Visualization of Traffic Accidents

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Abstract: Traffic accidents have tremendous impact on society. Annually approximately 6.4 million vehicle accidents are reported by police in the US and nearly half of them result in catastrophic injuries. Visualizations of traffic accidents using geographic information systems (GIS) greatly facilitate handling and analysis of traffic accidents in many aspects. Environmental Systems Research Institute (ESRI), Inc. is the world leader in GIS research and development. ArcGIS, a software package developed by ESRI, has the capabilities to display events associated with a road network, such as accident locations, and pavement quality. But when event locations related to a road network are processed, the existing algorithm used by ArcGIS does not utilize all the information related to the routes of the road network and produces erroneous visualization results of event locations. This software bug causes serious problems for applications in which accurate location information is critical for emergency responses, such as traffic accidents. This paper aims to address this problem and proposes an improved method that utilizes all relevant information of traffic accidents, namely, route number, direction, and mile post, and extracts correct event locations for accurate traffic accident visualization and analysis. The proposed method generates a new shape file for traffic accidents and displays them on top of the existing road network in ArcGIS. Visualization of traffic accidents along Hampton Roads Bridge Tunnel is included to demonstrate the effectiveness of the proposed method.

1. Introduction

Driving is an essential part of day-to-day life for most people. However, with so many people on the road with varied physical and psychological conditions, driving an automobile is usually a risky and dangerous activity. According to the report released by police, annually there are approximately 6.4 million vehicle accidents in the US and nearly half of them result in catastrophic injuries [1]. Besides various precautions against traffic accidents, prompt and efficient traffic accident handling is very important for saving lives and reducing the adverse impact caused by traffic accidents.

Geographic information systems (GIS) are computer-based systems used to store, manipulate, display, and analyze geographic information. Various GIS software tools have been widely used in transportation research and managements for many years due to their powerful geo-visualization capability, analytical capability and database management features [2]. Visualization of traffic information greatly improved the performance and efficiency of many traffic related applications such as traffic supervision, traffic scheduling, and so on. Among these applications, transportation safety can significantly benefit from the use of GIS [3]. Visualization of traffic accidents using GIS can greatly facilitate handling and analysis of traffic accidents in many aspects. The locations of traffic accidents are especially critical for rapid response of traffic accidents. Visualizations of traffic accidents over a large area can provide useful statistics and insight into the condition and state of the transportation network.

Environmental Systems Research Institute (ESRI), Inc. is the world leader in GIS software [4]. ArcGIS, a software package developed by ESRI, has the capabilities to display events associated with road networks. But during processing of the event locations related to the road network, the existing algorithm used in ArcGIS ignores the route direction information of the location and results in erroneous visualizations of the event locations. For example, the algorithm used in ArcGIS considers the route I-64 E and route I-64 W as the same route although in fact they are two separate routes. This software bug causes serious problems for applications in which accurate location information is critical for emergency responses, such as traffic accidents. In this paper, we describe a method that can extract correct event locations and create accurate visualizations of traffic accidents. The proposed method generates a new shape file for traffic accidents and displays them on top of the existing road network in ArcGIS.

The remainder of this paper is organized as follows. Section 2 introduces the method used by

ArcGIS that produces erroneous results. Section 3 discusses the proposed method and its results and compares them with those produced by ArcGIS. Finally conclusions are drawn in Section 4.

2. ArcGIS Algorithm

Route events can be added to ArcGIS in two ways: 1) using the *Make Route Event Layer* geo-processing tool; or 2) accessing the *Add Route Events* wizard from the ArcMap tool menu [3]. In ArcGIS, information about route events is stored in an associated table. Route is a link feature class with an identifier field for every record, which can be used as a reference in the event table. The route information is stored in a shape file that has associated attributes. To display route events on a road network, parameters of the relationship between the table storing events and the shape file that stores the routes should be defined first. The event table should also contain a field that indicates the measure or the precise location of the event. Figure 1 shows the graphical user interface in ArcGIS that is used to select the route file, route identifier, event table and measure field. In this paper traffic accident data provided by the Virginia Department of Transportation is utilized to illustrate and compare the results produced by ArcGIS and the proposed method.

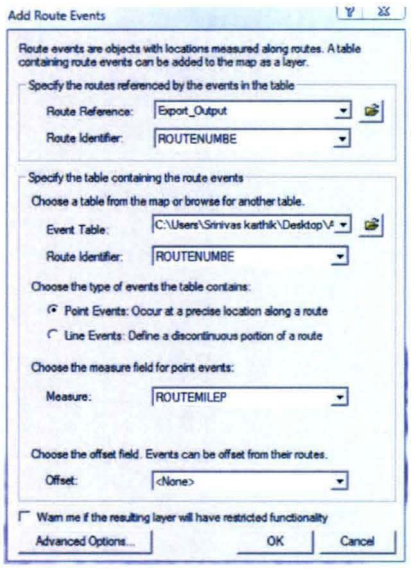

Figure 1: Interface for adding route events in ArcGIS

In Figure 1, the drop-down box *Route Reference* is used to select the shape file that contains the road network, including all routes. The drop-down box *Route Identifier* is used to specify the attribute of the road network shape file that identifies the route, which happens to be *ROUTENUMBER* in the example shown in Figure 1. The file containing the route events is then selected via the drop-down box *Event Table*. The same file should also contain a field for identifying the route. As shown in Fig. 1, route events can be either point type or line type. For traffic accidents, the event type is point type representing the traffic accident locations. A *Measure* is needed to specify the locations of point events and in this case *RouteMilePost* is used to specify the traffic accident locations, which is the distance from the starting point of the route. ArcGIS only makes use of the attributes specified in Table 1 and Table 2 for visualization of route accidents. It can be seen that the directions of the routes are ignored by ArcGIS, e.g., routes I-64 East and I-64 West are treated as the same route. Thus accidents are placed randomly along either direction of a route depending on the record location in the binary shape file. In the example shown in Figure 3, all traffic accidents are erroneously placed on I-64 East.

Table 1: Event table utilized by ArcGIS

Object ID	Route Number	--	Route Mile Post
0	0064	--	264
1	00264	--	249
2	00664	--	259
3	0064	--	294
4	00265	--	14
5	0095	--	4
6	0064	--	264

Table 2: Route Table Utilized By ArcGIS

FID	Shape	Object ID	--	Route Number
0	Polyline M	0	--	0064
1	Polyline M	1	--	00264
2	Polyline M	2	--	00664
3	Polyline M	3	--	0064
4	Polyline M	4	--	00265
5	Polyline M	5	--	0095
6	Polyline M	6	--	0064

3. Proposed Method

To address the problems in ArcGIS for traffic accident visualization, we developed a program that utilizes all the relevant information in the route table and event table for identifying accident locations. Specifically, the attribute *Route Suffix* in both tables are utilized, which indicates the directions of the routes. Some attributes of the event table and route table are shown in Tables 3 and 4, respectively. The block diagram of the proposed method is shown in Figure 2.

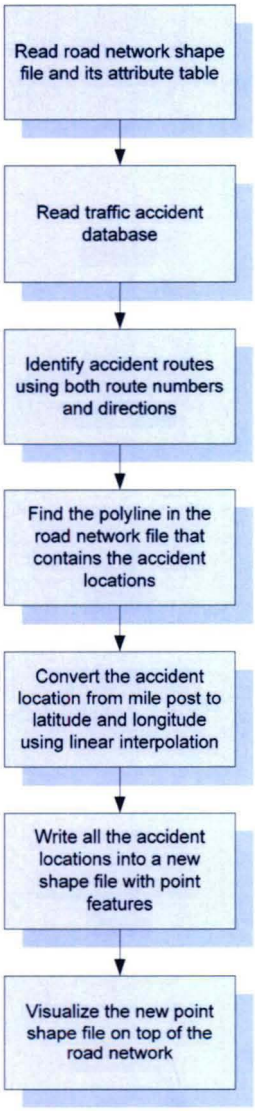

Figure 2: Block diagram of the proposed method

The proposed method first read the input files, including the shape file containing the road network, its associated attribute table, and the traffic accident database. Then it identifies traffic accident routes using both route numbers and directions, i.e., the attribute *Route Suffix*. In a shape file that contains a road network, each polyline is a part of roadway that consists of a series of vertices. The minimum and maximum mile posts of a polyline are stored as attributes of that polyline. Thus, based on the attribute *RouteMilePost* of the accident location, the polyline in the road network file that contains the accident location can be found by comparing *RouteMilePost* and the minimum and maximum mile posts of the polyline. After the polyline containing the accident location is identified, we need to further to find the two consecutive vertices of that polyline between which the accident is located. Each vertex of the polyline in a road network has three attributes: latitude, longitude, and mile post. The latitude and longitude of the accident location is computed as linear interpolation of two vertices based on the mile posts. Finally, the accident locations are written into a new shape file with point features and it is imported into ArcGIS and visualized on top of the original road network. Figure 4 shows the results generated by the proposed method. It can be seen that traffic accidents are correctly displayed along both directions of Interstate I-64. Figures 5 and 6 show enlarged views of Figure 3 and 4. It can be clearly seen that the proposed method corrected the error in ArcGIS.

The implementation of the proposed method utilized the Shapefile C Library [5], which provides the ability to read, write, and update ESRI shape files (.shp) and associated attribute files (.dbf).

Table 3: Event table utilized in the proposed approach

Object ID	Route Number	--	Route Mile Post	Route Suffix
0	0064	--	264	W
1	00264	--	249	E
2	00664	--	259	W
3	0064	--	294	E
4	00265	--	14	W
5	0095	--	4	N
6	0064	--	264	W

Table 4: Route table utilized in the proposed approach

FID	Shape	Object ID	--	Route Number	Route Suffix
0	Polyline M	0	--	0064	W
1	Polyline M	1	--	00264	E
2	Polyline M	2	--	00664	W
3	Polyline M	3	--	0064	E
4	Polyline M	4	--	00265	W
5	Polyline M	5	--	0095	N

4. Conclusions

Visualization of traffic accidents can greatly facilitate handling and analysis of traffic accidents. ArcGIS is the leading GIS solution provider and its software ArcGIS supports visualization of route events, such as traffic accidents. However, the default algorithm of ArcGIS does not consider route directions when displaying route events, and thus producing erroneous visualizations. This paper proposed a method that utilizes all relevant information of traffic accidents, namely, route number, direction, and mile post, and extracts correct event locations for accurate traffic accident visualization and analysis. The proposed method generates a new shape file for traffic accidents and displays them on top of the existing road network in ArcGIS. Included visualization of traffic accidents along Hampton Roads Bridge Tunnel demonstrated the effectiveness of the proposed method.

Figure 3: Traffic accidents displayed along HR Bridge Tunnel (I-64) generated by ArcGIS. All the accidents are errorneouly placed along I-64 East because ArcGIS discards the route directions.

Figure 4: Visualization of traffic accidents by the proposed method. Traffic accidents are placed correctly along both directions of I-64.

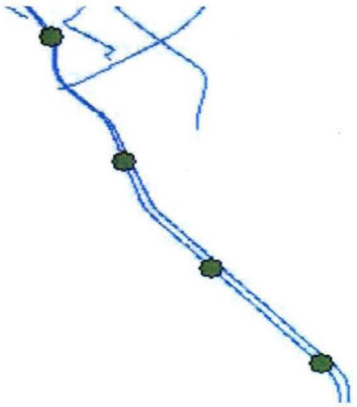

Figure 5: Enlarged view of traffic accidents displayed along HR Bridge Tunnel (I-64 East) generated by ArcGIS. All accidents are placed along I-64 East.

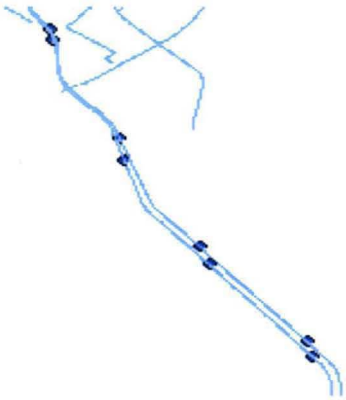

Figure 6: Enlarged view of traffic accidents produced by the proposed method. Accidents are placed correctly along both I-64 East and I-64 West.

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