A Google Earth-Based Dynamic Route Guidance Algorithm and Its Implementations

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Abstract: Since the traffic congestion become more and more serious in modern society due to the sharp increasing of private cars, how to improve the transportation efficiency and utilize the current road network more effectively has become a crucial issue. In this paper, a new dynamic route guidance algorithm was proposed in order to provide travelers humanized "optimal route" and to alleviate the loss caused by traffic jams. The study built a graph theory model for Beijing's ring road transportation system, and proposed a evaluation function $\sigma=V_f/[k\times(t+m^{(\rho-\rho 0)})]$ to describe the real time complex traffic flow, and realized the route searching by timed recomputation of classic Dijkstra algorithm. Meanwhile, due to the investigation of special features of ring roads, the study improved the priority of ring road nodes during the searching process. Comparing with Dijkstra algorithm, the time-complexity of this new algorithm decreases to $1/(16k^2)$ (k is the number of ring road in the road network), and extra mileage is less than 5%, which is more effective applying in large scale ring-road networks. The algorithm was realized by C++ language and connected to Google Earth's map database with easy operation interface. (The operation of the algorithm program was manifested in the appended video)

Keywords: Dynamic route guidance, humanized route searching, ring road priority, Dijkstra algorithm

1. Forward

With the development of economy and advanced technologies, the number of private cars is increasing rapidly at present. Consequently it facilitate people's daily lives, but on the contrary, it also largely exacerbates the burden undertook by city road networks, which leads to a series of negative effects on people's normal life, such as serious traffic jams and frequent accidents etc. According to the statistics by Economics and Technology Institute of Chinese Academy of Social Sciences(CASS), Beijing's average social loss caused by traffic jams is up to 40 million RMB per day, which is 14.6 billion a year, moreover, this figure reaches 170 billion annually in nationwide. Meanwhile, traffic jams decrease the speed of vehicles, resulting in the waste of energy, decreasing transport efficiency, and leading great loss of urban economic and social benefits as well [1]. Hence, to alleviate urban traffic jams has significant meaning of economic, environment and energy, which has now become the focus of the research [2].

Immediately attracted wide range of concerns when it was firstly proposed by the United States in 1960s, Intelligent Transportation Systems (ITS) is a new conception that integrates vehicle and road network system as a whole to solve the traffic problems. In ITS, the rapid development of information technology enables people integrate the automatically detect technology, digital communication technology, automation technology, intelligent information processing and decision-making technology as an effective working group. Such a working group can be applied into the entire integrated large-scale intelligent traffic management system [3], which contributes to improve the traffic situation and transport efficiency.

Advanced traveler information system (ATIS) is a sub-system of the ITS, which induces drivers with dynamic traffic information to avoid them driving through vehicle highly concentrated streets. It is substantiated that, the ATIS can help travelers drive more freely and make traffic flow re-distribute in the road network. Existing on-board GPS route guidance system is considered as a relatively primitive ATIS. For although it provides detailed map information, vehicle location, as well as route guidance, there are still four crucial issues remain unresolved:

(1) Too simple road network modeling: the road network model integrated in on-board GPS unit is generally based on graph theory and takes only the length of road into account, but with the negligence of many important factors, such as road width, traffic conditions, traffic lights delay, and the interference of Non-motor vehicles;

(2) Poorly match with large-scale road network: although the calculation of the classical Dijkstra's algorithm for *shortest path problem* can obtain the optimal solution, such algorithm has a very high time complexity $O(n^2)$. Furthermore, as with the low computability of the on-board system, it may take a long computation time in a large-scale road network of metropolises;

(3) Highly complex guidance route: since distance is the only parameter considered, drivers are lead to a nearer, but more twists, turns, and high driving difficulty road, which occurs particularly prevalent in the complex road network of large cities;

(4) Can not deal with route guidance through dynamic traffic information: dynamic route computation is the essence of the ITS system, the current on-board GPS guidance system can only induce the shortest road in geometric distance, without consideration of the vehicles and traffic congestion. Therefore, the current on-board GPS guidance system can only provide the shortest path but not the smoothest path, which may effectively save much of driving time in the cost of a little bit of extra mileages.

Based on the above four points, the current on-board GPS guidance system is more likely working as a multi-functional electronic map, but can neither provide intelligent route computation service nor meet the traveler's humanized demands.

Considering these shortages, some scholars combined graph theory and Optimal Search algorithm (such as Genetic Algorithms, A* search algorithm, Ant Colony Optimization, etc.) to deal with the problem of dynamic route guidance. However, these methods are actually search algorithms, although their functions have certain advantages, but a common and unavoidable problem is that the search algorithms present a similar or even higher time complexity compared with the classical Dijkstra algorithm. At the same time, the search algorithm also has many drawbacks, such as a local optimum, non-convergence search, and high requirements of on-board equipment [4]. Therefore, the current search algorithm is still far away from the practical application.

Base on the above background, in order to avoid local optimum and non-convergence search, the assumption of our research group is to achieve dynamic route guidance by setting the traditional Dijkstra algorithm as a basement, and through route timed re-calculation and computation structure optimization, which largely reduces algorithm time complexity.

The survey of our research group showed that the traffic lights obstruct the traffic flow. This is not only because of the delay of the red light, but also because of the waste time during acceleration and deceleration process; what's more, the vehicles are interfered by non-motor vehicles and pedestrians, which can not be neglected particularly in China. Therefore, this research highlighted the ring road and arterial road priority in modeling, and guided the travelers to choose ring roads prior to the ordinary urban roads under the same condition, which shall bring shorter driving time and lower driving difficulty at the cost of a bit extra distance. At the same time, considering the stagnation caused by unexpected traffic jams, the algorithm used Cluster Analysis Method to assess the regional traffic situation timely, and re-weight the found abnormal patterns and unusual local path, and then re-calculate the optimum path.

This study wrote the application program according to algorithm, and designed a more humanized man-machine interface display, such as: three-dimensional display for the recommended routes, travel time and fuel consumption estimation. (This paper also includes a real operation display video of the application program, which has been sent to the Secretariat-mail of the competition).

This study improved the current on-board GPS guidance system through the innovative algorithm and the evaluation function, and the specific assumption is as follows:

(1) Establish the road network model based on graph theory;

(2) Adopt evaluation function to deal with dynamic traffic information on road conditions;

(3) Assess the road smoothness and weight the road Smoothness degree;

(4) Layer the road network in order to optimize the algorithm computation structure;

(5) Search the "smoothest" path;

(6) Update and display the traffic information as well as guidance route on the visual man-machine interface.

2. Modeling and Database establishment

2.1 Introduction

The overall framework adopted in this study is the distributed dynamic route guidance system (DDRGS), which makes use of the dynamic traffic information received from urban traffic control system and calculate the smoothest path on the on-board unit [5].

DDRGS system includes two parts, the information center and on-board unit. In practical application, the information center sends dynamic traffic information to the on-board unit to process it in terms of wireless communication. In the on-board unit, traffic information and map database are integrated, the "shortest path" will be searched out through path planning algorithm, the final results will be shown by the man-machine interface and complete the dynamic path guidance according to the dynamic traffic information, as shown in Figure 1.

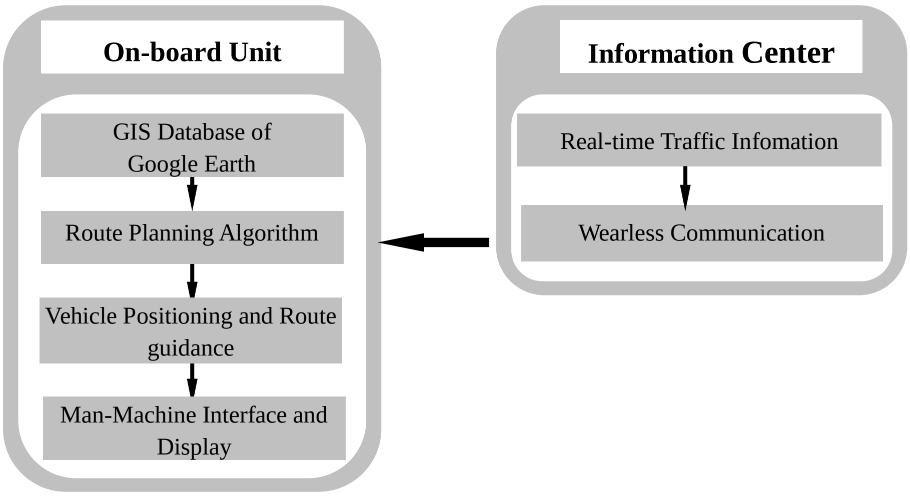

Figure 1. The framework of Dynamic Route Guidance System

This study focuses on path planning algorithms and man-machine interface display, which both are essential parts of the current dynamic route guidance problem.

2.2 The simulation of map information

Google Earth is the virtual globe software developed by Google's, which arranged the satellite photos, aerial photography and GIS in a three-dimensional model of the Earth; users can download the client software to their computers and browse the global high-resolution satellite images freely. This study selected Google Earth as the map information database, and combined with Graphical User Interface (GUI). The combination is clearer, more powerful and popular compared with ordinary electronic GIS map.

This study take Beijing's inner zone within 4th ring road as the road network model, 491 crossroads were detailed modeled and marked on the Google Earth version 4.03 electronic map, as shown in Figure 2 and Figure 3. Figure 2 shows all the marked crossroads, and Figure 3 shows the marked information of a crossroad on the north 4th ring road around National Stadium "Bird's Nest" on Google Earth.

Figure 2. All the marked crossroads within 4th ring road in Beijing on Google Earth

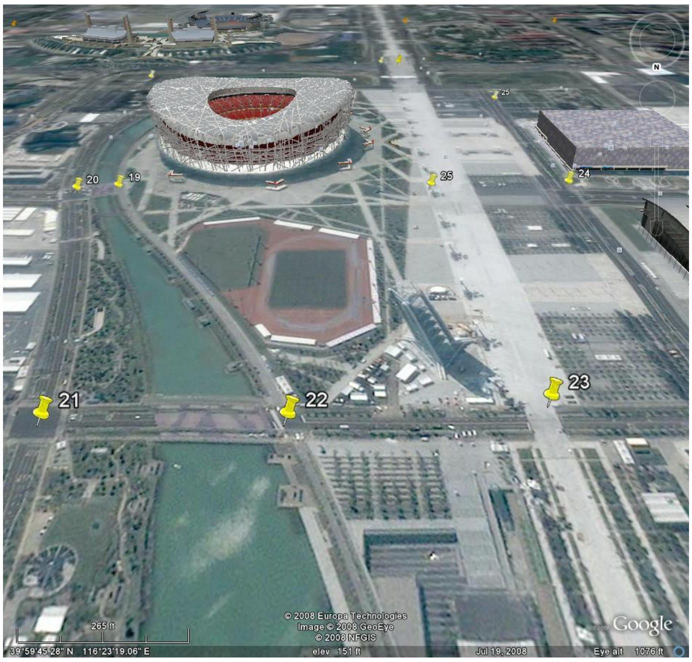

Figure 3. 3-D display of Bird’s Nest and marked crossroad on Google Earth's

Table 1. The storage format of crossroad information

Crossroad (label)	Longitude	Latitude	Average delay of traffic lights	The actual location
1	116°19'36.12"E	39°59'43.97"N	30s	East Gate of Tsinghua University campus
2	116°26'38.80"E	39°55'56.54"N	45s	North side of the Workers Stadium
3	116°20'56.50"E	39°56'21.21"N	25s	Xizhimen Bridge

Table 2. The storage format of road information

road segment	Intersection	road segment length	smoothness degree	weighed smoothness degree
R1	1-2	400m	3	time×1.6
R2	2-3	600m	1	time×1.2
R3	3-4	700m	2	time×1.4

The length of the segments in the table is calculated as follows:

The longitude and latitude coordinates of crossroad point A, B in AB road are gained through Google Earth: and marked as $(x_1, y_1), (x_2, y_2)$. Assuming the earth is a standard sphere with a radius of R, and the eastern longitude and northern latitude are assumed positive, and west longitude and south latitude are negative, then:

The coordinates of crossroad point A can be expressed as:

$$(\cos y_1 \times \cos x_1 \times R, \cos y_1 \times \sin x_1 \times R, \sin y_1 \times R)$$

B can be expressed as: $(\cos y_2 \times \cos x_2 \times R, \cos y_2 \times \sin x_2 \times R, \sin y_2 \times R)$

Then, the cosine of angle AOB is:

$$\cos y_2 \times \cos y_1 \times (\cos x_2 \times \cos x_1 + \sin x_2 \times \sin x_1) + \sin y_2 \times \sin y_1$$
$$= \cos y_2 \times \cos y_1 \times \cos(x_2 - x_1) + \sin y_2 \times \sin y_1$$

And the surface length of the AB points is:

$$R \times \arccos(\cos y_2 \times \cos y_1 \times \cos(x_2 - x_1) + \sin y_2 \times \sin y_1) \quad (1)$$

2.3 The mathematical description of the traffic flow

In the traditional traffic flow study, the movements of vehicles were considered as isolated moving particles. However, the modeling study of two-dimensional cellular automata and other fluid mechanic studies of recent years show that: vehicles in the road network form a whole in the movement, and reflect the general movement of fluid such as following, viscosity and continuity in the movement [6]. The research group selected traffic flow as a model to represent the movement of the entire system, the vehicle density ρ and the average speed V to describe road load capacity and pass ability. According to the change of traffic situation, the path is weighted according to the two dynamic parameters, thus an effective description the dynamic pass capacity of the road can be achieved.

Function definition

The road traffic information is assumed known and information collection is based on the video vehicle detection technology. The road number, lane number, road length, vehicle number, vehicle density, speed and pass time are marked as W, L, S, Q, ρ, V and T respectively, then:

(1) The total vehicles in road W, denoted as Q;

(2) The vehicles density ρ in road W: ρ = Q/(S×L) (vehicle number / (road length × lane));

(3) The average speed V in the road: The average time of vehicles on road W is denoted as T, then V = S/T.

The evaluation function

Generally, other studies usually use real speed as road weight but neglected the impact of vehicle density on traffic flow, which can not accurately reflect dynamic traffic situation. Traffic density is a hidden factor that may cause traffic congestions and slow down vehicles' speed [7]. For example, on a certain road section (such as ring road), the vehicle speed is high, if the vehicle density reaches a certain threshold, even though there is no traffic jam at the time, one still mostly happen in a short period of time. That is why even in the absence of traffic accident, high-density traffic on the ring roads will also be congested, called ghost-like jams. Therefore, this study aims to ease the delay and randomness of traffic flow forecasting model.

A fluid mechanic model proposed by Professor Yuki Sugiyama [8] believes that traffic congestion is due to the inherent instability of multi-particles, and the vehicle will be derived at the maximum speed under a certain vehicle density, that is

$dx_i/dt = v_i$ (2)

$dv_i/dt = a\,[V(x_{i+1}-x_i)-v_i]$ (3)

x_i is the location of the vehicle on the road section, v_i is the instantaneous speed, and variable "a" is following sensitivity. The model reveals the process of uniform fluid changed into the congestion.

Hyperbolic function V(b) = tanh (b-2) + tanh (2) was chose as a manifestation of the model, which indicates that the threshold speed depends on the distance between vehicles (vehicle density), as shown in Figure 4:

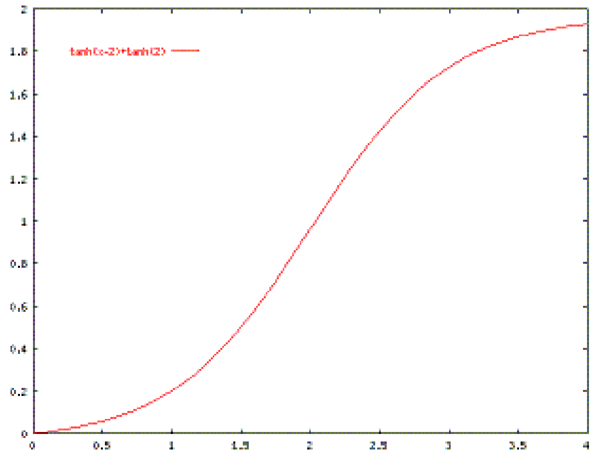

Figure 4. The curve of function V (b) = tanh (b-2) + tanh (2) function image [8]

Figure 5 is a steady-state analysis phase diagram of linear fractal movement, and the two parameters in the model are vehicle density “L/N” and following sensitivity “a”.

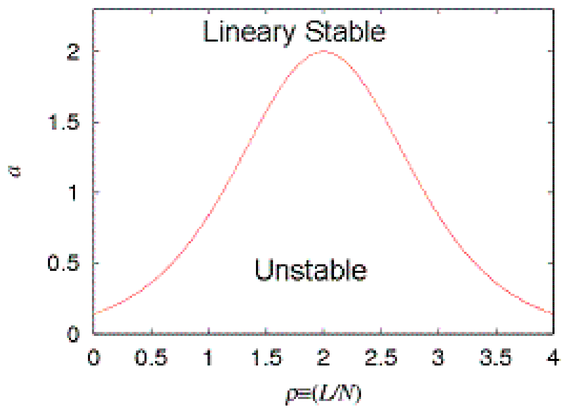

Figure 5. Stabilization analysis of linear fractal movement [8]

Figure 5 shows that when the density is greater than 2ρ (L/N), the homogeneous traffic flow is very unstable, therefore, the density is the threshold ρ_0.

The theory describes the continuous changes of the probability of traffic jams in the fluid dynamics model, and establishes the relationship between vehicle density and traffic jam. On this basis, in order to enhance the overall forecast ability of the road capacity as well as to reduce the occurrence of traffic jams. Therefore, “dynamic speed” is introduced to describe the smoothness of a certain road segment and density, an auxiliary parameter is also introduced to evaluate the traffic status of the segment.

According to the study, exponential function presents higher pertinence in characterizing the relationship between the probability of a traffic jam and vehicle density compared with hyperbolic function: when the vehicle density surges, the smoothness degree of the road will significantly decrease, so that the "turnoff" forms. The growth and symmetry description of the hyperbolic function to this phenomenon is less than sufficient warning, while the preceding paragraph of the exponential function is a better reflecting the smooth growth before the threshold of the density.

Smoothness degree was assumed as $\sigma = V_f/[k\times(t+m^{(\rho-\rho 0)})]$,(in which V_f is the free speed of vehicle flow, ρ (0,1) as the standard unit of vehicle density, ρ_0 (0,1) as the low threshold of V_f, t, k, m are the parameters to be determined). Figure 6 is the curve at V_f / k = 10, t = 2, m = e^{14}.

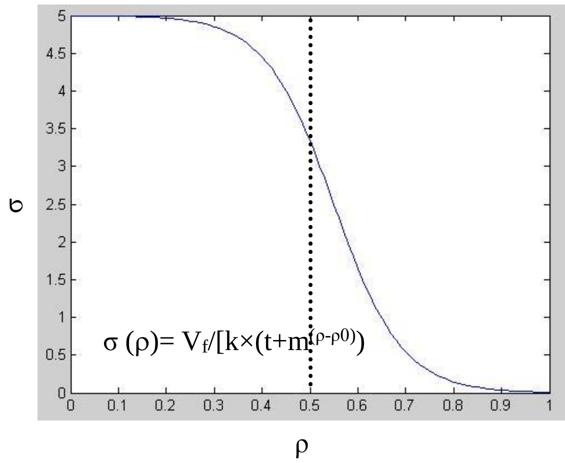

Figure 6. The curve of evaluation function $\sigma = V_f/[k\times(t+m^{(\rho-\rho 0)})]$(Set parameters: V_f/k=10, t=2, m=e^{14})

When ρ → 0, the road is empty, and $[k\times(t+m^{(\rho-\rho 0)})]$ tends to kt, σ reaches the largest, then the road is in the free flow state;

When ρ → 0, the vehicle density reaches the maximum, and $[k\times(t+m^{(\rho-\rho 0)})]$ tends to maximum, σ is minimum, which indicates the congested state;

When ρ is in the vicinity of the threshold ρ0 (0.5), $[k\times(t+m^{(\rho-\rho 0)})]$changes from slow growth, via the critical point to rapid growth, causing σ rapid decline, which indicates the critical state.

The values of t, k, m in the evaluation function can be gained through the simulation of the measured data, which has been fully discussed in this study.

This study analyzed the probability of establishing the relationship between the traffic jam prediction and dynamics weighting problem, which was raised as the evaluation function model in this study. Based on this model, further research can continue to improve the path guidance stability, predictability and reduce systematic errors of the algorithm, then achieve more accurate dynamic route guidance.

2.4 The simulation database of network information

The performance test of the algorithm for dynamic traffic flow needs to simulate actual road conditions, for simple, dynamic random weighting was used to simulate real traffic situation in this study, which would be as follows:

Step 1: Give the initial value of each road, which is directly proportional to the length of the road;

Step 2: In the per unit time, a smaller random incremental value is taken for changing the priority value of every road;

Step 3: Repeat Step2, and randomly change the road weight in the vicinity of the initial value.

3. Algorithm Design

Based on the model of the ring road system of Beijing, a corresponding path planning design was adopted in this type of road network in this study. The idea of this study is to design algorithm to enhance the capacity of the ring road and guide more vehicles to the ring road and arterial roads; at the same time, it will timely analysis the traffic accidents, road blockade, and other emergencies, then guide the vehicles leave the ring road and provides a new optimum path timely.

The method first determines the choice of the algorithm: when the coordinate distance between the start (O) and destination (D) is longer than 10km, it will choose the ring road priority algorithm to search the optimum path in the two points; when the coordinate distance is smaller than 10km, it will search the path with hierarchy algorithm.

The ring road priority algorithm proposed in this study has commons with the hierarchical algorithm and the block algorithm, but optimized the search structure in the orientation. The link of the Ring road and the regional grid between the ring roads build their own groups, and the path search is in regional grid and ring road unit, through pre-judge the likely come by ring road and region, the optimum path in the dynamic traffic network can be gained through the application of classical Dijkstra algorithm in every regional section. Because the algorithm will iterate the computation in the ring road during search, four virtual connections (as the dotted line in the following figure) will be generated to make the entire ring road connective. The algorithm process is as follows:

(1) First, mark ring road points as well as the arterial road points which connect the ring roads as the special points;

(2) Second, calculate the distance using Dijkstra algorithm from the starting point to find a number of special points which are the nearest between the starting point, and record the distance between these special points and the starting point respectively, then mark these distances as the distance tags for these special points, as shown in Figure 7 and Figure 8;

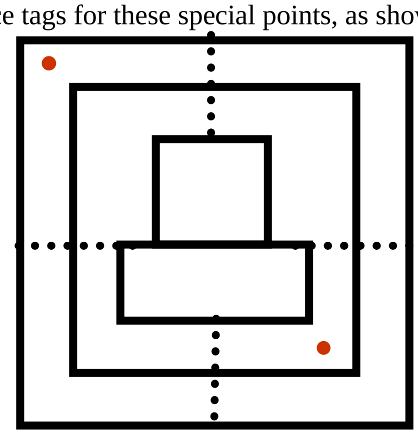

Figure 7. The starting and end point

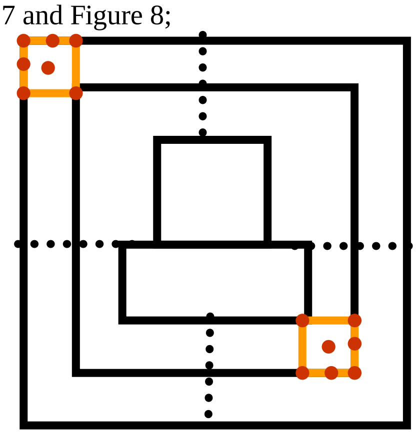

Figure 8. The link points found by Dijkstra algorithm in the ring road road

(3) Third, update the distance tags by using iterative algorithm for all the special points respectively, as shown in Figure 9;

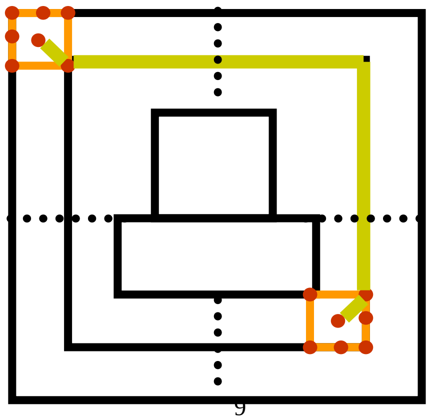

Figure 9. Determine the path on the ring road by the ring road iterative algorithm from the point of connection

(4) Fourth, use the Dijkstra algorithm from destination to search such special point whose sum of the distance tag (the starting point to point distance)and the distance between the destination is minimum, as shown in Figure 10;

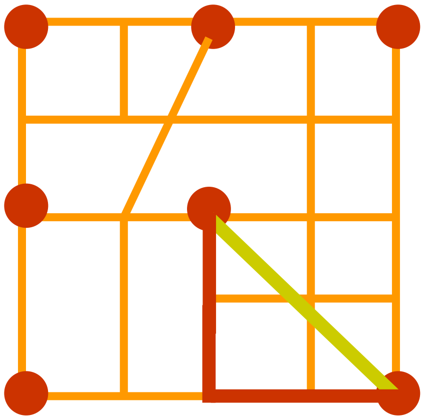

Figure 10. The connection between the start, destination and the ring road link in grid region

(5) The minimum distance between the starting point and the destination, as shown in Figure 11;

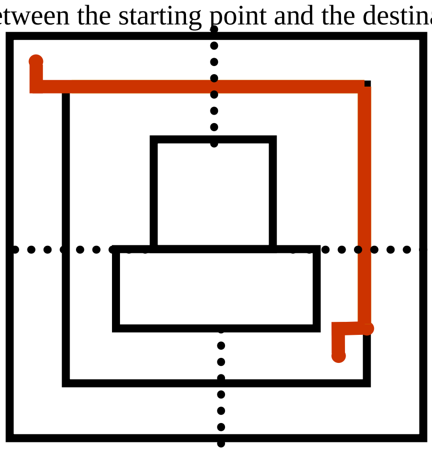

Figure 11. The optimum path gain through this algorithm

(6) Determine the location of the vehicle every 20 seconds, and re-calculate the path according to dynamic traffic situation.

According to this idea, this study wrote a visualization and intuitionist testing procedure to verify the work.

4. Results and Discussion

4.1 The performance comparison with the classic Dijkstra's algorithm

Dijkstra algorithm is the classical algorithm for solving the shortest path problem since the 1960s. However, due to the existence of its huge time-complexity, high on-board equipment requirements, too idealistic model, Dijkstra algorithm is rarely applied in real life. Through the observation and study, this study introduced the ring road priority on the basis of Dijkstra algorithm, making great improvement in the computing amount, the road complexity and the dynamic path guidance, which were mainly reflected in the following four aspects.

(1) The complexity of time

The complexity of algorithm is crucial in its application. Due to the high-performance of PC, the running time of the test algorithm is almost the same, however, when they were used in the low configuration on-board vehicle navigation devices, the complexity of the algorithm will lead to a long computing time. In particular, the traditional method and some of Optimal Searching Algorithm may need decades of minute in the large-scale road network, which is obviously difficult to meet people's needs.

Traditional Dijkstra algorithm is based on the breadth-first search strategy, starting from the specified nodes to all the other nodes through the iteration of priority value, then the shortest path tree from the specified nodes to all the other nodes is gained. The Traditional Dijkstra algorithm uses a linear array structure to storage its associated matrix, and needs to visit all the un-marked nodes during the obtaining the shortest path nodes, the time complexity of the algorithm is O (n^2).

As the research group set the region narrows to two parts, i.e., ring road and nodes between ring roads, the path search is only related to the search of related nodes and their adjacent ring road nodes, nodes between ring roads, but not all network nodes. Assume there is n nodes for a set of road network, k ring roads, then the network nodes can be divided into k-1 (n/k) node groups and the ring roads with a number of negligible nodes. When the node is in the red location, the traditional Dijkstra algorithm needs to calculate all the nodes within the rectangle, while the new algorithm only needs to calculate the nodes on ring roads and shadow region as shown in Figure 12.

Assume m nodes on the ring road, then the rough calculation amount of this algorithm in the worst-case is $O(m+n/4k)^2$. The value of m can be ignored in the large-scale network, then $O(n/4k)^2$ is about $1/(16k^2)$ of the traditional Dijkstra algorithm time complexity, and the real results are much smaller than this one.

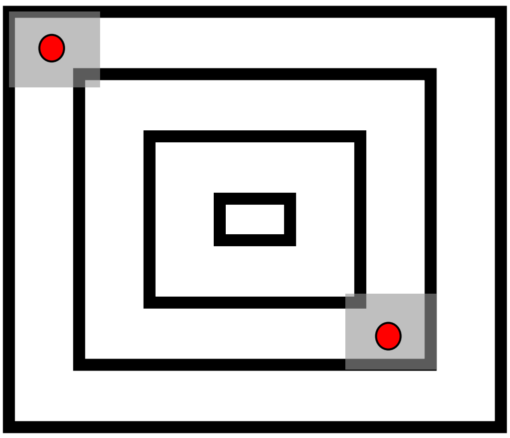

Figure 12. Ring road priority algorithms and the search region

This algorithm significantly reduces the number of unnecessary calculation and comparison, and optimizes the time complexity. The results were compared as shown in Table 3.

Table 3. The comparison of computing time

Accumulate tests: 1,000,000	Dijkstra algorithm	Our algorithm	proportion
computing time	92s	8.4s	11:1
calculation amount	25.3×10^9	2.87×10^9	9:1

Note: The calculation amount here is the number of the procedures implementing the basic operation, as the time cost of basic computing operating is not exactly the same, the computing time do not directly proportional to the computing amount.

(2) The comparison of mileage

The mileages comparison between the Dijkstra algorithm and the algorithm used in this study through experiment is shown in Figure 13.

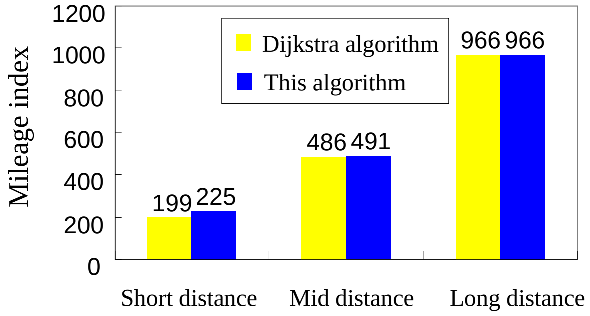

Figure 13. The comparison of the average mileage

(Note: Due to the particularity of the ring road road, the research group set relatively light weight on the ring road, and the vehicle often tends to travel on the ring road in the long-distance travel, which coincides with our usual habits.)

Figure 13 showed that this algorithm induced to go extra distance of 13.1% in the short-distance path guidance compared with Dijkstra, and the extra distance decreased to 1.3% in the middle-distance guidance, while there is almost no different in the long-distance guidance.

(3) The reduce of the road complexity

The high driving complexity of route is notable especially for routes induced by the traditional Dijkstra algorithm and some current optimum algorithm. Driving in a large road network, even experienced travelers may feel awkward when facing the complex driving directions provided by on-board vehicle navigation systems. Hierarchical algorithm can ease this problem to a certain extent, but the effects are not obvious.

The turn number was used to indirectly represent the complexity of the algorithm road in the test, and the use of the ring road priority mode can greatly decrease traffic crossroads, traffic lights during the driving and reduce the road complexity during the path induction, which is worth compared with the cost of a small amount of extra mileage.

(4) The actual choice

From the talks with taxi drivers, the research group found that the existing GPS guidance system was not widely accepted, mainly because it only can guide the geometric shortest path according to the original map information, in fact the shortest path often very congested. On the other hand, on-board radio traffic broadcast also has its drawbacks, since the information is from the surveillance camera, via the announcer, therefore the road situation information can not be quantified, neither be visualized.

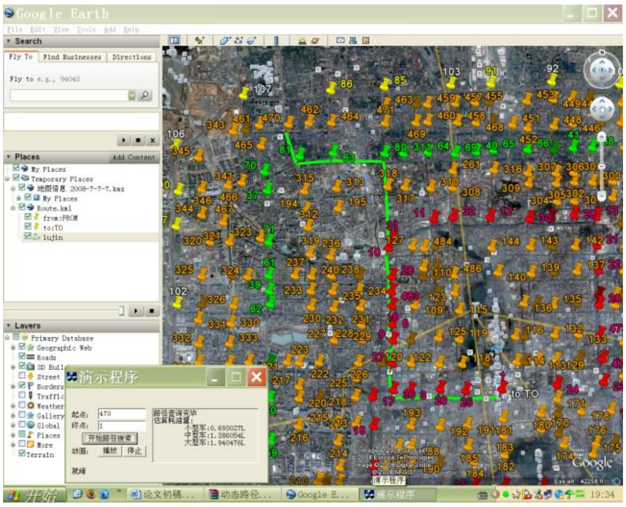

Figure 14. Path display “Suzhou Bridge- Tian’anmen square”

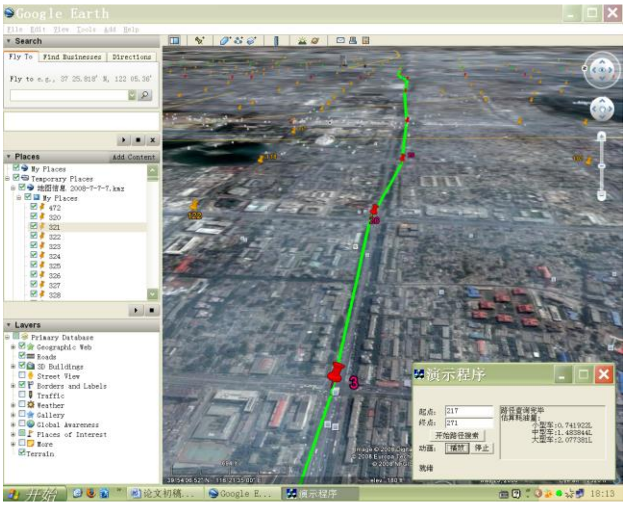

Figure 15 The snapshot of path display “Fuxing Road-Guomao Bridge”

4.2 The display of the interface information

Innovative designs of the interface result are as the following.

(1) The design of Graphical User Interface

Road traffic dynamic display system was called the demonstration program, which was built on the MFC framework based on the single document. The initial designs include the toolbar, form and the connect settings with Google Earth [9].

Menu bar mainly designed the start, path search, play, pause and withdraw functions, and they were associate with function OnStart, OnDisplay, OnDynamic, OnStop, OnExit respectively.

(2) The evaluation of fuel consumption

In the test program, the algorithm can more accurately gain and display the trip fuel consumption data by using dynamic traffic information and our own designed fuel consumption function.

Table 4. The function of fuel consumption - average speed

Fuel consumption per km	<40km/h	40~80km/h	>80km/h
Small cars	0.04	0.05	0.06
Middle cars	0.09	0.1	0.11
Large cars	0.13	0.14	0.15

Firstly, choose the model of vehicle, and then input the *start* and the *destination*, the calculated path S can be gained through the procedure. With the section length D_i and the average vehicle speed V_i of the result path into table 4, the average fuel consumption per km C_i is estimated and the total fuel consumption is $\sum D_i/C$.

(3) The play function of the path

In this study, we adopted not only Google Earth map information database, but also the broadcast function carried by Google Earth. Three-dimensional player and angle adjustable function for the calculated path is also added, which make the path guidance more visual and humanized acceptable .

5. Conclusions and prospects

The team work included five parts, they are the graph theory road network model establishment, the evaluation function discussion, the dynamic route guidance algorithm design, the application program compile and the algorithm performance test. According to the graph theory road network model, which was established based on the connection of 500 crossroads and 3000 streets within the Fourth ring road of Beijing; an evaluation function comprehensively considered the traffic flow was proposed through plenty of analysis and calculation. The dynamic route computation algorithm designed, the focus of the study, achieved a low time complexity, which is based on the traditional Dijkstra algorithm and the conception of ring road priority principle; the testing program of the algorithm was written in C++ language and connected with the Google Earth map information platform. The performance such as time complexity of the algorithm, the route driving complexity and extra mileage was simulated with the computer. Research findings and innovative points are as follows:

(1) In order to adapt the travelers' habits, a new dynamic route guidance algorithm was designed based on the traditional Dijkstra algorithm and a ring road priority principle was proposed. With its timed route re-calculation, such algorithm can deal with the dynamic route guidance without getting into troubles such as local optimum and non-convergence search.

(2) The algorithm optimized the path search results at a little cost of extra mileage, and the time complexity is about $1/(16k^2)$ (k is the number of ring road in the network) of the traditional Dijkstra algorithm. At the same time, with a humanized and practical feature, induced route significantly reduces road twists and turns, which is suitable for travelers driving by their own in city's large-scale road network.

(3) This algorithm adopted the new proposed traffic flow model $\sigma= V_f/[k\times(t+m^{(\rho-\rho0)})]$ as evaluation function, which combined parameters such as the probability of traffic congestions and dynamic traffic information with road's weighted graph model. This evaluation function can better characterize the traffic flow on roads, and can simulate the occurrence of some of the potential blockage, such as "ghost-jams".

The study has not been finished and the group is still working on the algorithm optimization to reduce the extra mileage and predict the traffic flow more precisely. Next, in order to test and improve the practical application of algorithms, the research group will negotiate with the Traffic Management Bureau for real-time traffic database.

References

[1] http://finance.ce.cn/macro/gdxw/200710/07/t20071007_12654737.shtml, 2007.10.

[2] Jagadeesh George, Srikanthan T, Route Computation in Large Road Networks: A Hierarchical Approach, IET Intelligent Transport Systems, 02-Mar-2008.

[3] Jing Ling, Huang Yuexi. The Structure Study on Dynamic Route Guidance Systems and the Shortest Route Choice Algorithm. Chongqing university Master's degree paper, 2002.05. (Chinese)

[4] Zou Liang, Xu Jianmin, Zhu Xiangling. Application of A* Algorithm in Dynamic Route Guidance System Based on Electronic Map. Journal of Wuhan University of Technology (Transportation Science & Engineering), 2006, 30(5): 885-888.

[5] Yang Zhaosheng, Chu Lianyu. Study on the Development of the Dynamic Route Guidance Systems (DRGS), Journal of Highway and Transportation Research and Development, 2000, 17(1): 34-38.

[6] Fu Chuan-Ji, Wang Bing-Hong, Yin Chuan-Yang, Gao Kun. Intelligent decision-making in a two-route traffic flow model. Acta Physica Sinica, 2006, 55(8): 4032-4038.

[7] http://scitech.people.com.cn/GB/7064372.html, 2008.03.

[8] Akihiro Nakayama, Katsuya Hasebe, Yuki Sugiyama. Instability of pedestrian flow in 2D optimal velocity model with attractive interaction. Computer Physics Communications, 2007, 177(1-2): 162-163.

[9] Jiang Kuan. The development of Google API: Google Maps and Google Earth. Publishing House of Electronics Industry, 2008.01.

[10] Huang Jiayan. Google Earth based Beijing’s traffic situation dynamic display system. Tsinghua university bachelor’s degree paper. 2008.06.

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