

Exploring Static Path Planning Algorithms for Efficient Route Calculation in E-commerce Vehicle Logistics Systems

Xin Wang^{1,*}

¹Yunnan University of Business Management, Anning, 650301, China

*Corresponding author: Xin Wang e-mail: vichyxin2008@126.com

Abstract: With the development of information technology, human activities in reality have become more and more convenient. In recent years, outdoor positioning and location-based services have matured. Location services based on GPS and maps have been widely used and become one of the most used applications on various mobile devices. With the development of science and technology, car navigation has gradually been applied to our daily lives. The so-called Vehicle Location and Navigation System uses the global positioning system (GPS) to obtain the current location and matches with an electronic map consistent with the road traffic network to obtain the exact location of the vehicle on the map. According to the given starting point, it can give an appropriate driving route and plan the shortest path between the two places. It can even intelligently predict real-time traffic information (ITS) to provide accurate services.

1. Path Planning Algorithm

The shortest path problem is a classic problem in graph theory research, which aims to find the shortest path between two nodes in a graph (composed of nodes and paths)[2]. The shortest path calculation is divided into static shortest path calculation and dynamic shortest path calculation. The static shortest path algorithm is used to calculate the shortest path without changing the external environment, such as Dijkstra algorithm, A* (A Star) algorithm, etc. The dynamic shortest path algorithm is used to calculate the shortest path when the external environment is constantly changing and unpredictable. For example, the same road section will have different traffic conditions in different time, so the required cost is also different. The D* algorithm is typical. Here we mainly discuss commonly used static path planning algorithms. For example, Dijkstra algorithm and A* algorithm.

2. The Basic Principle of The Algorithm

In the case that the location of the car and the person is known, how to plan the path and find a feasible path to save time to a greater extent? After reading a lot of literature and conducting many experiments, we designed a relatively simple and practical algorithm.

This article simulates several sets of data to illustrate the correctness and practicability of the algorithm[3-4]. The data will be given in the form of a set of coordinates, a feasible path will be planned, and the calculated path will be displayed on the app we designed.

(1) Function and derivation of algorithm formula

After opening the map module in the software, when the user navigates to the place that needs to be reached, the user's route from the start point to the end point will be displayed in the map interface. The distance of the user's location to the destination location is needed to implement this function, so the system needs to solve the problem of calculating the distance between these two points using the latitude and

longitude obtained through GPS. It needs to find the length of the arc formed by connecting these two points on the earth this problem.

The derivation process: As shown in the figure, the earth is a sphere, P1 (T1, Q1) and P2 (T2, Q2) are two positions on the earth, where T is its latitude, Q is the longitude, O is the center of the earth, and the radius of the earth is R, Pass point P1, make the latitude circle of P1 and let it intersect the longitude circle of P2 at point P3, then pass P2 and P3 to make the perpendicular line where point O is intersected at points P5 and P6, Pass point P2, make the perpendicular line of OG so that it intersects the extension line of P3P6 at point P4, and OP6 and the extension line of P2P3 intersect at point G. The schematic diagram is as follows Figure 1:

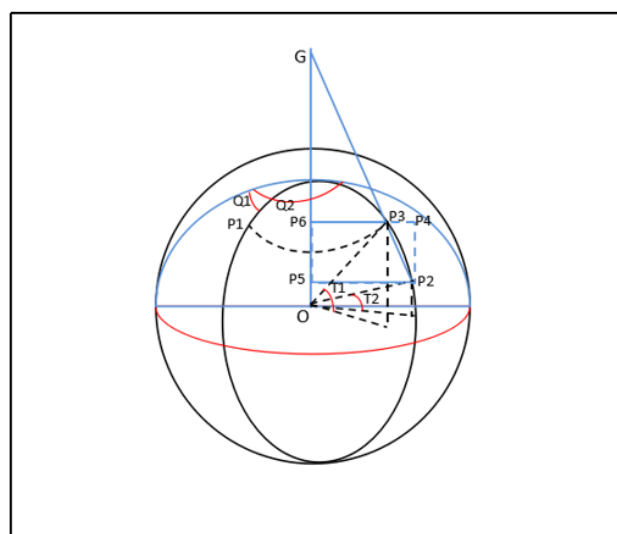


Figure 1. Schematic diagram of distance

It can be seen from Figure 5-9 that points P5 and P6 are the center points of the latitude circle where points P1 and P2 are located on the earth. P3 and P1 are in the same latitude circle and have the same latitude; point P3 and point P2 have the same longitude, point G is the intersection of the extension

lines of P2P3 and P5P6, so $\triangle OP3G \sim \triangle P2P3P$, therefore:

$$\frac{P3G}{P2P3} = \frac{P3P6}{P3P4} \Rightarrow P3G = \frac{P3P6 * P2P3}{P3P4} \quad (1)$$

$$\frac{GP6}{P2P4} = \frac{P3P6}{P3P4} \Rightarrow GP6 = \frac{P3P6 * P2P4}{P3P4} \quad (2)$$

Since $\triangle P1P6G$ is a right triangle, therefore:

$$P1G^2 + P1P6^2 = P6G^2 \quad (3)$$

Set $\angle P1P3G$ to α , then set $\angle P1P3P2$ to $\pi - \alpha$. According to the law of cosines:

$$P1G^2 = P1P3^2 + P3G^2 - 2 * P1P3 * P3G * \cos \alpha \quad (4)$$

$$P1P2^2 = P1P3^2 + P3P2^2 + 2 * P1P3 * P3P2 * \cos \alpha \quad (5)$$

In summary, we can know:

$$P1P2^2 + P1P3^2 * \frac{P2P5}{P3P6} + P2P3^2 \quad (6)$$

From the latitude and longitude of points P1 and P2, we can get:

$$P3P6 = \cos(T1), P2P6 = \cos(T2)$$

$$P2P3 = 2 \sin\left(\frac{T1-T2}{2}\right)$$

$$P1P3 = 2 * P3P6 * \sin\left(\frac{Q1-Q2}{2}\right) = 2 * \cos(T1) * \sin\left(\frac{Q1-Q2}{2}\right)$$

Incorporating formula (7) into:

$$P1P2^2 = 2[1 - \cos(T1 - T2) + \cos(T1) * \cos(T2) - \cos(T1) * \cos(T2) * \cos(Q1 - Q2)]$$

The arc length of the two points P1P2 (the distance between the two positions of P1P2) is:

$$L = 2R * \arcsin\left(\frac{P1P2}{2}\right) \quad (7)$$

Simplifying formula (8), we can see:

$$L = R * 2\arcsin\sqrt{\sin^2\frac{T1-T2}{2} + \cos(T1) * \cos(T2) * \sin^2\frac{Q1-Q2}{2}}$$

It is known that lat_a and lng_a are the latitude and longitude of point A, lat_b and lng_b are the latitude and

longitude of point B, and $R=EARTH_RADIUS$ is the radius of the earth. The mathematical formula for calculating the distance between two points of latitude and longitude is:

$$R * 2\arcsin\sqrt{\sin^2\frac{lat_a - lat_b}{2} + \cos(lat_a) * \cos(lat_b) * \sin^2\frac{lng_a - lng_b}{2}}$$

(2) The application of the algorithm in the code

```
S=2*Math.asin(Math.sqrt(Math.pow(Math.sin(a/2),2)+Math.cos(radLat1-radLat2)*Math.cos(radLat2)*Math.pow(Math.sin(b/2),2)));
```

(Where $radLat1 = (lat_a * Math.PI / 180.0)$, $radLat2 = (lat_b * Math.PI / 180.0)$, a is $radLat1 - radLat2$, b is $(lng_a - lng_b) * Math.PI / 180.0$)

(3) The necessity of the algorithm in the system

The use of this algorithm calculates the distance between the start point and the end point in the map navigation module. After calculating the distance between the two points, the distance between the destination and the user and the time when the user arrives at the end can be known in order to plan the route. Without this algorithm system, it is impossible to know how much time the user needs to spend on the journey, it is impossible to know which scenic spot is the smallest distance, and it is impossible to make a good travel plan.

(4) Use summary of the algorithm in the code

The system obtains the latitude and longitude of two locations on the earth through positioning firstly[5]. Since the latitude and longitude is an angle value, it needs to be converted to radians (latitude and longitude * $Math.PI / 180.0$ is the conversion formula)[6-8]. After the conversion is completed, through the known radius of the earth, we bring these data into the mathematical formula for calculating the arc length obtained by formulas such as trigonometric functions, so as to calculate the length of the arc formed by connecting two positions (that is, the distance between two points).

3. Algorithm Implementation

We conduct experiments on the research through the establishment of the model, we first integrate the collected data, and then encode the collected and integrated data.

The data set used this time comes from the data tested and displayed on the navigation data set of Baidu Map and Gaode Map. The data set is processed to obtain an intuitive data table, and a series of experimental operations are carried out through the data table.

Data processing: Convert the obtained data set into an intuitive table, which will make the basis for path distance and path selection, and obtain the result through data processing of the table. The data set and table data are shown in Table 1.

Table 1. Customer Data Table

Customer Number	Abscissa	Ordinate	Customer demand
0	360	244	1
1	279	301	1
2	238	359	1
3	234	168	1
...
...
...
49	175	28	1

We have obtained the artificially specified positioning center. This time the distribution center is selected as the center point of the area obtained by the accommodating

position, and the coordinate information of the positioning center is obtained as shown in Table 2.

Table 2. Positioning Center Data Table

Positioning center number	Abscissa	Ordinate	Cargo capacity	Vehicle capacity
50	360	305	50	2

2) Print each point through the code, where the blue point is the point where all customers are located, and the red point

is the distribution center, and the following discrete graphics are obtained:as follows Figure 2.

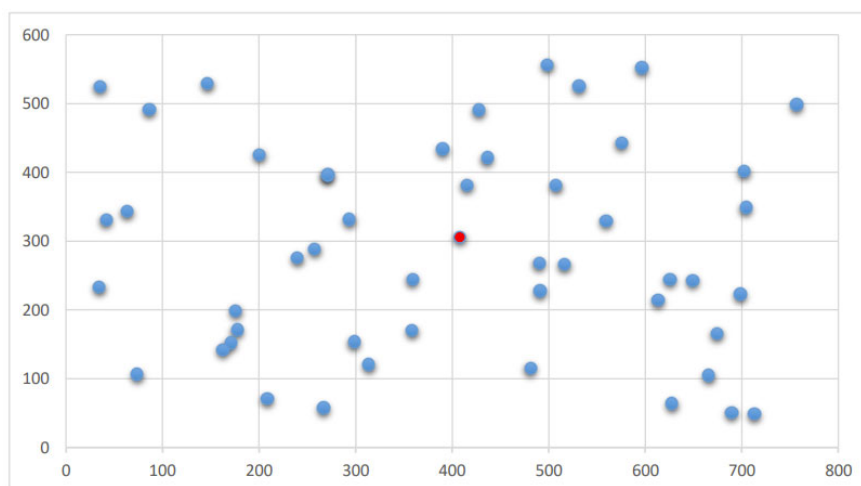


Figure 2. Discrete Graph: Customer Distribution and Distribution Center Visualization

4. Conclusion

The car navigation system integrates advanced global satellite positioning technology, geographic information technology, digital library technology, multimedia technology and communication technology. It can provide drivers with various information services in real time, efficiently and accurately, and it has a strong practical value and broad market prospects.

From the above simulated data and the results displayed on the app, the correctness of the algorithm is verified.

References

[1] Zhang Jiayu, Zhao Jian, Shi Zhengtang. Parallel parking path planning and tracking control based on cyclotron curve[J]. Journal of Jilin University (Engineering Edition), 2020(06): 2247-2257.

[2] Jiang Libiao, Yang Jie. Research on path tracking of automatic parking system based on sliding film control[J]. Journal of Agricultural Machinery, 2019, 50(2): 357-364.

[3] Han Xue, Ding Linhua, He Hongkai, etc. Urban parking lot navigation APP based on Android[J]. Computer Programming Skills and Maintenance, 2016 (7).

[4] Zhang Chi,Zhang Yonglin.Research on Optimal Control of Automatic Parking and Steering Path Tracking and Positioning[J].Computer Simulation,2019,36(06):179-185.

[5] Kim D,Chung W,Park S.Practical motion planning for car parking control in narrow environment[J].IET Control Theory&Applications,2020,4(1):129-139.

[6] Li Tao. Path planning and tracking of automatic parking system [D]. Harbin: Harbin Institute of Technology, 2017.

[7] Hu Jie , Zhu Qi et al . Global path planning for intelligent vehicles by introducing must-pass point constraints[J]. Automotive Engineering, 2023,45(03):350-360.

[8] Ge Shaoyun, Shen Kaiyue, etc. Urban Fast Charging Network Planning Considering Network Transfer Performance[J]. Power Grid Technology, 2021,45(09):3553-3564.