

# Path Optimization Method of Logistics Distribution Based on Mixed Multi-Intelligence Algorithms

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**Abstract** In order to improve the efficiency and benefit for logistics distribution system, a path optimization method based on mixed multi-intelligence algorithms for vehicle routing problem was developed. In the process of proposed method, it firstly calculates the shortest paths between nodes of road network by Floyd algorithm and then obtains the merge distribution paths by means of saving method. Finally, genetic algorithm is employed to optimize the merge distribution paths. The experimental results show that the proposed method of logistics distribution can well solve the complex network conditions and lower the cost of logistics distribution, illustrating that the proposed model is practical and effective.

**Keywords** Logistics distribution · Floyd algorithm · Shortest path · Genetic algorithm

## 1 Introduction

In modern society, logistics, business flow, and information flow are called the three pillars of the economy, logistics management system, reasonably can create considerable economic benefits for the enterprise. At the same time, the development of economic globalization makes the enterprise procurement, warehousing, sales and distribution becomes more and more complex, the competition between enterprises is not only the quality and performance of competing

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products, but also including logistics capability of competition. As an important part of enterprise management, logistics is based on the user's orders, in the distribution center to distribute goods to the consignee activity [1].

In recent years, many scholars have studied the logistics distribution system, as the distribution route optimization in response to a series of customer demand design appropriate, thereby reducing distribution costs, shortening the total mileage of vehicles, and improving vehicle utilization [2]. At present, to solve the problem of logistics distribution path optimization algorithm has two categories: exact algorithms and heuristic algorithm for [3]. Precision of the algorithm is the algorithm that can find the optimal solutions, including the branch and bound method, the network flow algorithm, and dynamic programming. The exact algorithm is only suitable for small problem or for solving the local optimal problem. Heuristic algorithm is a kind of intuition or experience structure algorithm based, to obtain a satisfactory solution, rather than the optimal solution. The heuristic algorithm can quickly obtain a satisfactory solution and can provide more effective solution of logistics distribution. However, a heuristic algorithm, a series of example, conservation law, cannot solve the complex node problem; genetic algorithm is an effective adaptive iterative heuristic probabilistic global search method, but it was "premature," and the search efficient of [4, 5].

In this case, the paper puts forward an optimization method of logistics distribution route based on mixed multi-intelligence algorithms, which wants to logistics enterprise to provide practical and efficient logistics distribution route optimization scheme.

## 2 Logistics Distribution Vehicle Scheduling Description

Logistics distribution vehicle scheduling problem that how to reasonably, higher efficiently, and lower costly solves freight. Distribution scheme should include two related links: [4, 5]

1. Which customers need to be assigned to the same path, namely what cargo boxes need to be arranged in the same car?
2. The connection order of the customer in each delivery routes. The optimal solution of distribution vehicle routing problem is actually a most efficient transport scheme. It should be made clear that sent vehicle model, the number of vehicles, and the route of each car. Implementing this distribution scheme cannot only meet customer demand, but also make the lowest total transport cost.

Combined with reality in general, small- and medium-sized logistics enterprise actual situation, given objective logistics center has a distribution center and multiple distribution centers, and each distribution center for most of the business

is focused on distribution center unified delivery, only to meet the following conditions, is sent directly by the distribution center:

1. The distribution center close a hub, and the freight rate  $r \geq Z_0$ .
2. A distribution line of freight rate  $r \geq Z_0$ , and the distribution costs of the distribution center less than the cost which the distribution center delivers to hub.

Assume the target logistics center has  $K$  vehicle models,  $k$  represents a vehicle model ( $k = 1, \dots, K$ ), the distribution center number is 0, the rest of the distribution center number with  $i$  ( $i = 1, \dots, m$ ), each task point number with  $j$  ( $j = 1, \dots, n$ ), the mission point  $j$  demand for  $q_j$ . If the minimal total cost is final target, then the mathematical model of logistics distribution problem is:

$$\min Z = \sum_{I=1}^m \sum_{J=1}^n \sum_{K=1}^K c_{ij} x_{ij}^{(k)}$$

$$\begin{cases} \sum_{j=1}^n x_{ij}^{(k)} < a_j^{(k)}, & (i = 1, 2, \dots, m), \\ \sum_{j=1}^n q_j < \sum_{i=1}^n \sum_{k=1}^K w^{(k)}, & (j = 1, 2, \dots, n; i = 1, 2, \dots, m; k = 1, 2, \dots, K), \\ x_{ij}^{(k)} \geq 0 \text{ and is an integer,} & (i = 1, 2, \dots, m; j = 1, 2, \dots, n; k = 1, 2, \dots, K). \end{cases} \quad (1)$$

In formula (1),  $x_{ij}^{(k)}$  represents  $k$  model vehicle which is sent from point  $i$  to point  $j$ ,  $a_i^{(k)}$  represents the quantity of  $k$  model vehicle in distribution center  $i$ ,  $q_j$  represents the demand of  $j$ ,  $w^{(k)}$  represents load capacity of  $k$  model vehicle,  $c_{ij}$  represents the cost from point  $i$  to point  $j$ , which includes distribution vehicle fixed cost and vehicle operating cost:  $c_{ij} = c_0 + c_1 t_{ij}$ ,  $C_0$  represents distribution vehicle fixed cost,  $c_1$  represents the coefficient which is relative to the running mileage charge. If the  $c_1 = 0$  and  $c_0 > 0$ , then the model objective is to minimize the number of used vehicles.

### 3 Proposed Logistics Distribution Path Optimization Method

This method adopts precision algorithm and heuristic algorithm to solve logistics distribution vehicle scheduling problem. To overcome the lack of saving method, this method firstly uses Floyd algorithm to get the shortest path between each point, then employs the saving method expand loop, subsequently adopts genetic algorithm to seek optimal solution, which can overcome the disadvantages of

premature and low searching efficiency of genetic algorithm. In this case, the method includes three stages to find the optimal distribution scheme.

First stage: Using Floyd algorithm to calculate the entire shortest paths and their path toward between two nodes to obtain an effective distribution vehicle route scheme.

Second stage: Employing saving method to expand the loop in permitted range of distribution vehicle load to optimize line scheme.

Third stage: Adopting genetic algorithm in moderate feasible solution to look for the optimal goal in the solution of adjacent domain to overcome the premature convergence and the lower searching efficiency of genetic algorithm.

### ***3.1 Solving the Shortest Path Based on Floyd Algorithm***

Floyd algorithm is one of the most effective algorithms which solves the shortest path between any two nodes in a general network, if find the shortest path from vertex  $i$  to  $j$ . If the edge from  $i$  to  $j$ , from  $V_i$  to  $V_j$  there is a path of length edges  $(i, j)$ , the path is not necessarily the most short path, the  $n$  test is required. First, consider the path  $(i, 0, j)$ , if it exists, is  $(i, j)$  and  $(i, 0, j)$  path length and short length is from  $i$  to intermediate vertex  $j$  numbers less than 0 shortest path. If the path to add a vertex 1, and that is to say, if  $(i, \dots, 1)$  and  $(1, \dots, j)$  are intermediate vertex currently, find number of not more than 0 shortest path, then  $(i, \dots, 1, \dots, j)$ , there may be from  $i$  to intermediate vertex  $j$  numbers less than 1 shortest path. If it is got from the  $i$  to the  $j$  intermediate vertex, the number is not greater than the 0, then the shortest path is compared and selected intermediate vertex from the serial number is not greater than the shortest path 1; add a vertex 2 and continue to test by analogy. So, after  $n$  times, finally obtained will be the shortest path from  $i$  to  $j$ . According to this method, can obtain the shortest path between points.

After getting the shortest path between any two points, the proposed method, respectively, judges  $x(x = 1, 2, \dots, n)$  whether is leaf node of spanning tree which is composed by distribution sites and client nodes, and then according to the principle, which the vehicle runs from distribution center to leaf node and back-track, distributes customers, respectively.

### ***3.2 Merging Paths Based on Saving Method***

Saving method which was presented by Hossain et al. [6] aims to solve the problem of logistics distribution, and its basic principle is as follows:

Given the distances between distribution center and the two customers are  $d_{oi}$  and the  $d_{oj}$ , respectively, and the distance of between  $i$  and  $j$  is  $d_{ij}$ . If a distribution center, respectively, delivers to two customer  $i$  and  $j$ , then it needs two vehicles: round-trip route are  $(0, i, 0)$  and  $(0, j, 0)$  and a total distance is  $y_1 = 2(d_{oi} + d_{oj})$ .

But, if a vehicle is used circuitly as delivery to two customer  $i$  and  $j$ , then it needs only a vehicle and the route is  $(0, i, j, 0)$ , total distance is  $y_1 = d_{oi} + d_{oj} + d_{ij}$ . We assume that if it was not a straight line at the distribution center,  $i$  and  $j$ , then  $(d_{oi} + d_{oj}) > d_{ij}$ . So, the second distribution scheme is better than the first, and the total savings is  $y = (d_{oi} + d_{oj} - d_{ij}) > 0$ .

By means of Floyd algorithm of the first stage, we obtain all shortest path value  $d_{ij}$  between two nodes value and related path toward. If the shortest path between any two nodes is considered as the edge of the two nodes, then we can get a new map, and then use the saving method merge paths. We firstly calculate all the savings  $d_{oi} + d_{oj} - d_{ij}(i, j = 0, 1, \dots, n)$  according to the principle of the save method, and sorted from small to large, and then expand its circuit. In process of loop expansion, we firstly select the node  $i$  and the node  $j$  in which the savings is largest and form a loop  $(0, i, j, 0)$  and then choose the second large savings. If the load conditions permit, we constantly merge loop, until the entire loop. Obviously, each with the total path the greatest savings, path length of each increase is the minimum current, and the distribution route of the total distance has been optimized.

### 3.3 Path Optimization Based on Genetic Algorithm

Genetic algorithm, which is similar to the natural evolution, acts on the gene on the chromosome to find good chromosomes to solve the problem. In genetic algorithm, it uses random way to produce several codes of the problem to be solved, namely chromosome, and forms the initial group. Through fitness function which gives each individual a numerical evaluation, it obsoletes lower-fitness individuals and chooses higher-fitness individuals to participate in the genetic operation. After genetic operation, individual species forms the next generation new species [7–9].

After the first two stages of solving method, we get merged distribution path set, and record the number of all kinds of box according to the merged record route, and count the number of box in vehicle. This stage uses genetic algorithm optimize the distribution path, the process is as follows:

1. Randomly generating  $N$  paths of initial gene sequence, the  $N$  paths which calculated the total costs (estimated costs) are set as the initial population  $s$ .
2. Sorting population according to the estimated cost of the path.
3. Randomly selecting two paths  $a$  and  $b$  in the group  $s$ .
4. According to a predefined probability,  $a$  and  $b$  are act on random mutation operation, a new distribution path  $(s(i), s(i + 1))$  is generated.
5. Calculating the cost of path  $(s(i), s(i + 1))$  and comparing with paths of population, obsolescing the two paths which distribution costs are the largest.
6. Determining whether a population reaches the preset evolution times, if the termination condition is met, then algorithm is stopped, otherwise, go to (3).

7. Selecting the optimal path  $s[0]$  of the offspring population as the returned results.
8. According to the optimal path, assigning all the cargo boxes to vehicles.

### 3.4 Optimized Logistics Distribution Path Process

Assuming that logistics center consists of  $n$  distribution centers and  $m$  destinations, first, we employ Floyd algorithm iteratively to calculate the shortest distances between any two nodes (including from distribution center to the destination and from one destination to other destination). Second, according to the preset delivery rules, we assign different cargo boxes to  $n$  distribution centers. For the distribution center  $k$  (the initial value of  $k$  is 1), we initialize the delivery routes and costs which the distribution center  $k$  assigns every cargo box to  $m$  destinations and calculate merged paths and distribution costs  $c(i, j)$  which the distribution center  $k$  assigns to every cargo box destination  $i$  and  $j$  based on saving method. Subsequently, we choose the next delivery destination  $i + 1$  (the initial value of  $i$  is 1) of the distribution center  $k$  do the same above operations, until all the delivery destination are merged into path set. And then, we adopt genetic algorithm to optimize the merged path set and obtain the best distribution paths from the distribution center  $k$  to  $m$  destinations. Finally, we select the next distribution center  $k + 1$  to do the same above operations, until the best distribution paths are gotten from  $n$  distribution centers to  $m$  destinations. Figure 1 shows the optimized logistics distribution path process.

## 4 Experimental Verification

In order to test the effectiveness of the path optimized method of logistics distribution, the experiment simulates logistics center to validate the method, the relevant data is as follows:

1. Logistics center has two distribution centers  $A$  and  $B$ , which  $A$  is hub center and  $B$  is the common distribution center.
2. Each distribution center has large, medium, and small three kinds of vehicles; length, width, and height are, respectively,  $12 \times 2 \times 1.8$  m,  $8 \times 2 \times 1.8$  m, and  $4 \times 2 \times 1.8$  m;
3. Each distribution center has large, medium, and small three kinds of cargo boxes; length, width, and height are, respectively,  $1 \times 2 \times 0.9$  m,  $1 \times 1 \times 0.9$  m,  $1 \times 0.5 \times 0.5$  m;
4. Cost per kilometer of large, medium, and small three kinds of vehicles are, respectively, 4, 3, and 2 RMB.

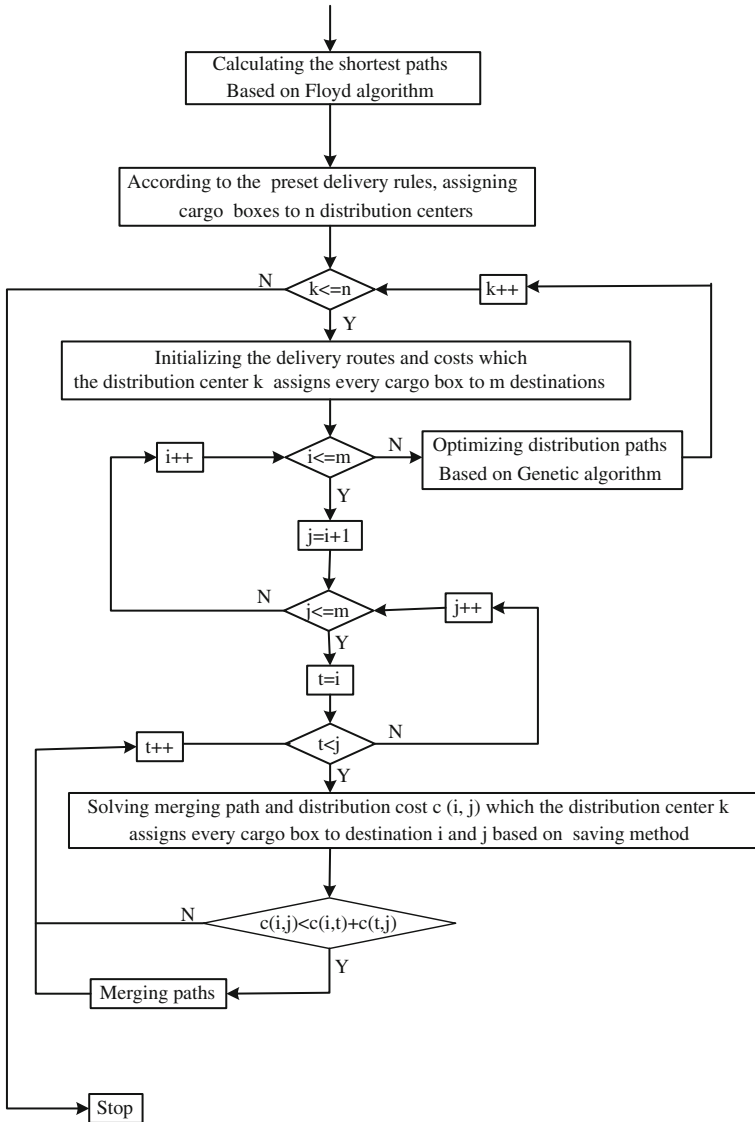


Fig. 1 Optimized logistics distribution path flowchart

5. Fixed send cost of large, medium, and small three kinds of vehicles are, respectively, 400, 350, and 300 RMB.
6. Logistics center is responsible for around 11 ( $C, D, E, \dots, H$ ) destinations.
7. Distances between every destination are shown in Table 1.
8. The number of assigned boxes of each destination is shown in Table 2, and the number of each box which is sent to the same destination is less than 9.

**Table 1** Distances between every destinations

	A	B	C	D	E	F	G	H	I	J	K	L	M
A	0												
B	226	0											
C	145	302	0										
D	92	286	195	0									
E	152	140	72	184	0								
F	91	307	123	84	68	0							
G	249	430	144	306	252	235	0						
H	102	138	172	153	233	178	153	0					
I	143	172	139	228	194	253	256	106	0				
J	269	192	225	337	275	362	352	193	148	0			
K	329	124	385	495	421	410	68	241	236	200	0		
L	155	96	210	352	291	235	225	66	94	181	195	0	
M	207	129	263	411	341	288	285	119	153	240	230	72	0

**Table 2** The original number of assigned boxes of each destination

Destination Point of origin	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12
D0	100	200	101	010	201	100	001	101	010	000	000
D1	01	000	000	000	101	000	000	010	100	010	100

9. Each distribution center has six vehicles which every kind of vehicles owns two vehicles.

We adopt the path optimization method of logistics distribution which is proposed in this paper to handle the above data. In the second stage of optimized method, we use the saving method merge path, the results as shown in Table 3, the needed vehicles are four, the total mileage is 2,670 km, and the total costs are 8,795 RMB (Table 4).

Subsequently, we employ genetic algorithm (Default is 10, initial population size is 10, preset evolutionary number is 8, mutation probability is 0.1) optimize delivery routes, the results as shown in Table 3, the needed vehicles are four, the total mileage is 2,370 km, and the total costs are 7,648 RMB.

Through the above experimental results, it can be seen that the proposed logistics distribution path optimization method combines saving method with genetic algorithm to optimize distribution paths and saves logistics cost, it shows this method the advantages in solving logistics distribution path selection problem. The distribution route scheme which is obtained by the proposed method can provide more intuitive and specific decision support for logistics companies and has certain practical value.



**Table 3** The number of assigned boxes of each destination after merging paths based on saving method

Path number	Vehicle type	Delivery routes	Total mileage	Total volume	Cost
1	Large	0->2->6->4->5->3->0	785	33.1	3,540
2	Medium	0->7->8->9->0	625	20.7	2,225
3	Small	0->10->1->0	679	7.2	1,568
4	Small	1->10->12->11->0	581	13.72	1,462

**Table 4** The number of assigned boxes of each destination after optimizing paths based on genetic algorithm

Path number	Vehicle type	Delivery routes	Total mileage	Total volume	Cost
1	Medium	0->2->6->4->5->0	700	25.65	2,450
2	Small	0->3->0	184	7.42	668
3	Medium	0->7->8->9->10->1->0	906	27.9	3,068
4	Small	1->10->12->11->0	581	13.72	1,462

## 5 Conclusion

This chapter studies logistics distribution path selection problem and establishes a new logistics distribution path optimization method. The method firstly uses Floyd algorithm to solve the shortest path between distribution sites and then employs saving method expand its circuits, subsequently, adopts genetic algorithms to seek optimal distribution route, which not only makes up for the deficiency of saving method, but also overcomes the problem of lower search efficiency and premature convergence of genetic algorithm. The experimental results show that the proposed method can realize complex logistics distribution route optimization, to a certain extent, reduce logistics cost, so that it can achieve good effect in practical application.

An effective adaptive iterative heuristic probabilistic global search method, but it was “premature”, and the search efficiency of [4].

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