Universe Scientific Publishing Volume 8 Issue 05

Study on optimization of express delivery cost considering dynamic demand

Fang Ouyang, XinpingChen, TingZhang, Jiayun zhang
Suzhou Institute of Industrial Technology, Suzhou Jiangsu215000

Abstract: In the process of express delivery, received a large number of unplanned customer orders, and have a certain time requirements, considering the two-way flow of goods, transportation costs, delivery time and other factors, obtain the dynamic data of GPS, GIS, MC and other platforms, use the city dynamic delivery point algorithm, calculate the shortest path, use the mileage saving method to combine the distribution path, Then use the hybrid genetic algorithm to optimize the overall integration of the minimum total distribution cost objective function, which can improve the convergence speed of the accounting, and get the sensitivity parameters that affect the optimal solution. An example shows that the proposed method can provide a better optimization scheme for express delivery cost.

Key words: Dynamic demand; Express delivery cost; Hybrid genetic algorithm.

I. Introduction

The ability of express delivery directly affects the customer experience, and the operation of express delivery is more complicated due to the convergence of services, low price competition and the continuous improvement of customer personalized needs. Aiming at reducing the total distribution cost, making efficient and flexible distribution adjustment plan to the dynamic changing market environment is an important way to improve the resource utilization and service level of express delivery enterprises.

The express delivery system has both the internal attributes of the natural system and the self-adaptability and coordination of the man-made system in accordance with the external environment. hybrid genetic algorithm (HGA) is a random optimization algorithm. As one of the effective algorithms for global optimization, Hybrid Genetic algorithm (HGA) can obtain the optimal solution through continuous iteration through computer simulation of the random change properties of nature, which has been proved to be effective in calculating vehicle distribution routes. Li Guojun et al. (2024) proposed a genetic algorithm with added memory function, which can memorize the best current state, showing its advantages in dealing with high-dimensional and high-complexity problems, and better solving nonlinear problems. Qin Zhidan et al. (2020) put forward the Dijkstra algorithm for dynamic path optimization, which is used to find the real-time shortest path and realize the dynamic adjustment of the traveling route. Different scholars have different algorithms for distribution route planning. When calculating the distribution cost, most of them do not consider the additional distribution requirements of a certain scale outside the plan and its cost accounting when considering the limiting factors such as vehicle capacity, time window and traffic conditions. In the environment of delivery (pick up) two-way logistics distribution in the face of random new customer demand, the introduction of hybrid genetic operation can solve the integer programming model including distribution vehicles, new dynamic distribution points, etc. A series of optimal solutions can be obtained through multiple iterative calculation, and sensitivity parameters are proposed to select the lowest cost scheme from a series of visual optimal solutions.

II. Description of distribution cost model

Due to the constant change of customer demand, in the process of distribution, couriers face a large number of unplanned customers put forward new real-time demand, so that the prior distribution plan has to be temporarily changed. The new route planning of couriers basically depends on the urgency of customer needs, their own familiarity with the geographical location of the delivery terminal, traffic conditions, and even personal preferences for the environment, which is subjective to a certain extent and cannot comprehensively consider speed, cost, service level and other factors. It is not conducive to the cost management of express delivery enterprises. The purpose of this study is to analyze the cost of express delivery under the background of a large number of new customer demands in the process of express delivery, compare different solutions, and provide the best scheme for express delivery enterprises to reduce the cost of delivery.

1. Mathematical modeling of express distribution cost

The calculation of real-time express delivery cost needs to obtain three basic dynamic information, that is, to obtain real-time express vehicle positioning information through GPS, to obtain dynamic client geographic location through M-Commerce, and to obtain real-time traffic information through GIS. It is assumed that the penalty cost of early arrival p_1 , the penalty cost of late arrival, the earliest start time of vehicle service to customers, the latest time of vehicle service to customers, the service time of customers is, the distance of the delivery point, the driving variable of vehicle k, the fixed cost of sending one more vehicle, the driving variable of multi-dispatched vehicles, the additional cost after exceeding the maximum trip. p_2 a_i i b_i i i t_i d_{ij} i j X_{ijk} c_0 X_{ojk} $P_{L(k)}$ Then its constraint conditions are:

$$P_{L(k)} = \begin{cases} pl\left(\sum_{i\in N}\sum_{j\in N} x_{ijk} d_{ij} \text{-L}\right) & , \sum_{i\in N}\sum_{j\in N} x_{ijk} d_{ij} \text{-L} \geq 0 \\ 0 & , \sum_{i\in N}\sum_{j\in N} x_{ijk} d_{ij} \text{-L} < 0 \end{cases}$$

(1) where, is the additional cost after exceeding the maximum driving distance, is the maximum driving distance; pl L

$P_{T(i)}$ Is the penalty cost for violating the time window limit, and its constraint conditions are:

$$P_{T(i)}=\begin{cases} A & ,\ TA_i \le a_i \\ p_0+p_1\left(ET_i-TA_i\right)^2 & ,a_i<TA_i\le ET_i \\ 0 & ,ET_i<TA_i\le LT_i \\ p_0+p_2\left(TA_i-LT_i\right)^2 & ,LT_i<TA_i\le b_i \\ A & ,TA_i>b_i \end{cases} \quad (2)$$

Therefore, a mixed integer programming model is used to construct the current distribution route with the minimum total distribution cost as the objective function. The minimum total distribution cost includes the transportation cost of the vehicle, the fixed cost of enabling the vehicle, the additional cost after exceeding the maximum trip and the penalty cost of violating the time window limit. Therefore, the objective function of the minimum distribution cost is set as:

$$\min Z=c\sum_{k\in M}\sum_{i\in N}\sum_{j\in N}d_{ij}x_{ijk}+c_0\sum_{k\in M}\sum_{j\in N}x_{0jk}+\sum_{k\in M}P_{L(k)}+\sum_{i\in N}P_{T(i)} \quad (3)$$

2. Steps of distribution cost optimization

The hybrid genetic algorithm is used to optimize the distribution route. The specific steps are as follows:

In the first step, all the cargo points are genetically coded by natural number coding method, and N parents are randomly generated; Randomly generate the sequence of unvisited delivery (pick up) points, and check whether each delivery (pick up) point meets the vehicle load limit one by one in order. If yes, the delivery (pick up) point will be added to the current distribution route; If not, it will be added to the next distribution route (that is, rearrange the vehicle)

In the second step, the individual fitness of the N parents is calculated according to the fitness function, the expression of the fitness function is:P=1/(Z+G*pw) (4)

Where, Z is the value of the directory function, and G is regarded as the number of infeasible paths of the distribution path scheme corresponding to the individual, and is the penalty weight of the total number of vehicles less than the number of distribution paths.

The third step is to obtain a new population through the roulette selection method, and the new population is used to replace the parent generation; Randomly select two parents to cross and produce a child generation, each time randomly select an operator to apply variation operation to the child, add a penalty function to the individual who breaks the distance constraint generated in the process of cross variation, and the best N individuals form a new population as the parent generation of the next cycle;

Fourth, the sequential crossover method is adopted to carry out repeated crossover operations on the new population, and judge whether the fitness of the individuals remains unchanged after repeated crossover variation. If so, the optimal current distribution route is obtained; Otherwise, return to the third step until the optimal distribution route is obtained.

In this study, the natural number coding method is adopted for genetic coding of all cargo points, and the sequence of unvisited cargo points is randomly generated, calculated according to the first step. The constraint conditions are as follows:

$$\begin{cases} \sum_{i\in N}\sum_{j\in N}q_i x_{ijk}\le Q & ,k\in M \\ \sum_{k\in M}\sum_{i\in N}x_{ijk}=1 & ,i\in N且i\ne 0 \\ \sum_{k\in M}\sum_{i\in N}x_{ijk}=1 & ,j\in N且j\ne 0 \end{cases} \quad (5)$$

Where, is the customer's delivery volume, is the maximum delivery volume. Further, the optimization criteria in the fourth step above are as follows: If the optimization result converges to the required accuracy range, the optimization convergence accuracy is taken as the optimization criterion, otherwise, the maximum simulation algebra of the algorithm is taken as the end condition.

III. Analysis of numerical examples

The VRPSPDTW (vehicle routing problem with simultaneous pickup and delivery and time windows) model is introduced, that is, in addition to considering the path in the original complex VRPSPD problem, And then introduce the time constraint. The mixed integer programming model of VRPSPDTW problem is the objective function of the minimum total distribution cost, and under the constraint of limited vehicles in the distribution center, it requires reasonable routing to minimize the total objective function value.

Time window: Both the distribution center and the customer are limited by the time window. The time window of the distribution center is that the vehicle cannot leave before a (a_i,b_i) 1 and cannot return after. b_i There are pre-set time Windows for customers. i (a_i,b_i)

Speed: The vehicle uses an electric tricycle, its speed is 1, the travel time from the delivery point to the delivery point is, and the distance is. i j t_{ij} d_{ij} $(i,j\in V_0,i\ne j)$ The objective function is to meet all customer needs with the minimum cost (such as the number of vehicles, driving distance, waiting time, etc.), and meet the following assumptions : ① the demand of each delivery point can only be completed by one car at the same time to pick up and deliver goods; ② Each vehicle can only serve one route, and the distribution vehicles start and end at the distribution center; ③ meet the requirements of the vehicle carrying capacity constraints and the time window limit of the delivery point.

In this example, taking Suzhou Shunfeng Company as an example, the time window is set at 6:00-18:00, that is, the vehicle must be delivered to the delivery point in this time period. Couriers carry out distribution according to 12 randomly distributed delivery points in Suzhou including pre-planned delivery task points 1, 2, 4, 5 and 6. With the new demand for delivery points added during the distribution process, 11 new delivery points 3, 7 and 8 appear at T time (instantaneity), thus generating a new business group and increasing to 23 delivery points. Considering that 23 terminals need to be delivered on the same day, Multiple vehicles are required to carry out the distribution at the same time. And the maximum driving distance of each vehicle is less than 300KM/ day, initially select 4 vehicles to complete the delivery. The situation of queuing for delivery is shown in Table 2.

Table 2 adds the parameters of the distribution point

Distribution Point Code name	Location coordinates	Amount of delivery	Time window	Distribution points Code name	Location coordinates	Amount of delivery	Time window
3	(134,50)	9	[0.5, 3]	17	(71,71)	1	[2,5]
7	(155,45)	5	[2,5]	20	(121,78)	12	[3,4]
8	(143,82)	7	[1,4]	19	(165,108)	7	[3,5]
10	(145,112)	12	[2,4]	21	(184,71)	8	[4,5]
13	(127,114)	4	[0,3]	23	(225,0)	3	[4,7]
14	(58,92)	2	[3,5]				

According to the mileage saving method, the calculation uses the constraint conditions (4) formula, (5) formula, the route of 4 distribution vehicles and the corresponding distribution cost are shown in Table 3;

Table 3 is based on the distribution cost calculation of saving mileage method

Couriers	Delivery route	Shipping costs	Fixed costs	Additional costs for exceeding the maximum distance	Penalty costs for violating time window limits	Total
1	0-1-3-10-1-3-10-0	217	100	0	0	317
2	0-6-5-20-6-5-20-22-0	324	100	92	26	592
3	0-17-8-12-16-15-0	217	100	0	46	363
4	0-9-2-4-21-14-0	185	100	57	0	292
Total Cost		943	400	149	72	1564

Determine the transport vehicle, time window penalty cost and other limiting factors, using the objective function (1) formula of hybrid genetic algorithm, the use of constraint condition (6) formula, as well as the additional cost after exceeding the maximum travel, the penalty cost of violating the time window limit; $P_{L(k)}$ $P_{T(i)}$ The coding and decoding design of MATLAB7.0 program was carried out, and the optimal solution of dynamically adjusted total distribution cost was obtained after 30 iterations with roulette selection method. After 30 iterations, the minimum total distribution cost was 1397 yuan. As shown in the above route, the solution set of K was 5, that is, adding a new car could significantly reduce the distribution cost by 11%.

IV. Conclusion

This paper discusses the optimization of delivery cost after adding a lot of real-time customer demand in the process of express delivery. According to the 11 new delivery points added in the delivery process and the 12 established delivery points.The new state is generated by the method of full array random extraction, which is essentially to optimize the distribution plan through cost accounting.

1. Based on the results of 23 distribution points, all distribution activities are dynamically tracked with cost as the medium. Each parameter in the hybrid genetic algorithm has different influences on the total distribution cost, in which the distribution point distribution, distribution quantity and other parameters are determined by the customer, while the remaining sensitivity parameters affecting the optimal solution are: total distribution mileage, cumulative time consuming, loading capacity, number of vehicles, extra cost over time and so on.

2. From the case calculation process, as the distribution cost optimization scheme and cost accounting automation tool under the dynamic demand of customers, the theoretical algorithm in this paper has been effectively supported by the experimental data, and provides a favorable reference for express delivery enterprises to shorten the service time, rationally choose and expand the regional business scope. In this calculation, the impact of dynamic factors such as transport unit price, customer service time and dynamic traffic conditions on distribution costs needs further research. In the future, the practical application of this algorithm in express delivery enterprises will be promoted, and the correlation between various dynamic parameters will be analyzed statistically with practical data.

References:

[1] Zhidan Qin, Zhangyue Chen, Xianwen Gong. Research on Logistics Distribution Cost Estimation based on Data Mining [J]. Modern Electronic Technology, 2019, 43 (13) : 183-186. (in Chinese

[2] Xiaojian Hu, Zhi Yang. Research on path planning of multi-pick car based on hybrid genetic algorithm [J]. Journal of Hefei University of Technology, 2022,45 (12) : 1715-1722

[3] Qiuhan Yan. Analysis of vegetable distribution cost optimization in Daqing City [J]. Agricultural Equipment Technology.2022,48(02):57-60. (in Chinese)

[4] Shun Zhang. Study on influencing factors and control optimization of fresh e-commerce distribution cost [J]. Marketing Circle, 2020 (41) : 131-132.

About the author: Fang Ouyang (1973-), female, born in Xinyu, Jiangxi Province, is an associate professor of Suzhou Polytechnic. Her research interests include logistics and Supply chain Management.

Fund Project: Jiangsu University Philosophy and Social Science Fund Project “Path Mechanism and Typical Case Study of Promoting Digital Transformation of Logistics Industry in Jiangsu” (2022SJYB1636).