A Road Traffic Management System for Dalian Based on GIS and WebGIS

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Abstract:

This papers aims to establish a road traffic management system for Dalian based on GIS and WebGIS technologies. First, based on the map of Dalian, digital road network database is constructed within GIS, and visualized database management programs are developed to realize a Graphic Use Interface (GUI) style query and maintenance of road and traffic information. Further, in order do network analysis in the database "shortest-path searching" module is developed whose core is Dijsktra shortest-path algorithm. Based on topology structure of road network and the traffic attributes of links, the module allows users to select nodes and display the shortest-path in GIS map window visually. Moreover, here Dynamic-Link Library (DLL) technique of Visual C++ is applied to accelerate Dijstra algorithm without hampering users' interfaces. Second, attributes and photo databases of traffic accidents are created, which records traffic accidents' information with the styles of GIS spatial data, generalized data and disc file data and supports access of several kinds of visits. Meantime, an integrated visualized management program is developed to realize queries and maintenances of various accident data. In this research database module integrates generalized and GIS databases, and combination of MapBasic and Visual Basic performs good effectiveness in dealing with spatial data and designing interfaces. Third, WebGIS is used as the platform for remote users and the mentioned models as severs' applications to display hypertext files and pictures to users through browsers. WebGIS utilizes both IIS package within Windows2000 operating system and MapXtreme to build the map system of online browsing.

Keywords：GIS, WebGIS, Database, Visualization, Shortest-path

1 INTRODUCTION

GIS is the crossing of multi-door discipline, such as computer science, geography, surveying and cartography, etc.. It is based on geographical spatial database, adopts the geographical model analytical method and offers many kinds of spatial and dynamic geographical information in good time. It's a computer technological system that serves for geographical research and geography decision.

The road and traffic data are the essential information of a city. The administrative department of road traffic usually regards them as the statistical data to save them in the format of tables. Because of the great volume and complex relations of data, it is very difficult to manage them systematically. Since the data of the format of the table are unable to express the spatial position, these materials seem very abstract for both

administrative staff and ordinary users. GIS technology offers the database structure of managing positions and attributes of objects visually. With GIS, administrative staff can save, query and search the data with attributes and can also carry out advanced analysis based on spatial analyses. For example, searching and expressing the shortest-path, showing road segments with given positions and attributes, showing road service level or traffic demand in traffic zones, locations and situations of accidents, road environmental loads. Commercial GIS software have not offered these special functions, interfaces of them cannot meet the actual demands. Therefore, based on MapInfo and MS-Access platforms we adopt many kinds of programming languages to develop a GIS system to manage the road and traffic information for Dalian City. In the system, visualized save, query, display, output and modification of various kinds of road and traffic data are realized and difficulty of too time cost in the shortest-path searching algorithm is overcome.

2 THE SOFTWARE ENVIRONMENT

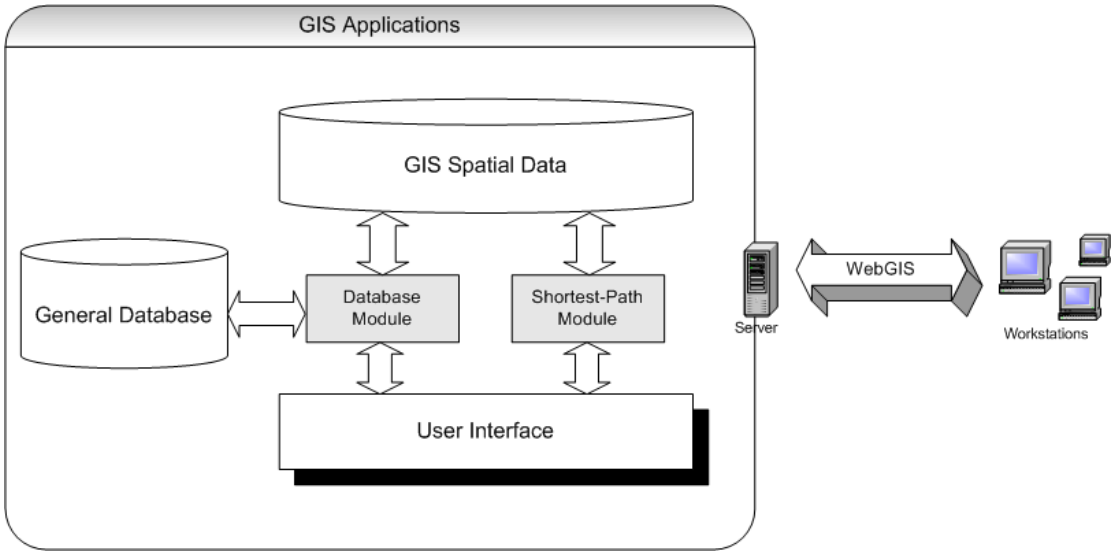
Among several GIS systems, MapInfo is commonly used. Factors such as lower hardware requirements, easy to learn and master, high quality and low cost make MapInfo become a popular system. Based on MapInfo operating platform, we develops our system, where MapBasic is used to realize some simple and complicated secondary development. Similar to Basic, MapBasic is a simple computer language; it has powerful graphics operating functions and is easy to use. However, it is not convenient to develop interfaces and debug with it. Visual Basic is a visualized computer language and can be used with friendly interface. Using these two languages to develop visual procedure on GIS is the characteristic of our development. Moreover, because of its high operational efficiency Visual C++ becomes first-selected tool of numerous systems. Here Dynamic-Link Library (DLL) technique of Visual C++ is applied to speed up Shortest-path-searching module. In addition, MapXtreme is adopted to build WebGIS platform to make remote users be able to access the system through Internet browser.

3 THE ENTIRE FRAMEWORK

Our system consists of three modules, namely “Database Module”, “Shortest Path Searching Module” and “WebGIS Module” (Fig. 1). The “Shortest Path Searching Model” and “Database Module” are the basic modules of the road and traffic management system. They interact with user through user interface; user can use the two modules to carry out complicated calculations and queries. Further, after putting them server through WebGIS module, remote users can visit the GIS application through Internet.

In the development of the Database module, MapBasic has been used to realize the access to the MapInfo data and build simple menu and button in MapInfo. Further VB offered interfaces are connected to MapInfo platform through OLE, then users can query

and maintain the database built both by Access and MapInfo through standard database interfaces. Our system contains two types of traffic data. One is information on road intersections and segments, which re stored in MapInfo tables. The other is traffic accident information, attributes of them are stored in Access Tables and pictures of them are put in Hard Disc as files format.



4 THE DATABASE MODULE

4.1 Intersections and Road Segments Database

Intersections and road segments information are represented as points and polylines in GIS. We digitized them based on 1/10000 map of Dalian, and added corresponding names, widths, traffic volumes, approach numbers to intersections and road segments. User can carry out logic operation to query the attributes; them can even use the advanced query button to edit terms of querying. The queried object will display on MapInfo map and the corresponding attributes will display on VB interfaces (Fig.2).

4.2 Traffic Accident Database

Traffic accidents data such as statement and pictures are often stored in straight sheet style; it is difficult for user to carry out management, maintenance and query. Therefore, management, query and analysis of traffic accidents data will be more convenience and efficiency if we combine them with road traffic database in GIS. We also applied OLE method to connect VB programs with MapInfo platform in traffic

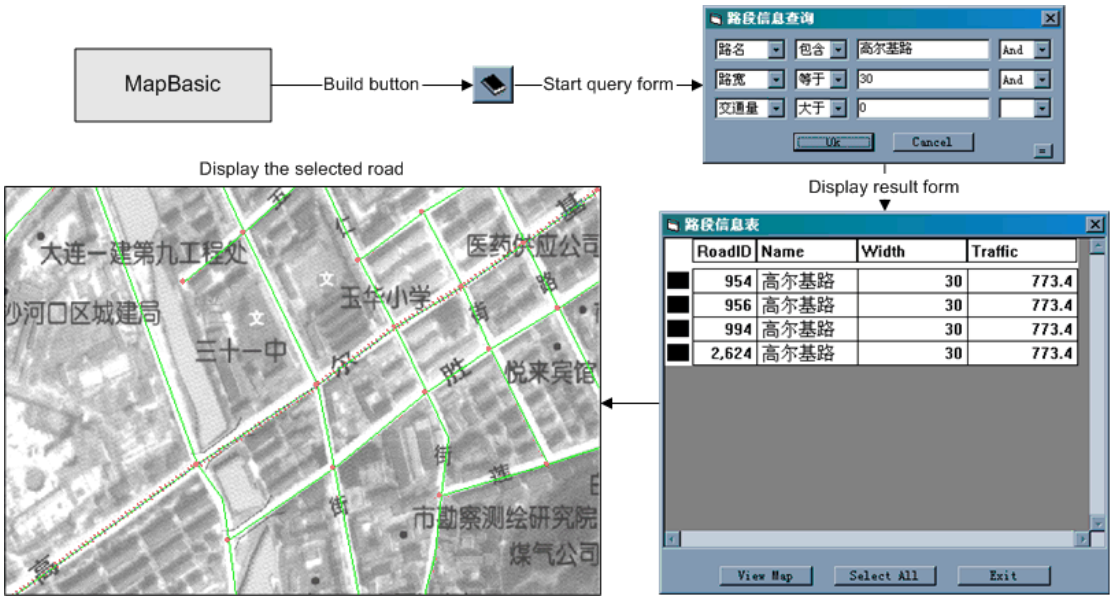


Fig. 2. The interface of road crossing and section information database

accident information management system. MapBasic programs run behind MapInfo are responsible for analyzing graphic object and attributes, while VB programs are responsible to connect, display and manage the outside database and offer photo showing and management functions. Then a visualized button click-query can be realized. We also offer Administrator function to give administrator more power operation rights. (Fig. 3)

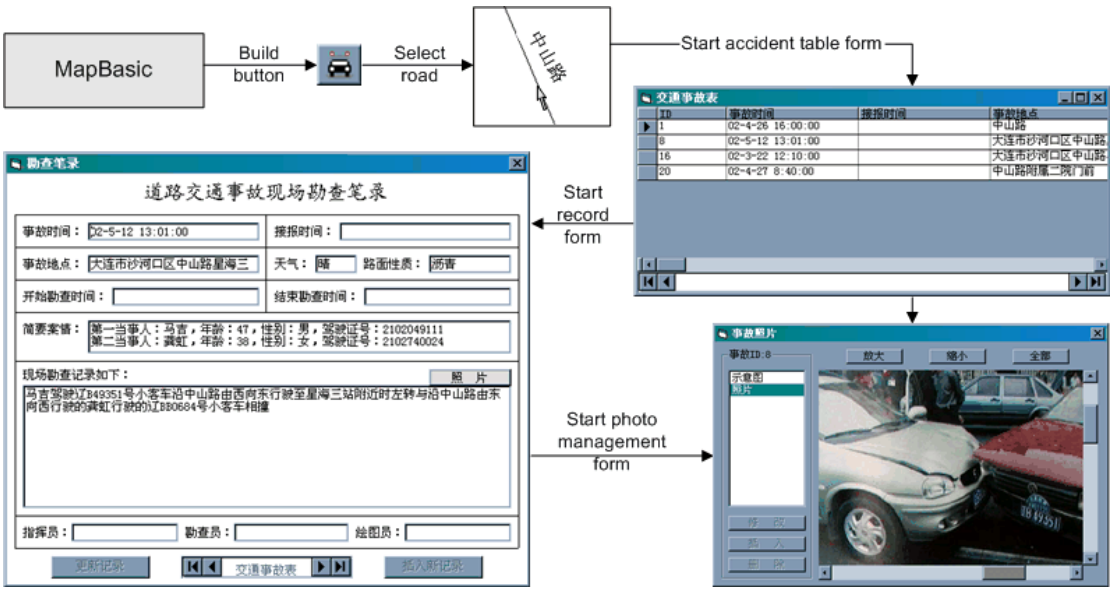
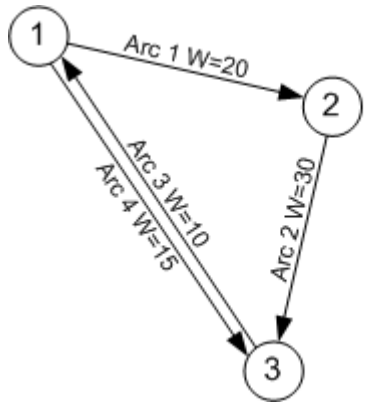


Fig. 3. The interface of traffic accident database

5 THE SHORTEST-PATH MODULE

5.1 The Topological Structure and Algorithm

Manual digitized road network in GIS has no topological structure, self-developed MapBasic programs realized the topological analysis to form physical road network. In order to save memory space and speed up shortest path searching algorithm we represent network with the Arc Section principle in which each Arc Section is marked with the origin and destination node IDs. (Fig.4)



Arc	Origin	Destination	Weight
1	1	2	20
2	2	3	30
3	3	1	10
4	1	3	15

Fig. 4. The memory structure of topological structure

We visualized Dijkstra algorithm for shortest path searching in GIS in shortest path searching module. 5.2 The improvement to the classical algorithm. In order to solve the difficulty of searching the path in a short time, our system adopt the method of indexed array that arrange arcs by their origin node ID to produce the scan range and a sorted chain table is created to sort all of the unmarked nodes by their shortest-path length. Thus the right node in every circle can be found directly.

Since MapBasic is a fake compiling language and SQL is very slow in MapInfo, our system stores all the arc information in array instead of the table in MapInfo, and then adopts array operation instead of SQL in shortest path searching module. Dynamic-Link Library (DLL) technique of Visual C++ is used to sort chain table, that is the most complicated operation in algorithm. Since Visual C++ operate very fast, MapBasic invoke the Dynamic-Link Library can get decuple and more speed. Through the above improvement; our shortest path searching module realize a immediate calculation and display of the shortest path between any two nodes; the speed is 10,000 times faster than before. (Fi.5)

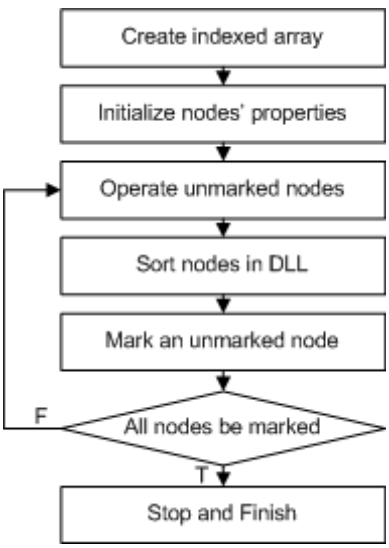


Fig. 5. Improved Dijkstra Algorithm

5.3 Visualization and other Options

The shortest path-searching module offers the visualization function, users can select Start and End node visually and get the shortest-path in MapInfo window (Fig.6). User can also use the “Find” button for accurate searching or interactive searching in the case of unknown the certain property of the node. The “Skim” button can enable user's choose nodes or arcs skimmed. This module also offers a "File" button to let users to record all paths into compressed binary file. As a stand-alone module, this module has the least degree of coupling with other modules. User will get a fully featured setup and install or uninstall the module as common software. The module also include detailed help documents in which user can get multimedia help supported by VB, Flash and Html techniques.

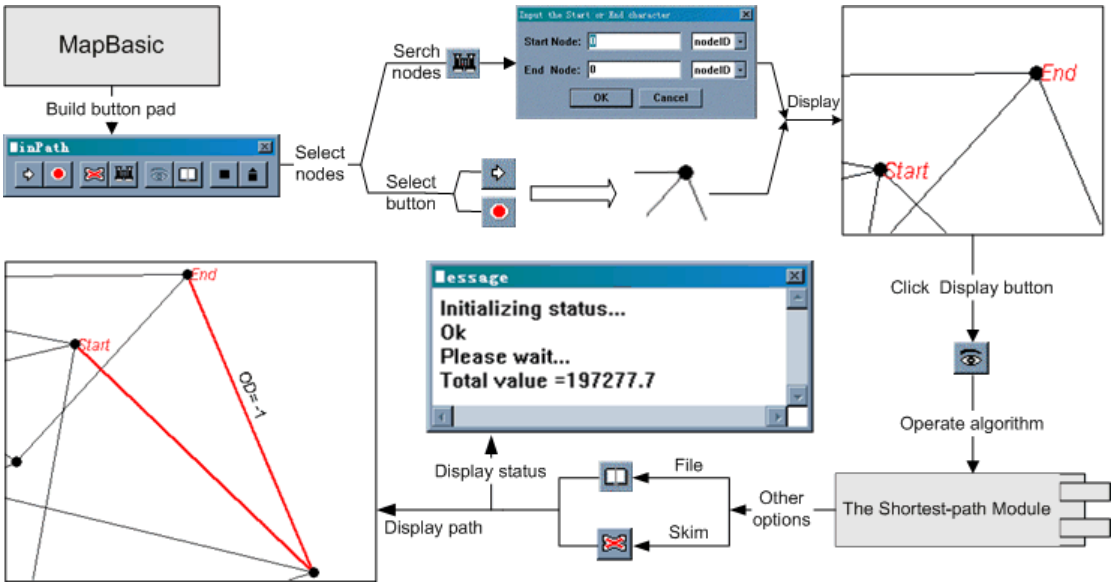


Fig. 6. Interface of the Shortest-Path-Searching Module

6 THE WEBGIS MODULE

6.1 The WebGIS framework

WebGIS make remote user to be able to visit the system in the server through Client-Server mode (Fig.7). Server will respond to the request through ASP of IIS while remote user types HTTP request. Users can visit GIS database through MapX object, the returned HTML page includes texts and pictures. Remote users need not to install any display plug-in to browser; all operations and analyses are finished in the server. This method has fully utilized resources of server and reduced the burden of remote user.

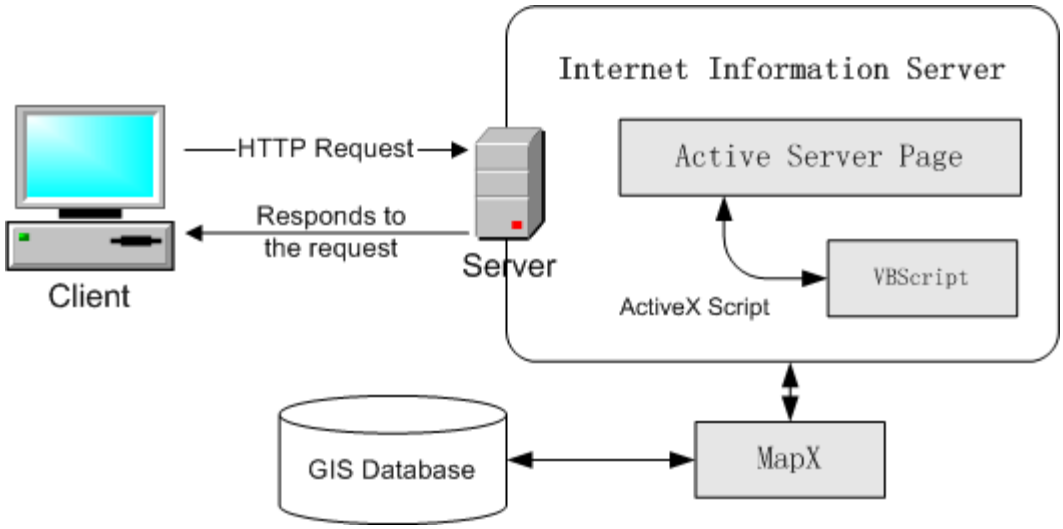


Fig. 7. The WebGIS framework

6.2 Configuration and Use of WebGIS

Realizing the WebGIS needs to configure the server at first. This system uses Windows2000 as server OS, and installs IIS, MapXtreme and MapX. In the system ASP and HTML files are put in virtual directory. To use the WebGIS, user has to input the address of the server in the browser at first, and then pages returned by the browser returns three frames. The main frame displays the map, on the top of mainframe there is a toolbar, users can use it to zoom and move the map and measure the distance on the map (Fig.8). There are also layer and searching for advanced user.

7 CONCLUSION

Several techniques have been applied in this GIS based road traffic management system. Users can manage the road traffic information more systematilly and scientifically with this system. Users can query the road traffic information of Dalian conveniently and swiftly through this system. Especially with visualized operation and online help, users can grasp the use this system easily. The synthesis of various programming language is used, and then contradictions of operational speed and friendly interface is solved. How to gather and update data automatically through ITS and offer the real-time information browsing to users through various ways (such as mobile devices) is the development direction of this system in the future.

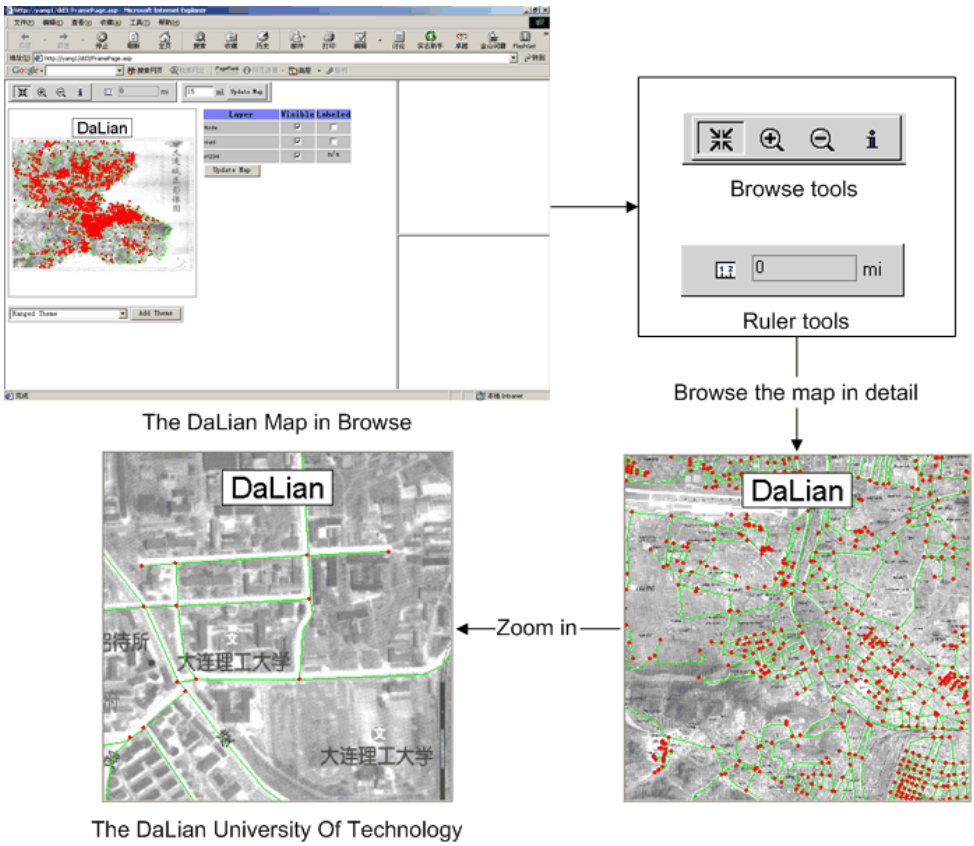


Fig. 8. Interface of WebGIS