

# Research And Implementation Of Sound Vehicle Navigation System Based On Real-Time Traffic Restriction And Embedded System

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**Abstract.** this paper presents an automatic vehicle navigation systems based on GPS, GIS and embedded system. Many functions be implemented in this system; including the rapid map engine in the embedded condition, intelligent route layout in real-time traffic restriction condition, map matching and sound leading. The system implement and the technique nodus are discussed in this paper in detail. The test result of system in some province and city shows it running well and having good performance.

**Key words:** Embedded system; Vehicle navigation systems; GPS; Real-time traffic restriction

## 0 Introduction

Along with fast development and applied universalities of technique of GPS and embedded system, Vehicle navigation systems which based on GPS, GIS and embedded system have become the important direction of the development of GIS .At present, the market demand for Vehicle navigation products has already appear, and the potential demand for market is huge. At the same time because of the rise of intelligence transportation system, Vehicle navigation systems as a pivotal part of this industry must have the vast development space.

Using the embedded system to carry out Vehicle navigation has the obvious advantage: 1)The product volume is smaller than the past navigation product, easy to take, install and dismantle; 2) Support the touch screen, operate more convenient for user; 3) Can combine more additional functions, such as: The car carries the television, car to carry the DVD, network of wireless etc..

Researches abroad on navigation was initiated earlier, compared with domestic, related products has almost functioned, but by far, there isn't real applied navigation products. Former questions which baffled the development of domestic

navigation products, such as data source, product demands in market and combination of technology has been solved.

Exploration was once done about car navigation technology based on Embedded System, but no practical product was formed in that limits from hardware condition, such as slow CPU velocity of Embedded System and inadequate display brightness, and old arithmetic research can't meet demands of practical applications. In addition, research on navigation under real-time traffic condition is almost blank.

The essay introduced a kind of vehicle-loaded self-navigation system with supports of satellites, which can do route layout and lead according real-time traffic states. The system synthesizes and utilizes technology of satellite communication and location, as well geography information system, solves well questions above, can meet demands of application, and has formed products.

## 1 The system constitutes and the function

The system structure diagram is shown as figure 1. The system hardware constitute: 1)The vehicle-loaded based on the WinCE.NET ;( take the function of TV); 2)The GPS receiver; 3)Satellite communication module; 4)accessories ( including the bracket, power cable...etc.).

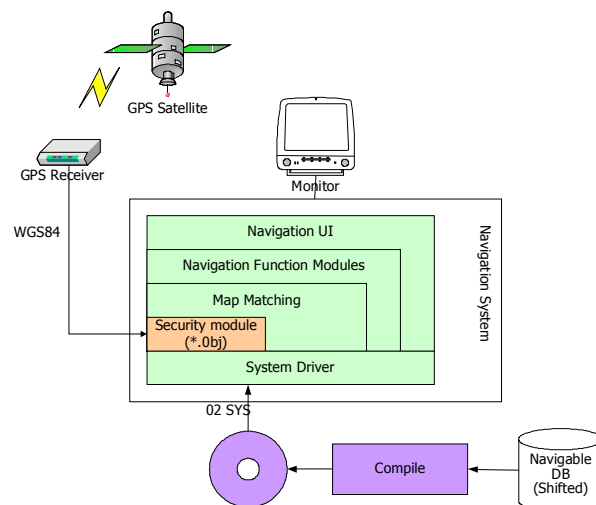


Fig.1 The system structure diagram

The system software is made up of eight parts: satellite communication and dealing module, GPS receiving and dealing module, maps engine, intelligent pathway programming module, voice lead module, communication demand module, system setting, affix function.

- 1) Satellite communication and dealing module: receive the real time traffic conditions data from control center, and deal with them according to the current district which the vehicle stays in, and so as to supporting dynamic pathway layout;
- 2) GPS receiving and dealing module: receiving and resolving GPS signal, displaying satellite calendar and state, automobile running direction, automobile site and so on;
- 3) Map engine: zoom out, zoom in, ramble, map auto-switch and refurbish and so on;
- 4) Path layout module: To plan path according current position, destination position and traffic restricted condition; re-plan path after departing from former path.

- 5) Voice lead module: based on path, which has been layout, according to the current site of automobile to clue on the voice and lead the user arrives the destination;
- 6) Communication inquire module: for the convenience of enactment destination, it is provide address inquire; the interest spot inquire; the path name inquire; the establishment around inquire, and so on;
- 7) System setting: including the shortcut setting, voice setting, mark of auto setting, map display setting and GPS setting;
- 8) Accessional function: including network, MP3 player, game, vehicle-loaded TV (DVD) and so on..

## **2 key technology analysis and implement**

### **2.1 Satellite communication**

Satellite communication using earth synchronous satellite as relay, realizes intercommunication between receiving stations. Transmitting paraboloid set on receiving stations aims at synchronous satellite in upper air orbits, and antenna of satellite receive ground signal, meantime send signal with transmitter. Navigation system can obtain real-time traffic information, using satellite communication technology to transfer real-time traffic states, and offer traffic restrict condition for route layout, and make better route layout.

Satellite communication in this system adopts broadcasting communication mode. Control center receive traffic information and do some processing with it, such as classification and encode, finally send it with satellite. Receiver set on navigation equipment terminal receive satellite signal. Because communication use non-respond mode and information can't be re-sent, we must assure that there is no data frame lost, so the system real-time monitor receive port with single thread, and process it meantime. The process is described as follow.

- 1) Check port buffer real-timely and send data to temporary storage queue as soon as it found data in buffer, then empty buffer meantime;
- 2) After it receives a data frame, verifying data to ensure data is received correctly, if defeated, thinking the data is not reliable, and cleaning it up from queue.
- 3) Resolving data after assure correct incept, including city coding of data received, map number, road name, road ID, traffic jam grade and direction (double-direction road).
- 4) Sending resolved data to traffic information storage units, for use of route layout and lead.

### **2.2 Map Engine**

Map engine is one of key technology of navigation system. The display speed of map affect whether the whole system can be applied into practice directly. Because of the limitation of ability of CPU management and small memory in the embedded product, and map engine must suit for the demand of real-time map renovate in the embedded system, so the demand of map engine in embedded system is much higher than in the general.

As the core of map engine, data structure determines the speed of map engine. Because the speed of CPU management is slow and the memory is small, the next principles must be complied during the design of structure: 1) when cut the map, data amount should not be too big, we must find a balance point between times of read data and data amount, to determine the data amount loaded every time. 2) layer structure is used to organize and store data to reduce redundancy.

### 2.2.1 map engine math model analysis

When static data be load to memory, it is supposed that some variables are defined as follows: the physics storage quantity engrossed by some space datum storage by vector is  $D$ ; the speed that datum read to memory is  $V_1$ ; the display speed is  $V_2$ ; the prepare time for datum read define is  $f(n)$ ; the waiting time the user can be accept is  $T$ ; the memory size of embedded system is  $M$ ; the number of blocks need to read is  $n$ ; the size of one block is  $D_i$ ; the time of datum loading is  $l(n)$ , then:

$$f(n) = n \times T_2 \quad l(n) = \sum_{i=1}^n (D_i \times \frac{1}{V_1})$$

$$D \frac{1}{V_2} + f(n) + l(n) \leq T \quad (D < M)$$

It is suppose that define  $V_1, V_2, T_2, T$  as constant, because of the prepare time for datum reading in direct proportion to the blocks of datum, so the more of blocks, the more prepare time to definite datum. But due to the display screen of embedded equipment is smaller, few partition will result in more unnecessary display redundant datum and more read time, so the size of block should be divide according the actual size of display screen and scale.

It must decrease  $D$  to satisfy the demand of datum display and dealing on the condition of definite memory and fixed prepare time for datum read. Because the graphics datum to display is only the part of read datum  $D$ , so, proper decrease the datum of need not display, which is not affect the display of graphics datum. The paper adopts a method of dynamic vector datum cut down to satisfy the demand of speediness display, which cut down the graphics datum of out display bound.

### 2.2. 2 The Delaminating and Classification of Vector Map Object Data

Because of the display screen of embedded system is small, during map zooming, if we display according to fixed factor, not only the speed is slow, and because of the too big load amount, the map data can't be read, so we must accept or reject and classification according to different scale to space data, organizing and displaying data according layer model. The level of data is more high if the scale is more smaller, the space data become more particular if the scale is more bigger.

During reading the space data, read a data layer with a small scale and display the general picture, when user select the interested region, in the foundation of vector data, read the vector information not included according to the level of display, to display more particular information of the region which had been selected by user, this process can be taken granted for process of small scale map additional information to get the big scale map object. To Palmed computer the data read is the added of the fore data every time, to avoid read redundant data repeated.

## **2.3 Map mapping**

### **2.3.1 Orientation Error of Navigation and Map Matching**

Orientation error of navigation is resulted from two aspects: GPS error and map data one. Generally if SA technology is used, GPS error is 100m; if not, is 20-30m. Due to the restrict of cost, navigation system can not implement high precision orientation because system can not realize real time difference to received data, and if data is not processed, the navigation can not realize. However, map data error mainly rooted in data collection error, when quality of data is high, in the same time, in case of auto is always running on the road, we think that data is reliable. Map mapping is based upon this hypothesis, in the base of map data; the received GPS data is rectified and data meet navigation demand.

### **2.3.2 Map Matching Based on Topological Restrict**

Map matching is commonly in the condition of space location and is mapped looking for the nearest road to GPS orientation point. In the course of auto running, different meanings occur when position of GPS orientation is nearer to crossing, and correct leading can not realize. The writer make use of running direction and topological restrict, so the correctness of matching is higher, the speed is also higher and the demand of real time matching and guiding are well satisfied. Actualizing processes as follows:

- 1) Obtaining original position and running direction of auto;
- 2) Searching some nearest roads to auto position;
- 3) According to running direction of auto, calculating some latest direction and affirming the road of auto in term of the latest distance and direction;
- 4) In the light of topological relation, looking for the connected roads to this road, and as the matching interrelated road, forming matching subset with this road;
- 5) On the assumption that auto running is continuous, and GPS signal is continuous incepted and not satiate, so next receipted position is located on this road or interrelated ones. In according to angle and position in this subset, matching is carried through and if matching is invalidate, GPS data is of no effect.

## **2.4 Intellectual route layout**

Optimal route layout means that to find a shorting route (or least time and cost) in road topology network, after told start and end point.

### **2.4.1 Dijkstra algorithm**

The Dijkstra map searching method is in mostly common used at present. The most conventional map searching methods are the depth searching method and the extent searching method. The approach of the depth searching method is extending the original node to the next level node in sequence, and extending the last formed node every time, lengthways developing grade by grade. The approach of the extent searching method is extending the original level

nodes to the next level son nodes in order, every time extending from the front node of the level nodes, repeating the operation, as far as finding target node. Dijkstra algorithm is a classical extent searching method. The searching steps are:

- 1) Build the temporary nodes set (TNS) and the permanent nodes set (PNS) for storing the middle node;
- 2) Specify original node to current node;
- 3) Push current node to the permanent nodes set, extend the son nodes of current nodes, and put the son nodes to temporary nodes set in the order from small to big distance between the node with the start point.
- 4) Pop the first one of the temporary nodes set, and specifies it to current node;
- 5) Repeat 3)- 4), until find the end node.

In above algorithm, the distance of two nodes means the distance of the path that connects the two nodes.

#### **2.4.2 Improved Dijkstra algorithm**

We improved the computing process of Dijkstra algorithm as follows:

- 1) Every created node is sorted by the distance of the nodes in TNS and PNS.
- 2) If a new extended node is found already in TNS, compare the new distance value of the node with the old one. If the new value is smaller than the exist one, the new one replace the old one. Otherwise the old value is remained;
- 3) If a new extended node has a same node number with one of PNS, the new distance value is certainly bigger than the old value. Then skip the new node.

The proposal improvements increase the computing speed of the algorithm and the efficiency of the path layout.

#### **2.4.3 Route layout in real-time traffic Restriction**

Route layout in real-time traffic Restriction can be more to fit real demand. The process of calculate as following:

- 1) Save the route information into restriction buffer.
- 2) Give the different weight value with the different traffic class.
- 3) Search the paths to destination that the car has not been passed currently and judge whether traffic jam according to its weight value, if yes, then to choose a new route.
- 4) When calculating new route, we can make the car's current site as start-point, and use a new method to calculate total weight value. The new method calculates the whole weight value by the road grade, the distance and the traffic jam status which used as one of the weight value.

5) The last step is to calculate new route used the improved Dijkstra arithmetic.

## 2.5 Voice lead

During the car run, voice lead can lead it drive according the appoint path. When it comes to the crossing, voice lead will remind driver to do relevant operation, such as “turn left”, “turn right”, “go straight”, and so on.

The process of voice navigation is taken as following:

- 1) Based on results of route layout, homonymous ways are incorporated to one.
- 2) Calculate inflexion coordinates of two paths border upon. According to direction of two ways calculate the state of the inflexion, then, get the inflexion sequence and relevant turning sequence.
- 3) Receiving and divide the GPS data and present position;
- 4) According to the present position and steer direction, judge whether the car is in the route which has designed. If not, voice lead will give proper alarm.
- 5) If current way is in the other route layout, calculate the distance from current position to next inflexion. At the same time, according to foregoing calculated value we judge whether voice indication should be given.
- 6) Before get to destination, repeat the steps from 3) to 5);
- 7) When the vehicle approach to the destination, the voice lead will give cue.

## 3 The End

In this paper, the embedded sound vehicle navigation system based on real-time traffic restriction was discussed deeply. Then some pivotal techniques and ameliorations about these techniques were introduced detailed. Based on these techniques, we manufactured a kind of navigation product.

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**Biography:**

Liu AiLong was born in 1973 and graduated as Bachelor of Engineering from Wu Han Technology University of Surveying and Mapping in 1996. He is currently for Master degree in Cartography and Geographic Information System in The PLA University of Information Science and Technology. His research interesting includes Geographic Information System (GIS), Vehicle Navigation, Embedded Information System.