THE USE OF GIS IN BLACK SPOT STUDIES

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Abstract: With the development of computer hardware and software, geographic related information can be analysed on digitalised maps and the intended results can be presented on a computer screen. Geographic Information Systems (GIS) offer a substantial platform for new concept to be formed and new tools to be developed. It can be employed to conduct spatial data analysis, graphic display, visual interface, data editing and information query. Apart from its other applications, these features provide a useful environment for comprehensive analysis of traffic safety problems. This paper attempts to report the development of an engineering tool using GIS for Black Spot studies. GIS ArcView was employed to analyse and display accident data. A case study using road accidents with fixed objects from Adelaide Australia will be used to demonstrate the features and functions of the tool. This study will provide advantages for traffic engineers and highway planners to assess the distribution and details of road traffic accidents and develop subsequent countermeasures.

Key Words: Geographic Information Systems (GIS), Traffic Accidents, Black Spots.

1. INTRODUCTION

Road traffic accidents cause monetary and general community losses. Although the general trend of frequency and severity on traffic accidents is stable with some variations in recent years, there are potential to minimise the number of accidents further through comprehensive research and effective countermeasure development. In studying and investigating traffic accidents, numerous methods have been tested (Symons and Cleal, 1982). Due to the random nature of road accidents, in particular for large areas, no method can be employed to classify, category and provide location-based information in a systematic way. Traditionally, the number of road accidents for a high-risk site, the accident rate based on road length or accident rate based on number of vehicles are often used as the criteria to identify and evaluate safety levels for a particular site or area. This method needs to investigate the accident history of the site and the accumulated accident statistics and even so the cross category interrelationships and the accident details could not be determined and presented in an easy to understand way. Therefore, efforts should be directed to continue the studies.

2. BLACK SPOTS IN ACCIDENT STUDIES

Among the available methods in accident studies, Black Spots is often regarded as an effective way to identify high-risk sites or areas. Once the accident sites can be positioned on

a map, certain criteria could be adopted, for instance, a definition for Black Spot (number of accidents for a site), the distance between the accidents which have been considered as at the same spot (Landles, 1979). In using Black Spot method, for accident-number only exercise, it is quite straightforward (Mcguigan, 1982). The principle in using Black Spot method are based on the following assumptions:

- The site/area must have enough accidents to identify a pattern
- The site/area must have enough accidents of the same type
- The accidents could be located on a map based platform

Once a Black Spot could be determined, the proposed engineering treatments could be assessed according to their capacity to eliminate or substantially reduce those accidents (Kanellaidis, 1999). This method of determining eligibility ensures that the sites that will return the most benefit to the community (in terms of greatest road accident reductions at lowest cost) are treated first. However, in studying the details of the accidents at the site/area, for example, the time of day, day of week, day/night time, weather conditions, gender differences, blood alcohol contents, accident types, physical characteristics of the locations, severity and cost, the complicated/combined natures may misleading the direction of the investigation if the analysis was not done properly. The traditional Black Spot method will be difficulty in practical situations.

3. THE USE OF GIS IN BLACK SPOTS STUDIES

With the development of computer hardware and software, spatial information can be analysed on digitalised maps. Geographic Information Systems (GIS) offer a substantial platform for new tools to be developed for accident studies (US Department of Transportation, 1999). GIS can be employed to conduct spatial data analysis, graphic display, visual interface, data editing and query. These features provide a useful environment for comprehensive analysis of road safety issues. The advantage of using GIS in Black Spot studies is that it can present both the geographical positions of the accidents and the information about the accident details. Some non-traditional databases that are available in GIS, such as land use, zoning ordinances, and population characteristics can also be adopted in problem identification and evaluation studies. For example, users not only can make queries about the geographical distribution of road accidents but also the types, severity level, time of day, weather condition, and the costs of the accident with a site/area. Apart from queries, the user can also set up his/her own criteria for some particular analysis. In addition, GIS based tools allow traffic engineers to access various types of supplemental information without leaving their desks. In this Black Spot studies, ArcView GIS was employed to form a platform for the tool development.

ArcView is one of the GIS platforms. It is a Geographical Information System that is designed to handle spatial data applications. ArcView is also designed to utilise data created by ESRI's other GIS software, ARC/INFO, as well as spreadsheets and various format images. It is a powerful and user-friendly program. The language "Avenue", available in ArcView, can be used to develop user-friendly features and analytical programs. The advantage of using GIS in Black Spot studies is that it can present both the geographical positions of the accidents and information about the accident details. Traffic accident data with coordinates can be easily analysed and presented on a computer screen and various queries about the accidents can be followed. ArcView GIS provides an excellent opportunity to develop engineering tools in accident studies.

4. THE STRUCTURE OF THE PROGRAM

Similar with many other programs, the program using ArcView for Black Spot studies contains three major phases. Each phase concentrates on a number of specific tasks. The program starts from making a query about the accident types from an accident database. Once an accident type is selected, through a number of user-program interactions, the program will conduct some necessary calculations to form the Black Spot. Then a Black Spot will be presented including the position of accident and the road network. It is also possible that the land use features could be displayed as well if they are in the database. As shown in Figure 1, another query can be made once the first one has been completed.

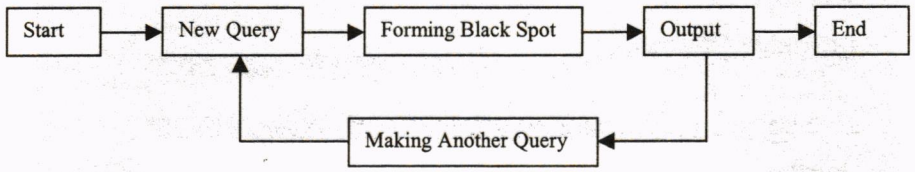

Figure 1 General Program Flow Chart

4.1. Information Query Phase

In the first phase, information query, the program loads data from an existing accident database. Any information contains geographical location details could be possibly analysed and presented as a Black Spot. The users can select the one which to be analysed from a database. For the selected data, the program will calculate their coordinates and then a Black Spot could be presented according to some preset criteria. At current stage the following data on traffic accident can be displayed by using Black Spot:

- **Accident with Casualties**: With the information query phase, all the accidents with casualties will be selected from the accident database. And for those accidents selected, a Black Spot analysis will be processed.

- **Accident Cost**: Cost caused by road accidents could some times be an indicator to establish accident treatment priorities. In the program, a user could make a query based on a specific amount as the benchmark. Based on the accident cost measures, a Black Spot can also be presented.

- **Number of People Involved in an Accident**: The number of people involved in an accident causes community concerns. The information could also be used to form a Black Spot to conduct further investigations.

- **Accidents Involving Pedestrians**: Pedestrians are the most vulnerable group among road users. It is necessary to conduct this analysis for the reasons causing this kind of accidents and to improve the infrastructure to minimise it. A few pedestrians in a same accident will be considered as a single accident (with same accident identification number). The number of pedestrians in any single accident will be shown in the legend.

- **Night Time Accidents**: The identification of frequently occurred night time accidents could provide evidences about sight distance and lighting condition of the site. Together with the geographical information, a Black Spot could help to evaluate the proposed treatment methods.

- **Peak Hours Accidents**: Accidents occurred during morning and afternoon peaks can be identified using the query functions. Once this information is selected, a Black Spot on peak hour accident can be analysed.

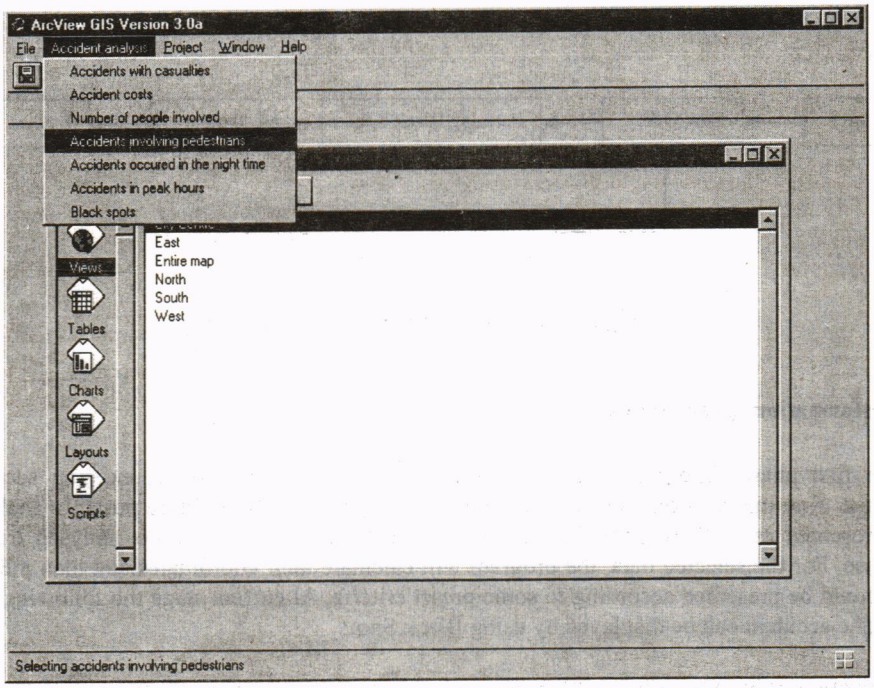

Figure 2 Information Query Window

Apart from a user can choose what to analyse, the user also has the opportunity to determine and select the region to be investigated, in particular, for a database containing a huge area. This function is mainly concerned with the computing time as road accident database often contains large amount of data. Figure 2 shows the window with which a user can make information query.

From the Accident Analysis operation manual, a user can choose and alter the data and make different queries. For example, in the above figure the Accident Involving Pedestrians were selected. Once an accident type has been selected, it will be highlighted on the manual and then will be displayed on the computer screen. User has the opportunity to confirm if it is the one needs to be analysed.

After an accident type has be selected, through a number of interactions with the program, the position of that type of accidents will be presented together with the road network. Figure 3

presents the locations of the accidents on the network for the City Centre region of Adelaide, South Australia.

As shown in Figure 2, the highlighted type was selected (Accident Involving Pedestrians). The displayed positions of those accidents involving pedestrians will provide the primary information on pedestrian safety and the site conditions (refer to Figure 3). If the user needs further details on the high-risk locations/site/spot, he/she may choose to continue and the program will start the Formation of Black Spot phase (the calculation may take some time depending on the size of the database).

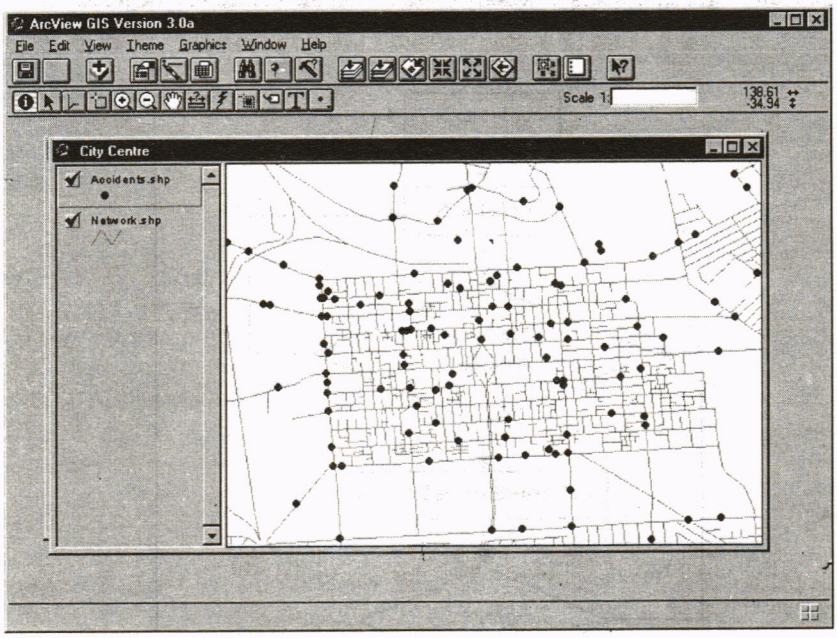

Figure 3 Accidents with Road Network for City Centre

4.2. Black Spot Formation Phase

Second phase is the formation of Black Spot. The program will conduct a series of calculations and comparisons to determine the Black Spot based on the preset criteria. Figure 4 shows the program flow chart in calculating the distance between all the accidents.

The distances between all the selected accidents from the first phase will be calculated in he calculation processes. In Figure 4, "N" represents the total number of accidents selected. "DI-J" represents the distances between accidents. As there are possibilities that multi-users may be involved in a single accident, all the involved parties are having the same accident identification number in the accident database. To avoid the same accident being considered more than once, the program considers the identifications of the accidents (refer to Figure 4). Once the distances between all the accidents are calculated, the program will conduct a comparison process to identify accidents being considered at the same spot. At this point, it is

necessary to define a Black Spot. In general, using distance between accidents as a criterion is widely known. In this exercise, a Black Spot is defined as a spot where 2 or more accidents occurred within a distance of 150 metres.

4.3 Output Phase

In the last phase, a Black Spot will be presented. A circle containing number of accidents can be displayed on a computer screen. Every time the distance of an accident to another accident is less than 150 meters a circle with a radius of 150 meter will be drawn around the accidents from where the distance was calculated. It is also important to notice that because the map unit in ArcView is in degrees it is necessary to transform the meters into degrees.

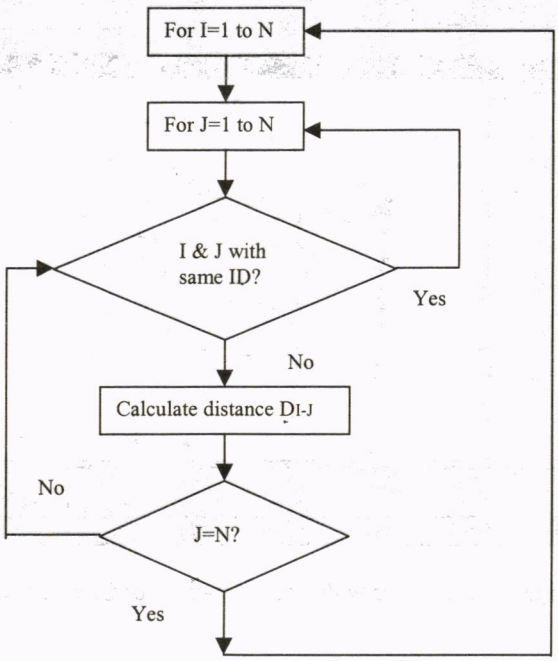

Figure 4 Distance Calculation Flow Chart

In this study 150 meters is approximately equal to 0.00133 degrees. Figure 5 presents a Black Spot with four accident points inside.

Figure 5 is an example of a Black Spot produced by the program. In the Black Spot output, the positions of road accidents, road network and a circle representing the spot can be viewed and investigated. It can be seen that the relationships between the accidents, the network and the site can be identified.

As mentioned in information query phase, users of this program can make different queries for different purposes of analysis. For example, for the accidents involving pedestrians, the

program can produce a Black Spot based on the number of pedestrian accidents (with different accident identifications). At the same time, the user could also set the legend to show different colours to represent how many pedestrians were involved in each single accident within the spot. Using this approach, the user not only can identify the high-risk site/spot but also the details of each accident point.

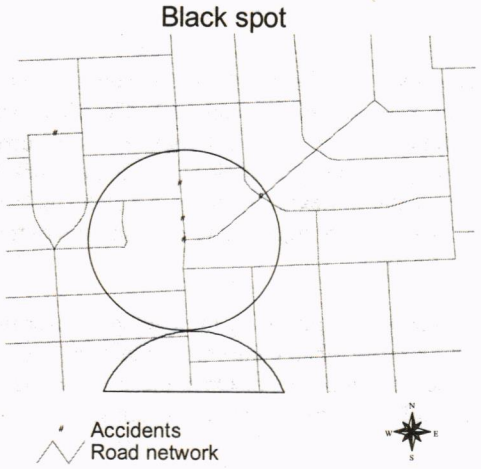

Figure 5 Presentation of Black Spot

5. Conclusions

With the development of computer hardware and software, spatial information can be analysed on digitalised maps. GIS offer a substantial platform for new tools to be developed. It can be employed to conduct spatial data analysis, graphic display, visual interface, data editing and query. These features provide a useful environment for comprehensive analysis of traffic safety problems.

This paper reported the development of an engineering tool using GIS for Black Spot studies. GIS ArcView was employed to analyse and display accident data. The language "Avenue", available in ArcView, was used to form a user-friendly interface. Users of the tool can make queries about the region and the types of accident to be analysed. The program will then produce a Black Spot for the query made. The Black Spot can be developed for the following accident types at this stage:

- Accident with casualties
- Accident cost
- Number of people involved in an accident
- Accident involving pedestrians
- Accident occurred at hight time

- Accident at peak hours

From the Black Spot produced by the program, engineers could classify the accident details and find out the dominant pattern and key factors behind the accidents. Accidents could also be grouped according to their types and site conditions to conduct further investigations.

6. Future Works

The tool in analysing Black Spot is at its on going development stage now. There are still many features and functions need to be implemented. The first task would be to have a powerful file management function then the users could use any format of database to start query phase. Users should be given the opportunity to define a Black Spot according to their needs. Users should be given more flexibility to manipulate their database. Furthermore, enquiries should be made to government agencies to compare the outputs of the program with their determination of Black Spots.

In general, ArcView is a powerful GIS platform. In developing user interface however, it has many limitations to corporate with other computer languages such as Visual Basic. It is necessary to find a way to solve this problem. Once these works have been completed, this tool would be more users friendly and have more applications.

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