

EMBEDDED GIS IN INTELLIGENT NAVIGATION SYSTEM

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ABSTRACT

Embedded GIS in Intelligent Navigation System is a special information system. This paper puts forward several basic principles and constraints during design for Embedded GIS at first, and then analyzes the feature of embedded platform and the function of Intelligent Navigation System, and presents a realization scheme of Embedded GIS.

KEY WORDS

GIS, Embedded System, The Spatial Concept Model, WINDOWSCE

INTRODUCTION

In the research and the implementation of Intelligent Land-Vehicle Navigation System, the digital map database is an important and basic part, and restricts the development of the navigation system all the while. As the development of the embedded hardware and software, the study of Intelligent Land-Vehicle Navigation System comes into a new stage, while new feature of digital map database is needed. The general GIS Platform such as MapInfo and ARC/INFO does not fit to new request any more, because they are huge, low efficient and incompatible with embedded operating system. Therefore, the research of the embedded GIS is very necessary.

FUNCTIONS AND MATHEMATIC MODELS OF GIS

GIS applied in vehicle navigation system can realize these main functions:

1. Display map.
2. Confirm some address or destination by street address and nearby crossing.
3. Calculate routing.
4. Let driver go along the route that has been calculated.
5. Matching route checked by sensor and known route net so that we can know more exact vehicle position.

6. Supplying tour information such as tour manual, signpost, hotel and restaurant.

As an information system, GIS uses binary digit as memory to realize reality. It process information from the reality, and stores them in computer. We hope not only GIS can supply plenty information, but also choice certain data that we require. But because of complexity of the reality, we must find some way to store data that can meet the demand. To realize, we must understand and express the impersonality world well. So data structure in GIS has an important role. Therefore, the first thing we do is to set up data structure that translates the reality to binary digit.

The Spatial Concept model is the spirit of GIS. The two typical data structure is topological relation data model (figure.1) and OO (orient-object) data model (figure.2).

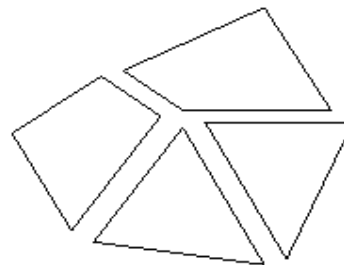
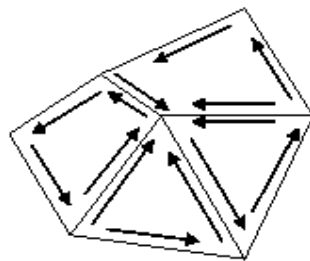


Fig.1 Topological Relation Data Model Fig.2 Orient-object Data Model

Topological relation data model is based on topology to organize and store geometry factors. It uses topology connection as center that is made up of dots, liners, sides, and their coordinate store is interdependent. The main advantages in this model are close data structures, clear topology .The topology stored in system before can improve the system efficiency in querying topology and analyzing net. But it still doesn't have high efficiency in managing single geography, and can't express complex geography, especially realizing quick querying and analyzing complex space. Moreover the system has difficulty in maintenance and expansion.

OO data model describing geographical space organizes by independent, integrate and geographical objects. In the implementation of the organization and storage, coordinate and attribute data can be stored in two ways. One is separately stored in the different file system and relation database; while the other is integrate to store in the relation database. OO data model can overcome the disadvantages of the topological relation data model. The advantages for OO data model can easily implement object managing, modification, query and easy for space analysis. The more important is that it can easily construct any complex geographical object as needed. OO data model is satisfied the experience for people recognizing the real world. In addition, OO data model is easy to maintain and expand for the future.

But it has a few shortcomings: topology structure requiring temporary building, receding efficiency of analyzing net; redundancy store of entities' commonality dots and liners; difficulties in managing, analyzing and positioning the geometry factor; topology requiring and analyzing between charts.

THE RESEARCH OF EMBEDDED GIS

The characteristic of Embedded GIS depends on the characteristic of the Embedded hardware and Embedded software.

The characteristics of Embedded system are as follows:

1. Embedded system applies Embedded CPU for special purpose. Most of the Embedded CPU is a compact, efficient, 32-bit RISC chip, which miniaturizes the Embedded design and reduces power consumption.
2. Embedded system is integrated by computer, semiconductor, electron technology and specific application.
3. Embedded system must be designed efficiently, in order to achieves the highest performance in the resource-restrained devices.
4. Embedded software stored in ROM and run in SDRAM to improve system performance.
5. Embedded operating system, such as WINDOWS CE and Embedded LINUX, is a microkernel, high real-time, resource-restrained, and full preemptive operating system.

Therefore, the Embedded GIS should save memory capacity as possible as it can, meeting the request of the navigation system. It should reduce the redundancy of data and accelerate the inquiry of data, also facilitate the maintenance of database.

THE IMPLEMENTATION OF EMBEDDED GIS

As described in last section, the two Spatial Concept model does not fit to request of the new GIS. So we must design a new Spatial Concept model. A new composite orient-object data model is as follows.

A layered vector graph structure is used in data model. Compared with grid graph structures, the vector graph structure can save a lot of memory capacity and reduce the time of require. In vector map, the operation of map objects become easy and the inherency relation of real geographical objects can be well reflected, because the connotative relation of map objects can be included in vector graph structure. The reason for using layer map is conveniently deal with the various geographical objects. There is a basic principle that different map object belong to different layer in layer map. When each map layer is display in an order, the whole map constructs as showed in

figure.3. In the process of geographical information, the different map objects in different layer can be inquired in higher speed.

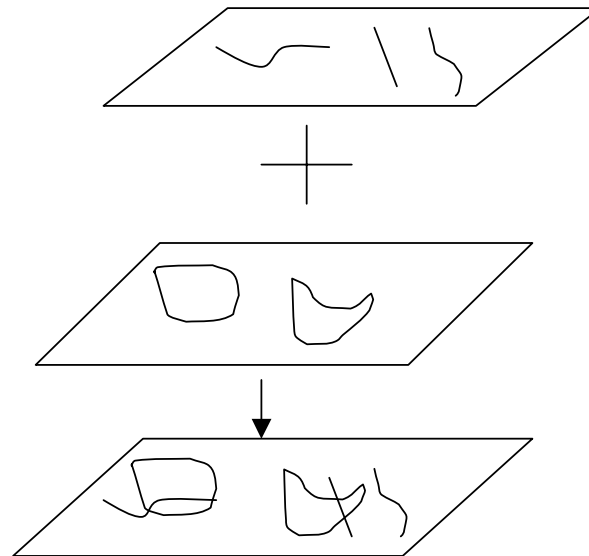


Fig.3 The relation between various layers

According to different object and different attribute of an object, we use different data model and coding mode. The principle is that topological relation data model is designed for the geographical attribute, while OO (orient-object) data model for other attributes. This model can meet the request of the embedded systems very well. The index mechanism and the applications module base on this model also satisfy the need of navigation systems.

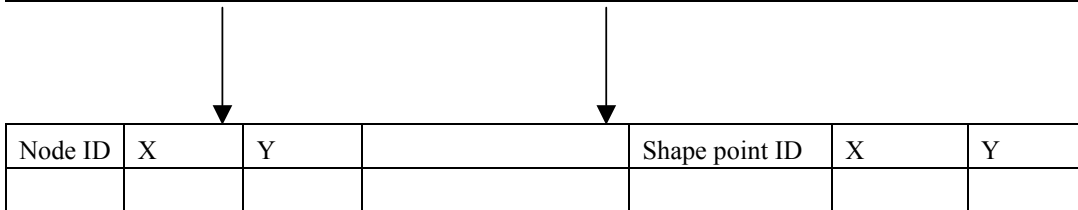
According to geometrical element, geographical objects are made up of five kinds of object: dot, line, region, label and complicated object. Complicated object derives from single object, including two types that are single complicated object and mixed complicated object. Many same single objects construct single-complicated object, and many different single objects construct mixed complicated object. Many objects integrated together are called object sets, so there are five object sets. Usage of object sets is for the convenience of data storage and data management. Map layer is different from the object sets; map layer is the object sets that has graphic attribute. The relation of map layer and object sets is as follow: object sets stores the spatial data and attribute data, but map layer controls the display style and display operate attribute about object sets; a map layer correspond to a object sets, but a object sets correspond to several map layer.

Different object types correspond to different tables. All of the object sets can be implemented as the table 1 showed. It should be pointed that organization and attribute field names in the space coordinate would be different for different types object sets.

Object ID	User ID	Space info	Relation	Attribute 1	Attribute n

Tab.1 Data structure of all kinds of objects

Road ID	Node start ID	Node end ID	Shape point start ID	Shape point end ID	Road name ID	Road drawing pen	Road style



Node information

Shape point information

Tab.2 Data structure of the road

Because the GIS are designed for vehicle navigation system, the manipulation for roads is especially important and special. One node represents one road or cross of the road or point of the road. Shape points represent the curve attribute of the road. Table structure for road storage is shown as table 2.

File and database mixture storage is preferred to, which means that space data store in the file system, while attribute data store in the object database. This technology can save storage space and improve query speed. Geographical data maintenance would be very convenient by this technology.

When data are stored in certain format, access approach is first important to be concerned. How to efficiently access data needs to be deeply designed and organized. Considered the embedded GIS features and multi-storage media, we implement two access approaches. One is space index and the other is object-oriented access. As for space data, because they are stored as files by certain format, which means they have fixable field structure, space index is applied. One object sets corresponds to one space index and the entire object sets in the database and the corresponding space indexes correspond one top-level table. We can query space data for different objects by these indexes. As to non-geographical attribute, we use object-oriented access approach. These attribute are single object oriented and can be access as the approach to access relation database. Figure 4 shows such approach.

Based on the data motel and index mechanism, we have finished the development of the whole system based on WINDOWS CE. Besides the GIS database, some applications modules based on the database have been realized that consist of the database information management module, geographical information inquiry module, the data processing and map matching module, the minimum cost paths search module and map display module.

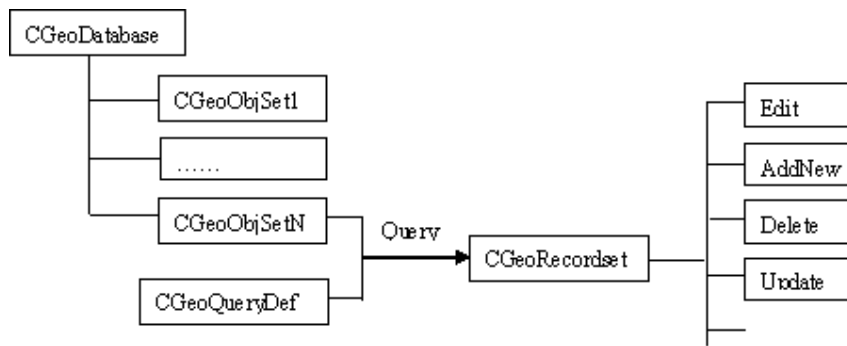


Fig.4 The data access of the GIS

The data processing and map matching module correct the errors of positioning system, and matching the position (or trajectory) measured by a positioning module to a position associated with a location (or route) on a map provided by the digital map. The best route is generated based on a best route selecting algorithm by the minimum cost paths search module, and the user will be guided along the route with the positioning data.

CONCLUSIONS

The kernel and fundamental part of navigation system is digital map database and geographical information system. A good organization of map data may improve the performance of the whole system, and a functional GIS ensure the proper work of the other modules.

By this time, we have completed the WINDOWS CE design of Embedded GIS based on the above scheme, and the LINUX product will be accomplished this year. The GIS on Windows CE is proved to be powerful, efficient, and reliable.

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