An Urban Traffic Monitoring System Based on the ArcGIS Engine

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Abstract: The growing number of vehicles makes traffic jams and accidents significant problems. Making people get to know the real-time road condition can mitigate the effect of congestions greatly, but this is not supported by traditional traffic assistant systems. The intelligent traffic system is born to settle these problems. By making full use of the ArcGIS (Arc Geographic Information System) Engine characteristics, this paper designs and implements an urban traffic monitoring system. The main functions of the system include the real-time road condition information display, layer-control, supervisory control management and the basic operations of a map. With the data collected by monitors deployed in intersections, different road conditions are calculated and shown with different colors on the map and users can choose suitable roads to get away from the traffic congestion; meanwhile it can offer a reference for a traffic management department to make decisions on traffic control. The system has been deployed and shows high practicability and reliability in practical use.

Key words: ArcGIS Engine; traffic control; intelligent traffic system; road condition display

1 Introduction

With the steady economic growth, a big rise occurs on people´s level of living, and the urbanization and growing number of vehicles make traffic jams and accidents become significant problems. The intelligent traffic system is born to settle these problems. How to make full use of computer techniques, network techniques, communication techniques, and geographic techniques et. al to enforce the management of traffic to improve the utilization, safety and comfort level of the existing urban roads have become hot research topics in both developing and developed countries [1].

Current research mainly focuses on analysis or prediction of traffic data, architecture of intelligent control systems and some integrated vehicle routing systems in mobile devices like PDA (Personal Digital Assistant). Some models have been proposed to simulate the traffic flow of urban areas, such as the neural network based model [2] and local polynomial fitting based model [3], while these techniques have not been used in practical systems. Some promising techniques and trends have been adopted in the development of intelligent traffic systems like cloud computing and distributing computing [4]; all these techniques aim to improve the utilization of current transport systems and give out unblocked travels. But with the constraints of devices and real-time data collection, the real-time road condition has not been supported by these systems very well.

GIS can make integrated analysis and processes on spatial data, can collect, store, search, model, analyze and display the spatial data effectively, and plays a more and more important role in the field of intelligent traffic. But traditional routine display, recommendation techniques are not enough because real-time road condition display has become an urgent requirement and famous "Google Map" and "Baidu Map" have also added the "Real-Time Road Condition" functions. Our system can display the real-time road conditions of cities on a map with computer network transmission. To make the user comprehend the road condition more clearly, differ-

Received 28 April 2013

ent road conditions are represented by different colors, such that red stands for jam, orange for congestion, yellow for normal condition and green for passage clear. Real-time road data can reveal the current traffic information which can help a user stay away from congestion and annoyance. So people can avoid the jammed road with just a glance, the effectiveness of travelling and transportation is improved greatly [2].

2 System overview

2.1 Features of the ArcGIS Engine

The ArcGIS Engine is an application independent ArcObject programming environment [6]; developers can customize the embed GIS component libraries for specified application; the Engine includes core components of ArcView, ArcEditor, ArcInfo and ArcGIS Server. We can use the ArcGIS Engine to develop new applications and make extensions to existing ones; developers construct specified GIS applications based on a combination of different GIS functions with the help of interface techniques of C + +, COM, .Net or Java. A majority of ArcObject components are included in the ArcGIS Engine which implements most functions of ArcObject [7].

2.2 System architecture

The urban real-time road condition display system based on the ArcGIS Engine is a new traffic management system which collects the statistics of road vehicles, computes the traffic condition level and displays the road condition by using digital supervisory facilities, wireless communication, and geographic information techniques.

The whole system consists of monitoring equipment, network communication and supervisory center, which corresponds to data collection module, communication module and road condition display module. The architecture of the system is shown in Figure 1.

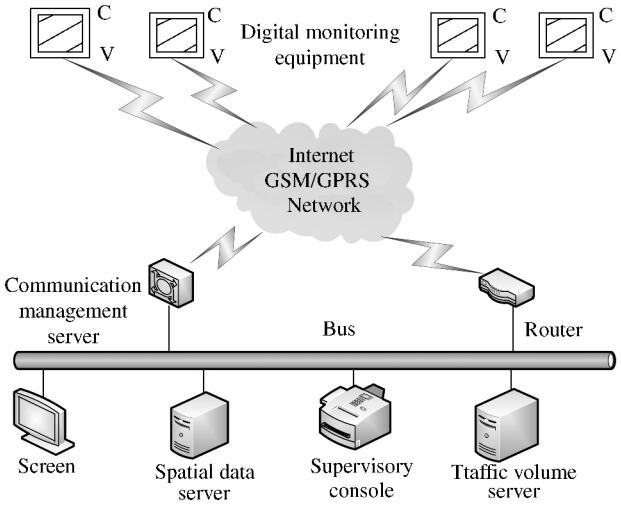

Figure 1 System architecture

1) Digital monitoring equipment

The digital monitor is the "Electronic eye" installed in traffic intersections, which we often call "Digital Cop" and consists of communication, camera and control modules. The main function of digital monitoring equipment is capturing the vehicle license plate and computing the traffic volume, then the information gathered will be sent to the supervisory center by a wireless communication system, and it can also receive and execute the center's orders.

2) Communication network

The communication methods of the intelligent traffic system include both wired and wireless transmission, and most of the data transmission relay on wired trans-

mission. With the help of existing network facilities, the transmission system can win a higher transmission tare, and as the 10 Gps network come into real life, optical fiber data transmission is a competitive option. Wireless transmission relies mainly on microwave, radio and 3G et. al; we can setup a private network or rent a public network to construct the network for data transmission from monitoring equipment to a supervisory center.

3) Supervisory center

The supervisory center consists of a management center for digital monitoring equipment, server of traffic volume database, monitor console, screens for data display, system information management software and application system et. al.

By far, the digital monitoring equipment has been used widely and can meet the requirements of precision. The data transmission is achieved by normal network and cluster communication. We mainly focus on the real-time road condition display module of the intelligent traffic system. The core problem of user interface design is how to use the vehicle volume information to calculate the traffic condition precisely which will be displayed on the computer screen and then saved in a database.

2.3 Principles of system

Digital monitoring equipment sends the vehicle license plates or vehicle volume information to a communication network by a nested control module and communication module; then the information is transmitted to the supervisory center for digital monitoring equipment by a communication network. After the data is resolved, we can get the traffic volume and send it to a server by serial port or network. When the data has been converted properly, it can be written to a database and displayed on the monitoring computer's screen to show the real-time road condition. After all of these procedures, we can get the real-time urban traffic condition from a map that renders the road with different colors.

2.4 System functionality

The system functionality architecture is shown in Figure 2.

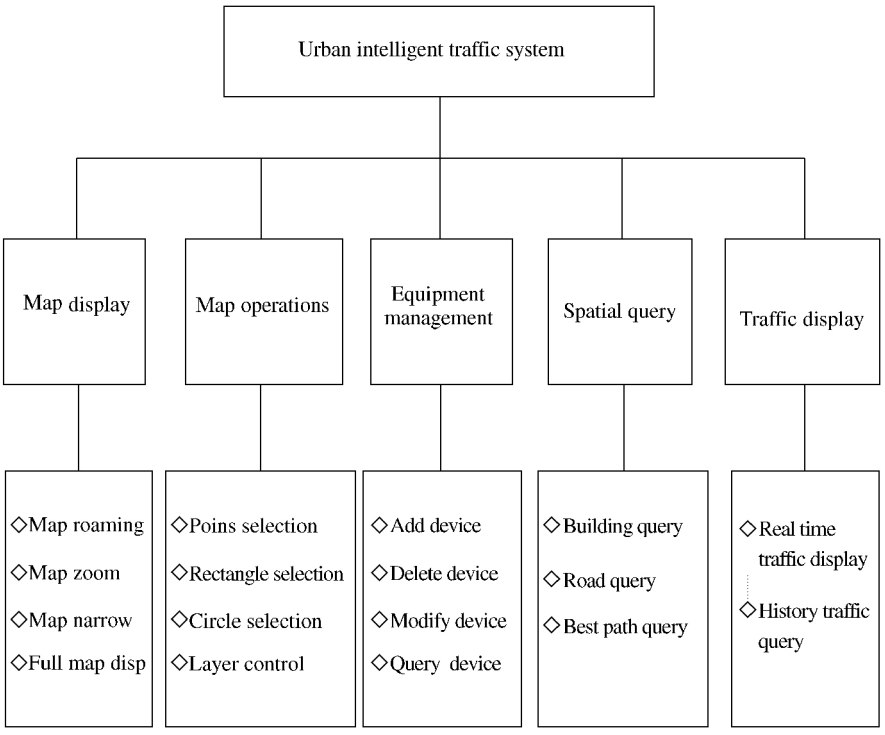

Figure 2 System functionality architecture

The system's main functions are as follows:

1) Map operations. Such as map roaming, zoom, narrow, full map display, primitive selection and layer control et. al.

2) Digital facilities management. Like query and edit the information of digital monitoring equipment et. al.

3) Spatial query. User can query the current or history road condition of a specified place; query the building information like restaurant, hospital or hotel; query the shortest path between two points on the map.

4) Road condition display. Urban real-time road condition display, when the data acquired by digital equipment has been properly transformed, the road condition is displayed on the map with specified symbols. According to the time that a user inputs, the system can display the road condition on the map after a query to the database for the specified time's road condition.

3 System implementation

The system supervisory center software uses the ArcGIS Engine as the support platform for GIS, and Visual C + + as the develop tools, the SQL Server2005 and ArcSDE as a database. We mainly implement the map display, digital monitoring equipment management, urban road condition display and spatial query functions. Then the implementation details of each part will be elaborated.

3.1 Map organization and display

In an intelligent urban traffic system, the map should display the real-time road condition, and the organization and display of maps plays a key role in whole system.

1) Map organization

The digital map can be divided into different layers, which includes points, lines and faces; points layer use a point object to represent a position, such as a bank, supermarket and restaurant; the point layer can be further divided into some sub-layers, like bank and supermarket sub-layer. The line layer is used to represent the object that covers a specified distance such as electric wire, traffic roads et. al. Face layer is used to represent the object that covers specified area like rivers, countries et. al. Dividing maps into sub-layers can improve the efficiency of a map display and data management.

2) Map display

The function is implemented by "ESRI MapControl" in Visual C + +, MapControl encapsulates the Map object, and it is used to display and analyze the geography data and constructs the digital map. The MapControl is mainly responsible for managing and adding data layers, loading the map files and displaying and saving the map. Loading the map is achieved by invoking the LoadMxFile method of MapControl object. Map roaming is implemented by invoking the Pan method.

3.2 Digital monitoring equipment management

Our system can manage the digital monitoring equipment in a visual way to achieve visualization of the equipment supervisory; user should input the precise latitude and longitude when installing a new monitoring device with which the position on a graphic layer is confirmed, and all this information will be stored in a database. Removal of a specified device also involves two procedures, deleting the device graphic layer symbol and corresponding information in the database. Let's take adding a monitoring device visually, for example, the steps and their corresponding key codes are shown as follows:

1) Get the layer to add from the Layer attribute and set the workspace editable;

```
pMapCtrl - > get_Layer( i,&ipLayer) ;
//get the i + 1th layer's graphic layer
iFeatureLayerPtr iFeatureLayerPtr = ipLayer;
```

```
iFeatureLayerPtr - >get _ FeatureClass( &iFeatureClassPtr);
iFeatureClassWritePtr = ( iFeatureClassWritePtr)
iFeatureClassPtr;
( ( IDatasetPtr) iFeatureClassPtr) - > get _ Work-
space ( &iWorkspacePtr) ;
iWorkspaceEditPtr = ( IWorkspaceEditPtr) iWork-
spacePtr; //Set workspace to be editable
iWorkspaceEditPtr - > StartEditing ( VARIANT _
TRUE) ;
iWorkspaceEditPtr - > StartEditOperation( ) ;
```

2) Create point symbol in (xCoord,yCoord) ;

```
pMapCtrl - >get _ SpatialReference( &iSpatialReferencePtr);
//get the spatial referenceiPointPtr - > putref _
SpatialReference( iSpatialReferencePtr) ;
iPointPtr - > put _ X( xCoord) ; iPointPtr - > put _
Y( yCoord) ;
IGeometryPtr iGeometryPtr = iPointPtr;
iFeatureClassPtr - > CreateFeature( &iFeaturePtr) ;
iFeaturePtr - > putref _ Shape( iGeometryPtr) ;
```

3) Save the point symbol and finish the edit process;

```
iFeaturePtr - > Store( ) ;
iFeatureClassWritePtr - > WriteFeature ( iFea-
turePtr) ;
iWorkspaceEditPtr - > StopEditOperation( ) ;
iWorkspaceEditPtr - > StopEditing ( VARIANT _
TRUE) ;
```

3.3 Spatial query

In a spatial query, a function to find the shortest path between two points will be introduced. In the ArcGIS Engine, the algorithm for best path has been encapsulated to implement this function. SolvePath and some other auxiliary methods in the PathFinder module should be invoked, and put _ WeightByName(WeightName) in INetSchemaPtr interface can be used to set the weights of edges, such as length, volume and type et. al. With the PathPloyLine method the best path calculating with specified weight (WeightName) can be displayed on a digital map.

3.4 Road condition display

When the supervisory center gets the real-time road condition, the roads´ state will be set according to different traffic conditions and renders the roads on the map with corresponding color and information about the road is revealed. The core parts of the display are modifying the road´s traffic state and rendering the road´s display state. To achieve this, the following steps should be followed:

1) Get the road layer information and set a unique rendering field

```
pMapCtrl - > get _ Layer( 0,&ipLayer) ;
//Get the road layer iFeatureLayerPtr = ipLayer;
ipGeoFeatureLayer = iFeatureLayerPtr;
ipGeoFeatureLayer ->get _ Renderer( &ipFeatureRenderer);
if ( ( ipUniqueValueRenderer = ipFeatureRender-
er) = = NULL)
{
ipUniqueValueRenderer. CreateInstance ( CLSID _
UniqueValueRenderer) ;
ipFeatureRenderer = ipUniqueValueRenderer;
}
ipUniqueValueRenderer - > put _ FieldCount( 1) ;
//Unique rendering value 1
ipUniqueValueRenderer - > put _ Field ( 0,
"STATES") ;
//Render according to the state
```

2) Set the state color

```
iRgbColorPtr - > put _ RGB ( ( OLE _ COLOR)
RGB( 255,0,0) ) ;
//Set color red RGB( 255, 0, 0)
iSimpleLineSymbolPtr - > put _ Color( iRgbColorPtr) ;
ipUniqueValueRenderer - >AddValue( ( "unblocked") ,
( "STATES") ,
( ISymbolPtr) iSimpleLineSymbolPtr) ;
```

3) Render the roads with unique value

```
iFeatureRendererPtr pFeatureRenderer;
```

```
pFeatureRenderer = ipUniqueValueRenderer;
ipGeoFeatureLayer - > putref_Renderer( pFeatur-
eRenderer) ;
```

5 Conclusions

Based on the ArcGIS Engine, our system integrates computer techniques, network techniques and geography information techniques into an intelligent traffic system. By assigning different colors to different roads according to the road condition resolved from real-time vehicle volume information, the real-time road condition is displayed on a map, which can help users get to know the road condition and guide them to get away from traffic congestion. It can also offer a reference for a traffic management department to make decisions which can improve the safety and effectiveness of urban traffic. The system has been deployed and works well.

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Brief Biographies

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