A ROAD NETWORK DATA MODEL AND ITS APPLICATION IN VEHICLE NAVIGATION SYSTEM

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ABSTRACT:

This paper presents a study on road network data model and its application in the vehicle navigation. Traffic network has many characteristic attributes, such as lane, cloverleaf junction and turn restrictions, which distinguish road network from general category of "directed graphs". The characteristic attributes are significant to many operations in the vehicle navigation system. However, traditional Geographical Information System (GIS) only describes the general network topology relationship, which can't satisfy the applied requirements in vehicle navigation system. So a road network data model is proposed in this paper, based on analysis of the characteristic attributes of traffic network.

1. INTRODUCTION

The development of the vehicle navigation system started to be researched in the early 90's last century in China. The progress of the research and development in the 10 years was gone slow, especially in the vehicle independence navigation. There is not one of molding products in the Chinese market. The key issue is the electronic map data in the vehicle navigation system. At a certain extent, the issue has counteracted the development of the industrial of vehicle independence navigation. For resolving the issue of the electronic map data in the vehicle navigation system, the research is offered hereinafter: the requirements to the electronic map data in the navigation system, the traffic road geographic information (such as level roads, city streets, main place name and water system) and dissertational information (such as gas stations, passageways of freeway, all kinds of the city road traffic restrictions) required of the vehicle navigation electronic map data in and between the cities in china, the updating of the vehicle navigation electronic map data.

The vehicle navigation system is an information system in substance, so it is necessary of the frame structure, organizing and management of electronic map data, because all powerful system functions must be run based on it. Unlike the organizing and management of electronic map data of the normal GIS, there is a key difficult issue hereinafter to be solved in the vehicle navigation system: Improving on the road network data model. There are many lanes, viaduct, cloverleaf junctions in the means of transportation of city. It is need of improving on the road network data modal to represent the topology relations of the road network, especially in viaduct and cloverleaf junctions(LI et al , 2000).

2. CONTENT OF MAP DATA IN SYSTEM

In the vehicle navigation system, road network is the most essential part of the electronic map data. It is also a must of the information of traffic sign, such as toll-gate, traffic lights, speed limit sign, swerving sign. For the civilian vehicle navigation system, electronic map data should include the information about travel, entertainment, commerce, shopping, education, medical treatment. The electronic map data may include some parts (WEI & ZHU,2000;CHEN et al,2000;CHANG,2000):

1) Base map, base information, including boundary (country, province, city, zone) , building, river, lake, farmland, greenbelt, mountain, rail way, bridge, and so on;
2) Road network information, all levels of road, including main-trunk road, hypo-trunk road, street, the topology between the roads;
3) Traffic sign information, including toll-gate, traffic lights, speed limit sign, swerving sign;
4) Enterprise and institution information, including assert, party and politics department, travel industry sites, education and culture institution, hotel, bank, hospital, marketplace, manufactory and company, entertainment place, and so on.

Road network information is the basic of the electronic map data. Most of functions in the vehicle navigation system is implemented based on it. So it is very important to design the road network information. The spatial information of road network is the data represented the spatial place of road section, including road section jumping-off point and road section end-point. The character information of road network is the data represented the character place of road section, including name, level, width, length, number of driveway, traffic, direction, turn Penalties, prihibitions, free of charge.

Field Name	Data Type	Illuminate
ID	Char	Key
Name	Char	
Level	Char	
Width	Float	
Length	Float	
Driveway	Integer	
Traffic	Long	
Direction	Logical	0/1
FreeOfCharge	Logical	0/1

Table 1. The Character Data Structure of Road Network

3. AN IMPROVING ROAD NETWORK DATA MODEL

The vehicle navigation system is based on the integration of geographic information system (GIS), global positioning system (GPS) and global system for mobile communication (GSM) technologies. One of the key issues for vehicle navigation is to find the optimal route for the driver before or during the travel. And the most important foundation to find the optimal route is the topology of the road network. So it is necessary to build a road network data model that has advantage to find optimal route.

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. Among other things, a GIS facilitates the modeling of spatial networks (e.g. road network), offering algorithms to query and analyze them(Derekenaris et al,2001). Spatial networks are modeled with graphs. In the case of road network, the graph's arcs correspond to street segments whereas the nodes correspond to street segment intersections. Each arc has a weight associated with it, representing the impedance (cost) of traversing it, in most cases, an arc's length and traffic volume.

However, traffic network has many characteristic attributes, such as lane, viaduct, intersection with turn restrictions and cloverleaf junction, which distinguish road network from general category of "directed graphs"(HAN et al,2001). The characteristic attributes are significant to many operations in the vehicle navigation system. But the spatial network topology in traditional GIS data only emphasizes the connections between nodes and arcs, which can't satisfy the applied requirements in vehicle navigation system. For example, the optimal route computing must consider the many characteristic attributes, which will change the topology of the road network. The lane will be only considered as a simple directed arc. The viaduct should be considered as two double directed arcs with the different impedance of traversing it. And it must also consider the all of the possible of the cloverleaf junction and intersection with turn restrictions.

(a) viaduct

(b) intersection with more than 4 nodes

(c) intersection with turn restrictions

(d) cloverleaf junction

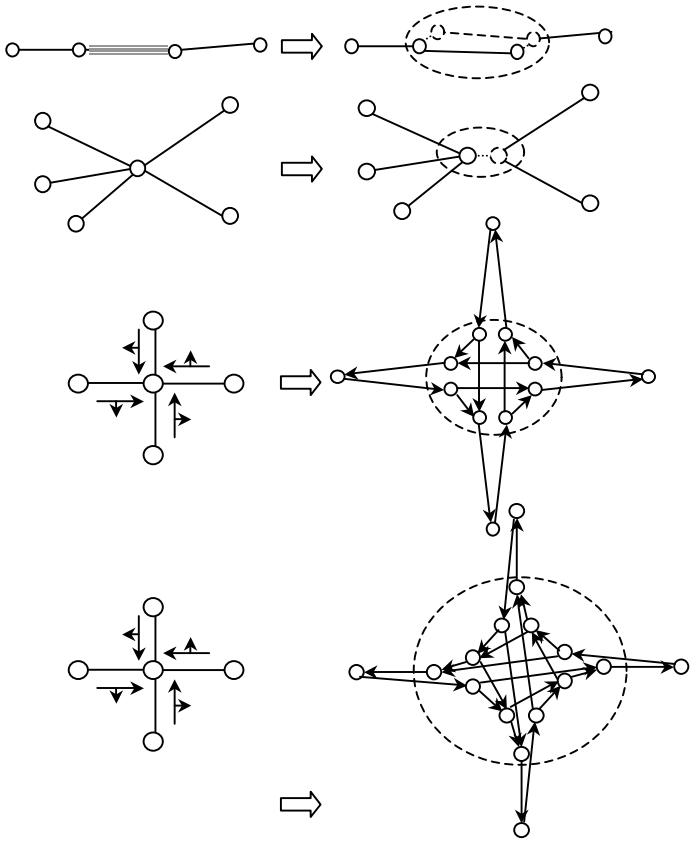

Figure 1. Methods of the new road network model

Having systematically analyzed the characteristic attributes of traffic network and their influence in vehicle navigation system, a integrated road network data model is proposed in this paper. The model represents the topology of the road network by quad-tree structure. In the model, a node only connects with four nodes. As the traffic network has many characteristic attributes, it is restructured by the special methods. The node represented the intersection with more than four branches splits into two adjoining nodes, which the distance between them are very small (Figure.2 b). Much more of the intersections in actual traffic network have only three or four branches, so that the process method can't bring too much redundancy data. The viaduct is considered as another road distinguishingly by splitting the nodes represented the two sides of it (Figure.2 a). And for cloverleaf junction and intersection of turn restrictions, a sub-map can be used to represent them, which has many dummy nodes connected each other and the dummy directed arcs between them that restructure a sub-network (Figure.2 c, d). They are not a simple node, but a sub-network, so that the original road network becomes a more complex network in the road network data model.

The topology of the new road network can be represented by many relation-table based on the quad-tree principle in the vehicle navigation system. Traditional optimal route computing is based on adjoining matrix. There is a large of data junk, because the adjoining matrix is the adjoining relationship between a node and all the other nodes. However, it can reduce data junk for using many adjoining tables with *N* rows and *M* columns to represent the topology of the road network. And DBMS is a advantageous tool for management of adjoining table. Moreover, many GIS platform soft offer the ODBC function, an interface between DBMS and it. So in the integrating vehicle navigation system, the road network data model can easily implement by building relation table. Two topologies should be built in the road network data model. One is the adjoining relationship between nodes, and the other is the relationship between nodes and arcs.

4. CONCLUSION

This paper introduces the content of electronic map data in the vehicle navigation system. The electronic map data includes basic map, road network, traffic sign and enterprise and institution. And then it presents a many-measure information frame structure to organize and manage the large vehicle navigation information. A new road network model is presented to improve the topology relationship of traffic network and the system function.

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Road ID	NumberOfNodes	Node n	Node ID	X	Y

Table 2. Arc-Node Relationship Table

Node ID	AdjointNode1 ID	AdjointNode2 ID	AdjointNode3 ID	AdjointNode4 ID

Table 3. Node-Node Relationship Table