(℃)	End Time(s)	Shortest distance
4	50.00	0.98	1.00	11.42	3803.04
5	100.00	0.98	1.00	14.09	3921.13
6	100.00	0.99	1.00	34.76	3721.24

6. Advantages and Disadvantages of Annealing Simulation Algorithm

6.1. Advantages of Annealing Simulation Algorithm

We analyzed and verified various data through the above table 3, and reached the following conclusions:

1) Heuristic algorithms almost have a shortcoming for calculations in actual research, that is, they will fall into locally optimal solution, but compared to the hard-core calculation of Dijkstra's algorithm (Dijkstra), the calculation time is much faster.

2) According to the results in Table 3, the annealing simulation depends on the establishment of the parameters. When the established end temperature and the annealing coefficient are the same value, the level of the start temperature and the calculation time,

After a large number of experiments, the average result tends to be approximately higher in the starting temperature and the calculation time under the same conditions, but the shorter the shortest path obtained, the optimal solution is better than the result at low temperature.

In the same way, when the starting temperature and ending temperature are the same, the difference in the annealing coefficient also determines the difference in the optimal solution. A large number of experiments are carried out to obtain the average result. When the annealing coefficient is higher, the minimum path obtained under the same ending temperature and starting temperature is smaller.

6.2. Disadvantages of Annealing Simulation Algorithm

Through the results of Table 4 obtained by sampling a series of experimental errors that occurred during the experiment, some characteristics and limitations of annealing simulation are obtained.

1) Annealing simulation depends on the establishment of parameters. If the starting temperature and annealing coefficient are set too large, it will increase the cost of calculation time and cause inconvenience. However, if the setting of the starting temperature and annealing coefficient is too small, it will lead to a certain gap between the final result and the optimal solution, which makes the experiment unable to get the optimal solution [7].

2) The randomness of the heuristic algorithm, as shown in Table 4 obtained by sampling, the randomness of the annealing simulation leads to the fact that the sampled results are contrary to the actual conclusions, and the completely opposite conclusions are drawn. This is a common problem with annealing simulation and other heuristic algorithms, but under the premise of fast calculation to sacrifice a little accuracy, it is also a trade-off in reality. Therefore, how to optimize the annealing simulation algorithm to make it not only calculate quickly, but also get more accurate values under a few experiments, it is worthy of in-depth thinking.

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