ISSN: 2414-1895 DOI: 10.6919/ICJE.202001_6(1).0035

Optimization of Urban Logistics Distribution path under dynamic Traffic Network

Yang Shen

School of Shanghai Maritime University, Shanghai 200000, China;

1193880877@qq.com

Abstract

in view of the common distribution mode of urban logistics under the environment of electronic commerce,the dynamic uncertainty of urban road network is considered on the basis of the optimization of distribution path.Taking the minimum cost as the objective function, the logistics distribution path optimization model of hard time window under dynamic road network is established. Genetic algorithm is used to solve the model. Finally, an example is given to verify the validity of the model.

Keywords

Urban logistics; Path optimization; Dynamic road network; Hard time window; Genetic algorithm.

1. Introduction

With the rapid development of urban logistics industry, logistics distribution is also facing many problems. On the one hand, the online transaction orders of merchants and customers increase year by year under the environment of e-commerce; on the other hand, due to traffic accidents, traffic flow, rush hour and so on, the speed of distribution vehicles will change with the density of the actual road network. At present, most of the research on vehicle path (VRP) problem is to set the driving speed of distribution vehicle as a static constant, which will lead to the distribution vehicle falling into the crowded road environment of the city, at the same time, the actual operation cost and the cost error are very large, which makes the research of dynamic vehicle routing problem become urgent need. In urban logistics distribution, when customers have time requirements, they are divided into soft time window and hard time window. The soft time window means that when the vehicle arrives later than the end time of the time window, there will be a penalty cost, and the hard time window means that if the vehicle fails to provide service within the time window, the customer refuses the service.

The dynamic vehicle path problem (DVRP) includes the demand dynamics of customers and the driving time dynamics of vehicles [1]. Among them, the dynamic travel time is divided into two cases [2], one is affected by sudden traffic congestion, the driving route cannot be determined in advance, and the route needs to be updated according to the real-time traffic information; the other is affected by regular traffic jams,such as the rush hour period of going to work and the driving route of vehicles according to the pre-determined route. For this kind of problems, the day will be divided into several periods according to the peak and off-peak hours of traffic flow, the driving time of vehicles in different periods is different[3]. Li Yanfeng [4] simultaneously considers regular congestion and sudden congestion to solve new real-time update lines for DVRP under real-time traffic information; Sun Yi [5] proposes vehicle scheduling strategy in time-varying road network based on time-varying road network considering vehicle capacity; Wu Yao [6] considers the time-varying characteristics of road network during perishable food distribution, and establishes an optimization model with time window.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202001_6(1).0035

In the aspect of VRP research under dynamic traffic network, there is little consideration of hard time window. In this paper, the constraint of hard time window is added to the time-varying traffic network to study the logistics distribution path under the e-commerce environment.

2. Problem description

In a dynamic traffic network, multiple distribution vehicles are distributed to each distribution point from a common distribution centre, and the position and demand of each distribution point are known, and the sum of the demand of each distribution point is not more than the maximum load of the vehicle. Each distribution point is served by and only by one vehicle, the distribution point has a time window, the distribution vehicle has to arrive within the time window of each distribution point.If they arrive early, they need to wait. If they arrive late, they will be rejected. Each vehicle starts from the distribution centre, passes through several distribution points on the way, and finally returns to the distribution centre.Each distribution path forms a loop.Meanwhile,the constraints of hard time window are considered to meet the needs of each distribution point and arrange the distribution vehicle routes reasonably to minimize the total cost.

Basic assumptions:

the location of each distribution point is known, the demand must be met and can only be served by one vehicle;

the distribution vehicle must be arrived within the service time window of each distribution point;

(3) the vehicle has a unified vehicle type and the maximum capacity is known;

(4) the sum of the requirements of each distribution point does not exceed the load of the vehicle;

3. Model construction

3.1 Parameter introduction

K:Number of vehicles in distribution centre;

AD:The collection of the customer demand point to the end point;

DE:The collection of the customer demand point to the end point

α :The cost of transportation per unit of time per unit of goods;

T_{ijk} :Driving time of vehicle k from customer i to customer j;

q_{ij} :Distribution quantity of distribution point i ;

β :Unit cost of the active vehicle;

x_{ojk} :Number of vehicles from the distribution centre;

Q_k :Maximum load of a vehicle;

y_{ik} :1 if vehicle k service distribution point i , otherwise 0;

t_i :Time to arrive at distribution point i;

set_i :Service hours of vehicles at distribution point i;

T_{ij} :The travel time of the vehicle from the dispensing point i to the dispensing point j;

w_i :The waiting time for early arrival of vehicles at distribution i;

$[E_i, L_i]$:Time window accepted by each distribution point;

L_k :Time for the K car to return to the distribution centre;

ISSN: 2414-1895 DOI: 10.6919/ICJE.202001_6(1).0035

3.2 Modeling

With the minimum distribution cost as the optimization goal, the distribution cost is composed of the running cost of the vehicle and the cost of enabling the delivery vehicle, and the mathematical model is as follows:

Objective :

$$\min\ F(i,j,k)=\alpha\sum_{k=1}^{K}\sum_{j\in DE}\sum_{i\in AD}T_{ijk}q_{ij}+\beta\sum_{k=1}^{K}\sum_{j\in DE}x_{ojk} \tag{1}$$

Subject to:

$$\sum_{k\in K}\sum_{i\in SD}x_{ijk}=\sum_{k\in K}\sum_{j\in DE}x_{ijk}=1 \tag{2}$$

$$\sum_{i\in S}\sum_{j\in DE}\sum_{k=1}^{K}x_{ijk}=\sum_{i\in SD}\sum_{j\in E}\sum_{k=1}^{K}x_{ijk} \tag{3}$$

$$\sum_{i\in D}q_i y_{ik}\le Q_k \tag{4}$$

$$t_j=t_i+set_i+T_{ij}+w_j\le L_j \tag{5}$$

$$L_k\le L \tag{6}$$

S is a collection of distribution centre departure nodes, D is a collection of customer demand nodes. In the mathematical model , equation 1 indicates the minimum transportation cost ;equation 2 indicates that a distribution node can only be served by one vehicle and only once; equation 3 indicates that the distribution path is a loop, and the vehicle will eventually have to return to the distribution centre; equation 4 indicates that the distribution volume of distribution point i does not exceed the maximum load capacity of the vehicle; equation 5 is the time constraint to reach the distribution point j; equation 6 is the time constraint that the vehicle finally returns to the distribution centre.

3.3 Running speed

The speed of vehicles is affected by the density of roads. Lchoua [7] calculates the speed of vehicles across different periods in order to solve the problem of different driving times of different sections of dynamic road network. The speed of the vehicle remains unchanged for a very small period of time.The following formula is used to calculate the running time of the vehicle from distribution point i to distribution point j:

$$T_{ij}(l,t)=\begin{cases}t_m+T_{ij}(l-l_m,t+t_m),l_{ij}>l_m\\ l/v_{ij},l_{ij}\le l_m\end{cases} \tag{7}$$

Where $T_{ij}(l,t)$ is the time that the vehicle starts from distribution point i and drives the rest Length d required. The vehicle runs at the current speed at the time t. If the vehicle does not reach point j after the speed changes in the next period, then the travel time from distribution point i to j is $t_m+T_{ij}(l-l_m,t+t_m)$. t_m is the time of the next speed change from point i, and it is the distance driving at the current speed before the speed changes.

4. Genetic algorithm solving model

4.1 genetic algorithm

Genetic algorithm simulates the evolution process of survival of the fittest in the biological world, searches randomly in the potential optimal solution, solves in turn, selects individuals with high adaptability and carries out combination, crossover and variation, so as to obtain new species groups

ISSN: 2414-1895 DOI: 10.6919/ICJE.202001_6(1).0035

that are more suitable for the environment. The optimal individual in the new species group is equivalent to an optimal solution.

Step 1: construct the chromosome of initial feasible distribution route by natural coding;

Step 2: set the running parameters of genetic algorithm: population size m, crossover probability p_c, mutation probability p_m and termination evolution algebra Gen;

Step 3: mark the running algebra Gen = 0, randomly generate the initial population;

Step 4: Mark cycle variable s = 0;

Step 5: calculate the fitness of individuals in the population: the higher the cost, the lower the fitness;

Step 6: S = S + 1;

Step 7: if $s \le m$, go to step 5, otherwise go to step 8;

Step 8: select the next generation of chromosomes according to individual fitness, and the probability of being selected is $P_i = {f_i}/{\sum f_i}$;

Step 9: Cross and mutate the population and calculate $p(Gen+1)$;

Step 10: the evolutionary algebra Gen = Gen + 1, if Gen = 100, stop the calculation, otherwise turn to step 4 .

4.2 Example analysis

Solomon R101 is selected as the basic example to solve the model. R101 problem can be described as: there is a distribution centre for 25 distribution points to distribute goods, the location and demand of distribution points are known, and the time windows of each distribution point are different. The load capacity of distribution vehicles is set as 200 units in a unified way; The time window of the distribution centre, the location, demand, time window and service time of each distribution point are shown in table 4-1 below.

Under the regular traffic jam on the road, different driving speeds are set according to the peak and off -peak periods, with the peak speed of 50 km/h and off-peak speed of 80 km/h.

Table 4-1. Delivery requirements

Distribution point	X coordinates	Y coordinates	Requirement	Time window	service time
0	3	35	0	[0,230]	10
1	41	49	10	[161,171]	10
2	35	17	7	[50,60]	10
3	55	45	13	[116,126]	10
4	15	20	19	[149,159]	10
5	25	30	26	[34,44]	10
6	20	30	8	[99,109]	10
7	10	50	5	[81,91]	10
8	5	43	9	[95,105]	10
9	30	60	16	[97,107]	10
10	20	60	16	[124,134]	10
11	50	65	12	[67,77]	10

ISSN: 2414-1895 DOI: 10.6919/ICJE.202001_6(1).0035

12	30	35	19	[63,73]	10
13	15	60	28	[159,169]	10
14	30	10	20	[32,42]	10
15	10	5	8	[61,71]	10
16	5	20	19	[75,85]	10
17	20	30	2	[157,167]	10
18	15	40	12	[87,97]	10
19	45	60	17	[76,86]	10
20	45	65	9	[126,136]	10
21	45	20	11	[62,72]	10
22	45	10	18	[97,107]	10
23	65	5	29	[68,78]	10
24	65	35	3	[153,163]	10
25	65	20	6	[172,182]	10

4.3 Model parameter setting

The parameters of genetic algorithm are set as follows: population size m = 80, crossover probability P_c = 0.85, mutation probability P_m = 0.15, termination evolution algebra Gen = 100. The model parameters are set as follows: running on MATLAB according to the steps of genetic algorithm, the results are as follows:

Table 4-2. Vehicle distribution path

Result	Optimal solution	Vehicle number	Iteration steps
Calculation results	5937	7	100
Path number	Delivery path		
1	0-11-19-18-10-0		
2	0-2-21-3-24-0		
3	0-14-15-6-17-0		
4	0-5-16-13-0		
5	0-7-8-0		
6	0-12-9-20-1-0		
7	0-25-23-22-4-0		

5. Conclusion

In this paper, the logistics distribution path optimization model of hard time window under dynamic road network is established. The running speed of distribution vehicles is calculated across time periods. Based on R101 calculation example, the distribution path is solved by genetic algorithm. The results show that the model is effective, because there are too many variable information in the dynamic road network, there are many factors that are not taken into account, we can continue to

ISSN: 2414-1895 DOI: 10.6919/ICJE.202001_6(1).0035

study the optimization of the logistics distribution path of different road levels, multiple vehicles distribution, customer random demand.

References

[1] Psaraftis H N. Dynamic vehicle routing:Status and prospects, Annals of Operations Research, vol. 61 (1995), 143-164.

[2] Taniguchi E,Shimamoto H. Intelligent transportation system based dynamic vehicle routing and scheduling with variable travel times, Transportation Research Part C,vol. 12(2004), 235-250.

[3] Malandraki C. Time dependent vehicle routing problems:Formulations,solution algorithms and computational experiments, Northwestern University,(1989).

[4] Li Yan Feng，Li Jun. Vehicle routing optimization of urban dynamic network based on real-time traffic information, System engineering theory and Practice, vol. 7(2013).

[5] Sun Yi. Hybrid algorithm for vehicle scheduling in time-varying network, Shanghai：Shanghai Jiaotong University,(2014).

[6] Wu Yao，Ma Zu Jun. Production and distribution of perishable food with time window under time-varying road network, Theory and practice of system engineering,vol. 37(2017).

[7] Lchoua S,Gendreau M,Potvin J Y. Vehicle dispatching with time-dependent travel times, European Journal of Operational Reaearch,vol. 144(2003), 370-396.