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Research on the Pathway Planning of Unmanned Vehicle on Campus

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Abstract

With the gradual development of autonomous driving technology, unmanned logistics distribution has played an increasingly important role in the current era. In order to study the scheduling and path planning of campus express unmanned vehicle distribution, determine the departure time interval and planning of unmanned vehicles on campus. The optimal driving path of unmanned vehicles is based on the relevant data of a school in Beijing, using MATLAB, LINGO and other software to carry out simulation experiments, programming solutions, and in-depth research on the path planning problem of unmanned vehicles on campus.

Keywords

Unmanned vehicle , Path planning , MATLAB , LINGO .

1. Introduction

With the rapid development of e-commerce, online shopping has become an important part of daily consumption. Among them, college students have become the main force of consumption on e-commerce platforms, and the demand for express delivery services on campuses in colleges and universities has also developed explosively. In recent years, domestic unmanned delivery technology has developed rapidly. JD.com has successfully developed unmanned delivery stations, and Cainiao has established unmanned warehouses, all of which have made unmanned delivery a reality. During the epidemic, the unmanned distribution equipment showed its talents. With the characteristics of high efficiency and unmannedness, it effectively avoided personnel contact and blocked the spread of the epidemic [1], which verified the feasibility and safety of its technology and showed a huge future. development potential. Under the situation that the epidemic prevention and control situation at home and abroad is still severe, unmanned distribution is undoubtedly the safest and most efficient distribution method, and will become the mainstream trend in the future [2]. Schools are high-incidence places for public emergencies of infectious diseases. Therefore, a campus unmanned distribution plan is proposed. Unlike traditional point-to-point distribution, unmanned distribution needs to consider the customer's time requirements. In the face of special environment and complex distribution tasks, research on campus unmanned distribution path planning is beneficial to the realization of unmanned distribution on campus [3].

2. Method overview

This project focuses on the scheduling and path planning of campus express delivery unmanned vehicles, including determining the departure time interval of unmanned vehicles and planning the optimal driving path of unmanned vehicles. First we need to get the data. Design a questionnaire to collect students' recognition of campus express unmanned vehicle delivery, the possibility of using unmanned vehicles, and the relationship between the time of sdelayed delivery and user satisfaction, and issue questionnaires to students on campus; Consult the operator or search the Internet for literature on the use of express unmanned vehicles,

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including power consumption, damage probability during delivery, average unmanned vehicle life, etc.; and obtain a campus map to clarify the location distribution of each building on the campus. Roads for unmanned vehicles on campus. Then, the cost is estimated. The cost is divided into the cost of the unmanned vehicle, including power consumption, depreciation, replacement, etc., and the time cost for the user to wait for the express delivery to arrive. In the case where the two costs are basically inversely proportional, a slight balance is optimal. The solution is the case where the sum of the two costs is the smallest. To solve the optimal solution, methods such as operations research knowledge, establishment of mathematical models, and programming are required. After the solution is obtained, a simulation test is carried out, and the collected data is substituted into the calculation to obtain the total cost of the solution, which is compared with the total cost of the existing unmanned vehicle dispatching at the same time, observe the effect of the solution, and make improvements. Finally, write a research report and propose a more reasonable dispatch and route planning scheme for express unmanned vehicles to operators.

3. Project Research Implementation Model

3.1. Data collection

①Investigate the current situation of unmanned vehicle operation on campus. Collect the daily order quantity of campus express unmanned vehicles, order arrival distribution, operating cost of unmanned vehicles, driving route, departure time interval, power consumption, service life (depreciation of damage during delivery), etc.

Collect express school maps, clarify the location and road distribution of each building on the campus, the roads where unmanned vehicles can travel on campus, and the delivery time of other forms of express delivery.

②Investigate information such as the cost and satisfaction of users waiting for express delivery. Design and distribute questionnaires, collect user satisfaction information, collect users' satisfaction under different waiting times in the form of self-scoring, etc., collect customer time costs, and the city's average hourly income of college students.

JD.com JD.com unmanned delivery vehicle1JD.com unmanned delivery vehicle.

3.1.1. JD.com unmanned delivery vehicle

(1)Basic data of unmanned delivery vehicles

Table 1:Basic data of unmanned delivery vehicles

Index	Numerical Value	Remarks
Vehicle size (long/wide/high)	1800x135x1700 (mm)	Both sides are double-sided, and both sides have lattice openings
Vehicle load	> 200kg	
Vehicle deadweight	< 400kg	
A vehicle (Two layers)	The upper four notches are: 25*42cm The under four notches are: 38*42cm	

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B vehicle (Three layers)	Trumpet：45*10cm Medium：45*21cm Large：45*33cm	
Maximum speed	18km/h	
Battery capacity	3.6Kwh	Average usage one day
Dispatch duration	5min/piece	Depending on the specific road conditions
Charging duration	2h	
Perception module	8 cameras, 4 large and 4 small	
Ambient temperature	-10 ℃～45 ℃	
Waterproof grade	Moderate rain, light rain, light snow (no snow) can be operated	
Unit Price	JD pieces (free) Others: 0.9 yuan/order	
Operation reference	30 orders/day	Up to 100 orders/day

(2)Technical features of unmanned delivery vehicles

JD.com unmanned vehicle is the terminal in the ecological chain of the smart logistics system. The delivery scenarios it faces are very complex. It needs to deal with the on-site environment, roads, pedestrians, other means of transportation, and various scenarios of users for various orders to be delivered in a timely and effective manner. decision-making and rapid execution, which requires the distribution of unmanned vehicles with a high degree of intelligence and self-learning capabilities.

At the same time, it has cognitive-based intelligent decision-making planning technology. When encountering an obstacle, it judges the pedestrian's position while judging the obstacle, and judges the direction and speed of the obstacle and the pedestrian's movement, and makes intelligent behavior decisions through continuous deep learning and calculation.

Mao Yian, the head of Meituan's drone business, told the "IT Times" reporter that at present, the drone independently developed by Meituan can carry 2.3 kilograms of meals and fly 6 kilometers round-trip in 15 minutes. It can still remain stable, and the stopping accuracy can be within 20 cm error; and each drone is equipped with 6 power sources at the same time, even if individual failures will not affect the flight, plus the drones are equipped with parachutes, multiple To ensure the safety of drones, "Technically speaking, whether it is stability or safety, Meituan drones are very mature, but to achieve the normalization of drone delivery, local policy support is still needed. "Wu Xiaoying, brand manager of Xunyi Network Technology Co., Ltd., also told reporters that the drone distribution technology has matured. In addition to being able to carry 5 kg of items for 20 kilometers in an environment below grade 6 wind, it also realizes the connection between the merchant and the cabinet. UAVs operate autonomously [4].

(3)School Express Center Delivery Schedule

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Table 2: School Express Center Delivery Schedule

Dispatch scenario analysis	Average dispatch time
Self taken parts	720s/piece
Take parts from the self lifting cabinet	600s/piece
Delivery time of unmanned vehicle	300s/piece

3.2. Data analysis

Sort out the cost of unmanned vehicles and customer satisfaction as the main module data, carry out statistical analysis, and display the data collected by each module in a clearer form by drawing and other methods, further dig the information and laws contained in the data, and prepare to establish mathematics Model.

3.2.1. Queationnaire-based satiafaction rating scale

Table 3: Queationnaire-based satiafaction rating scale

Time horizon/minute	Average satisfaction
<15	97.57
15~30	88.29
30~45	78.13
45~60	68.75
60~75	59.25
75~90	45.5
>90	33.88

3.2.2. Analysis of questionnaire results

As can be seen from the above table:

Students pick up express delivery at different times of the day. There are fewer people in the morning and evening, and the most people at noon and afternoon. The overall trend is a first increase and then a decrease. You can consider using a quadratic function or a cubic function to fit.

The average waiting time for students to use the unmanned express car to pick up the package.

Students' satisfaction with different waiting times.

Students are more inclined to deliver 4 or 6 times a day by unmanned vehicles.

(This graph is the relationship between customer satisfaction and customer waiting time drawn from the results of a questionnaire survey)

The revenue that the customer should have received can be estimated as the customer's lost revenue due to waiting for the delivery. According to the survey, the salary of college students working part-time is 15 RMB/hour. The salary of fresh graduates is about 5,600 RMB. According to the calculation of working 25 days a month and 8 hours a day, the hourly income is about 28 RMB. Taking the average of the two, customers can earn about 20 RMB per hour.

Time cost (hourly)= 25/60*20=8.33 RMB

Calculate the operating cost of express unmanned vehicles

The cost of operating the express unmanned vehicle itself = the cost of each kilometer of unmanned vehicles + the cost of electricity consumption per kilometer + labor costs

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According to the search, an express unmanned vehicle is about 450,000 RMB, which can be used for 3-5 years, and the average cost is calculated according to 4 years.

450000/(4*365)=308 RMB/day

The cost of driving each kilometer of unmanned vehicles = 308/60 = 5.13 RMB

The battery capacity of the express unmanned vehicle is 3.6 kWh, and it can travel 60 kilometers on a single charge, and the electricity fee is 0.5 RMB per kWh.

Power consumption cost per kilometer = 3.6/60*0.5=0.03 RMB

The hourly wage of college students working in the express station is 15 RMB. But there is no need to wait for the delivery of the self-driving car, so a day can be calculated as an hour.

Labor cost = 15/60 = 0.25 RMB

The cost of operating the express unmanned vehicle itself (per kilometer) = 5.13 + 0.03 + 0.25 = 5.41 RMB

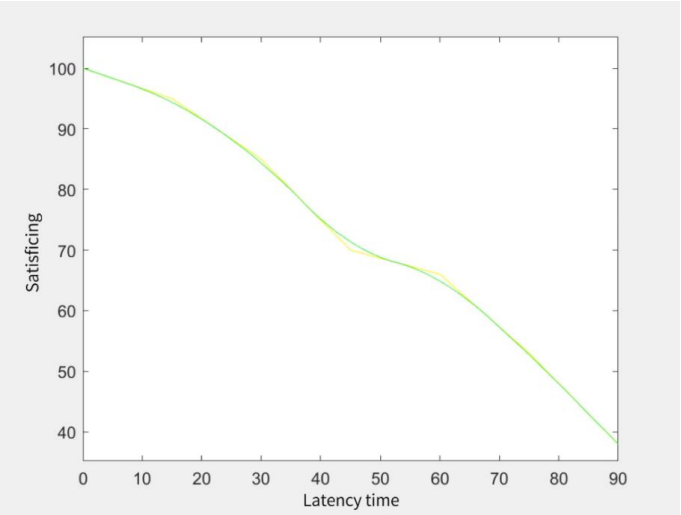

Figure 3: Latency time

3.2.3. Time cost and operating coat analysis

The cost of campus express unmanned vehicles consists of two parts: one is the time cost for customers to wait due to the difference between the expected arrival time and the actual arrival time, and the second is the cost of operating the express unmanned vehicle itself.

Calculate customer time cost

Time cost = average waiting time for customers * benefits that customers should have received

Since customer satisfaction will decrease as the waiting time increases, according to the relationship between the average customer waiting time (delay time) and satisfaction, we can use the longer waiting time when the customer satisfaction is higher as the average customer waiting time. The average waiting time for customers is 25 minutes.

3.3. Build an optimization model and solve the model

Based on the results of data analysis, using operations research methods, with the goal of minimizing the operating cost of unmanned vehicles and the total cost of waiting for users, a mathematical model of unmanned vehicle scheduling and path planning is established. According to the characteristics of the model, the algorithm to solve the model is designed, and the algorithm implementation program is written.

3.3.1. The algorithm flow of the route planning mode

(1)Label each marker on the map

(2)Simulate orders with random numbers

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(3)Excluding duplicate values, considering that when the unmanned vehicle arrives at a point, it will definitely deliver all the orders at that point, so here it is only necessary to count orders with a total of several points. Using C language, after running on Dev-C++, we get the points that need to be delivered.

(4)Get the matrix of shortest paths.Use Freud's algorithm to calculate the matrix of the shortest path between any two points, use Matlab, lingo to complete the planning of the route and find the minimum value of the distance, then use the TSP problem solving algorithm, use linear programming to find the minimum value and output.

3.3.2. Establishment of unmanned vehicle scheduling fitting function model

①Use Excel to fit the distribution change of the number of orders per unit time over time.

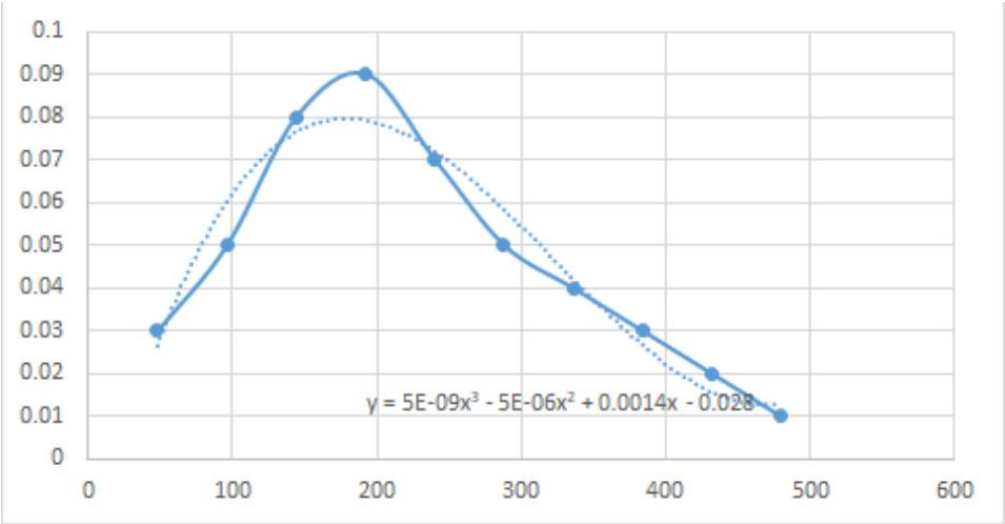

Figure 2: Get the fitting function $y=5E-09x^3-5E-06x^2+0.0014x-0.028$

②Use Excel to fit the relationship between the average kilometers and the number of trips.

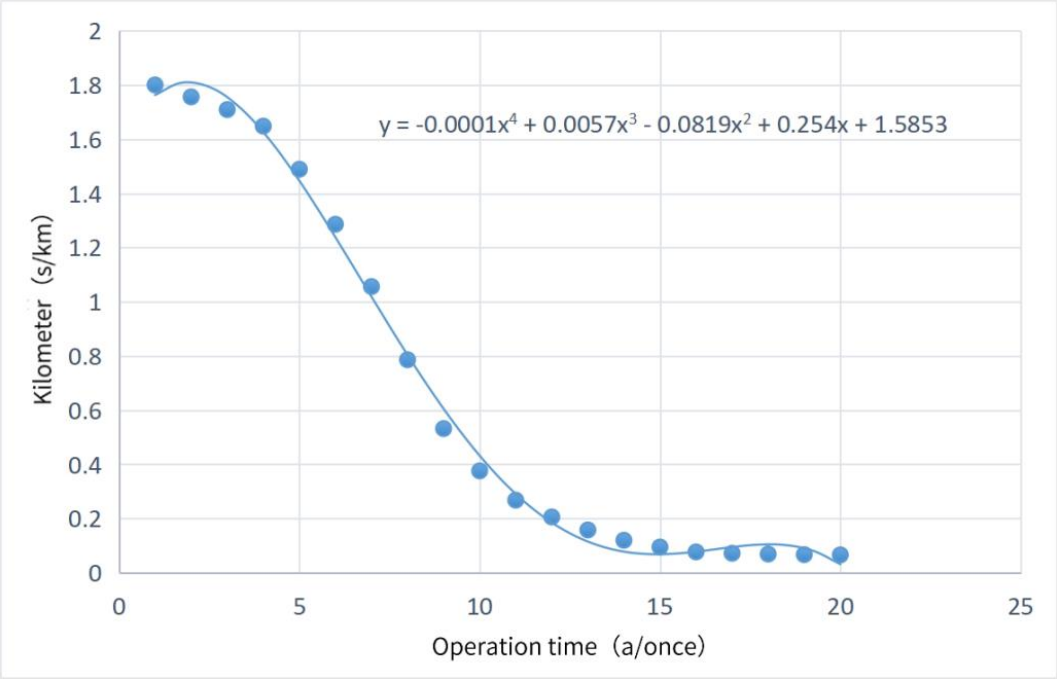

Figure 3: Operation time:$y=-0.0001x^4+0.0057x^3-0.0819x^2+0.254x+1.5853$

3.4. Simulation calculation and inspection

Using the real data of the college campus express center, simulation simulation is carried out to test the calculation effect of the model and algorithm. Substitute the collected data into the

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model for calculation, obtain the optimized unmanned vehicle scheduling scheme, and calculate the total cost of the scheme. Compare with the total cost corresponding to the existing unmanned vehicle scheduling scheme, and analyze the optimization effect of the model and algorithm. Comprehensively analyze the simulation test results, and modify the model and algorithm according to the actual situation.

4. Model improvement direction

（1）The fitting function is not accurate enough

The first fitting function, that is, the distribution of the number of orders per unit time with time, needs to be modified. The numerical algorithm is not very stable, and the error is large. It may be more appropriate to use other distributions.

The second fitting function, the sample value is too small, and then the sample value should be increased to re-fit.

（2）Lingo's d(i) formula in unmanned vehicle dispatching

d(i) is the total cost of the ith trip, which is the sum of the customer waiting cost and the operating cost of the unmanned vehicle in a single delivery.At present, it is assumed that the self-driving car delivery does not take time, and you can come back immediately when you go out. But it actually takes time. The cost of this part of the time is not calculated, and this part needs to be added later.

The value of t(i)-t(i-1) should be greater than the time it takes for an unmanned vehicle to deliver once, which is a constraint, and should be added later

（3）30 orders cannot be delivered at one time

The delivery window for unmanned vehicles is limited, and 30 orders cannot be delivered at one time, so they should be delivered in batches.

（4）Eliminate duplicate values in route planning

When removing duplicate values, the number of occurrences of duplicate values should be recorded and such data should be retained.

（5）Order batches should be divided into consideration of the distribution of dormitory buildings

①The operating cost of unmanned vehicles is the smallest: if a batch of orders are basically sent to an area, the operating cost can be reduced. On the contrary, if the distribution is very scattered, the distance that the autonomous vehicle needs to travel will be large and the cost will increase. Therefore, when dividing order batches, try to divide the orders in the distribution set into the same batch.

②Minimum waiting cost: If the number of orders in the divided batches is not equal, it is more appropriate to dispatch the batch with the largest number of orders first, because this can make the waiting time for customers the shortest and the waiting cost is also the lowest.

5. Conclusion

The introduction of unmanned delivery technology into schools can not only improve the delivery efficiency of schools, but also effectively solve the "last mile" problem of schools. Based on the university campus environment, a path planning model for unmanned vehicles based on time constraints to transport goods to multiple sub-stations under a certain time limit is established, and it is compared with the traditional logistics model. The implementation of unmanned distribution can greatly improve the efficiency of logistics, and has a certain guiding role for the implementation of unmanned distribution in campuses in the future. As the

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operation management system becomes more and more perfect, driverless technology will also be an inevitable choice for future urban rail transit [5].

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