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TRAFFIC ACCIDENT APPLICATION USING GEOGRAPHIC INFORMATION SYSTEM

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Abstract: Many highway agencies have been using Geographic Information System (GIS) for analyzing accident data. Identification of problematic locations is one of the most important aspects in accident studies. The GIS based application combines the information collection capabilities with the visualization. The GIS and Road Accident View System are a set of applications developed for managing accident database entries. The developed system was designed based on the Universiti Putra Malaysia (UPM) community area and may be adapted very easily to any other places. The system was developed using Microsoft Visual Basic 6.0 in Windows XP platform. The database was designed in term of textual format. The Accident Report from UPM security unit used as the source for information needed in the database development. The location of the accident was recorded on a map. And by indication on it, the user can perform queries on a particular condition to get the number of accidents.

Key Words: Geographical Information, Road Accident, Database

1. INTRODUCTION

Highways and transportation engineers rely heavily on geographic information systems. Previously, the paper maps which our predecessors have used for centuries. While there is a certain comfort from having a record system containing large numbers of paper maps with highways data marked on them, such systems have serious disadvantages and hidden costs. The terms GIS (Geographical Information System) is now invariability used to describe computerized systems, which comprise a digital map background and layers of additional information, which can be viewed in any desired combination and at any scale.

Nowadays, many highway agencies have been using GIS for analyzing accident data. Identification of problem locations is one of the most important aspects of accident studies.

Using the system, the user can merge accident and roadway data, match the accident data and locations, analyze the data using fixed segment, sliding and spot analysis, calculate frequency and rate of accidents, select a variable for stratification to calculate mean and standard deviation of accident rates and frequencies and sort the sections based on selected criteria.

University Putra Malaysia (UPM) is an open campus where traveled by an estimated 35,000 to 40,000 people each day. The vehicles traveled in the UPM campus have been increasing dramatically compared to past few years. Since then, traffic accidents have become more common. Most of these accidents result from the error and carelessness on the part of the drivers or pedestrians. However, the probability of occurrence, and its severity, can often be reduced by the application of proper traffic control devices, and good roadway design features. The success or failure of such control devices and design specifications however, depends extensively upon the analysis of traffic accident recorded at specific locations. It has been recognized that the most effective means towards accident reduction lies in a systematic and scientific approach based of use of accurate and reliable traffic accident data. But the quantity and quality of important data for the analysis are not always sufficient.

Conventional accident analysis has not been successful in reducing the occurrence of traffic related accidents. There is a need for better information on the circumstances of collisions, especially with regard to location in order to come up with a general picture of the data. More precise location data could help provide facts to guide programs including enforcement, education, maintenance, vehicle inspection, emergency medical services, and engineering to improve streets and highways.

A prototype Geographic Information System and Road Accident View System (GIS-RAVS) was developed for the purpose of reducing the number of accidents. Using the system, the user can identify high accident location, obtain the accident location's ranking, visualize the road accident and location information, input and retrieve the accident database, perform statistical analysis on the selected accident location and so on within a short period. The system is able to perform two types of analysis. The first analysis is node analysis, which is functioning to display the accident data and visualize a particular area. The second analysis is distribution plot, which is able to display the overall of the accident cases in general. Besides, two minor functions named Search Engine and Accident Ranking are included

2. LITERATURE REVIEW

The main problem in identifying the accident blackspot is to determine the highest rate accident locations and the causes of these accidents. This is because the recorded data were not precise enough to carry out the accident study. Some diagnosis system will only be done if the accident data were recorded systematically. The criterion which will be taking into account in identifying the accident blackspot are the accident location areas, types of road where the accidents happened, the road geometry and the light factor.

Accident Database and GIS History

GIS permits users to display database information geographically. It can also provide a common link between two or more previously unrelated databases. The most useful aspect of GIS as a management tool is its ability to associate spatial objects (street names, milepost, route number, etc.) with attribute information (accidents, cause, etc.). Most of the documents reviewed consider the use of GIS in transportation under either for general data maintenance (primarily inventory of transportation-related incidents) or for simple data analysis.

Several studies describe how GIS help the integration of many transportation elements. Meyer and Sarasua (1996) envisioned a common and coordinated database system that will serve all aspects of transportation management such as congestion, pavement, bridges, safety, inter-modal activities, and public transportation. Martin (1993) did a similar study, in which he proves that incorporating GIS in a pavement management program improves the reporting and analysis of data through the production of maps and graphic displays.

GIS has been proven to work well in addressing transportation problems related to safety. Affum and Taylor (1996) described the development of a Safety Evaluation Method for a Local Area Traffic Management (SELATM), which is a GIS-based program for analyzing accident patterns over time and the evaluation of the safety benefits. GIS can also be implemented in determining roadway and surface conditions. This was proven by Gharaibeh et. al. (1994) when they proposed to use GIS to obtain statistical and spatial analyses of roadway characteristics such as safety, congestion level and pavement conditions.

In a separate study by Johnson and Demetsky (1994), the capabilities of GIS in providing a framework for a management system were proven once again. It highlighted the fact that many transportation analysts reap benefits from improved access to data. Establishment of the geographic referencing scheme is the major contributor in making data more readily available.

There also have been studied that aimed at showing how GIS can be applied in accident management systems. Faghri and Raman (1995) developed a GIS-based traffic accident information system for Kent County, Delaware. Their system included knowledge about the occurrence of crashes, such as conditions of incident site, and frequency of incidents at any given location (mile-point) on a roadway. Since the early stages of GIS, it was noticed that a vision of information technology outside the traditional transportation data analysis and even outside GIS was needed to implement this technology (Lewis, 1990).

GIS Applications in Transportation

In recent years, there has been much discussion about GIS technology and applications across a wide variety of settings. Moreover, there have been many GIS-related developments in transportation planning and engineering (FHWA, 1993; Lewis, 1990; Kim and Levine, 1996). The power of them is rooted in the fact that GIS allows inferences to be drawn about the spatial nature of the data. Examples of GIS applications in transportation include pavement management systems that work with road segments, optimal vehicle routing, Automated Mapping Facilities Management (AM/FM) used for infrastructure management, drainage design, traffic modeling and accident analysis, demographic analysis for funding justification, and the option of displaying any form of tabular data that has a spatial component.

Spatial Relationships and Technology

When viewing a map, the map-reader must interpret a variety of points, lines, and other symbols to identify spatial relationships among the geographic entities represented. For example, you can use a map to find a route from one city to another. The information required to perform this analysis is not explicit in the map; rather, the map-reader must interpret the required spatial relationships from mapped objects. In a GIS database, the method by which spatial relationships are explicitly represented is termed topology. Topology is used to describe how linear objects connect, to define areas, and to identify the areas lying to either side of a linear object. Information about the spatial relationships is stored in a topological data structure and is essential to carrying out most GIS functions.

Diagnosis Framework in Malaysia

Accident treatment process is a continuous program of work, which required concerted effort at both the macro and micro levels. At the macro level, accident-prone areas or blackspot locations are identified and prioritized according to the safety target or the extent of the problem. At this stage, the general patterns and trends of the accident are established. At the micro level, a more detailed analysis of the factors contributing to the accident is carried out. Since accidents are rare events, appropriate statistical analysis or statistical modeling is required for a greater understanding of the problem. There are 6 major steps in the accident diagnosis and treatment framework in Malaysia.

Step 1: Collection and Compilation of Accident Data

The first step in the production of the national database was the compilation of the accident form in the respective Police Districts. The forms were stocked temporary in a special storeroom at Police Districts before they were dispatching to the Road Safety Research Center (RSRC) in UPM.

Step 2: Computerization and Processing of the Accident Records.

The data input, processing and analysis framework is summarized schematically. The MAAP Version 5 has been designed and customized in line with the POL27. This package has been adopted as the standard analysis package for analysis accident blackspot problems in Malaysia.

Step 3: Identification and Prioritization of the Accident Blackspot Locations.

There are a number of the location identification systems that can be used for referencing the location of accidents. The location identification system can be based either on the road maps that are digitized and converted in DCM format or in MAAP textual output.

Step 4: Blackspots Prioritization and Diagnosis

Ranking of blackspot could then be carried out such as: Ranking by Accident Maps, Nodal Analysis, Analysis on Link Accidents, Analysis on Cell Accidents, Ranking by Accident Point, Ranking by Accident Cost, and Kilometer-Post Analysis.

Step 5: Detailed Diagnosis and Countermeasure.

This step outlines the methods of in-depth diagnosis and developed of countermeasure of a selected blackspots. Site study was carried out to capture the near misses, approach speeds, vehicles and pedestrian flows and their maneuvers.

Step 6: Evaluation Techniques

There is also a number of evaluation techniques currently used in evaluating safety interventions. The selection of each technique depends on the nature of work, availability of data and precision required. Among the available techniques are the cumulative plot techniques, chi-squared before and after analysis and multivariate analysis.

3. METHODOLOGY

The overview of the methodology for system development can be seen the Figure 1 below, and a brief description of each phase will follow.

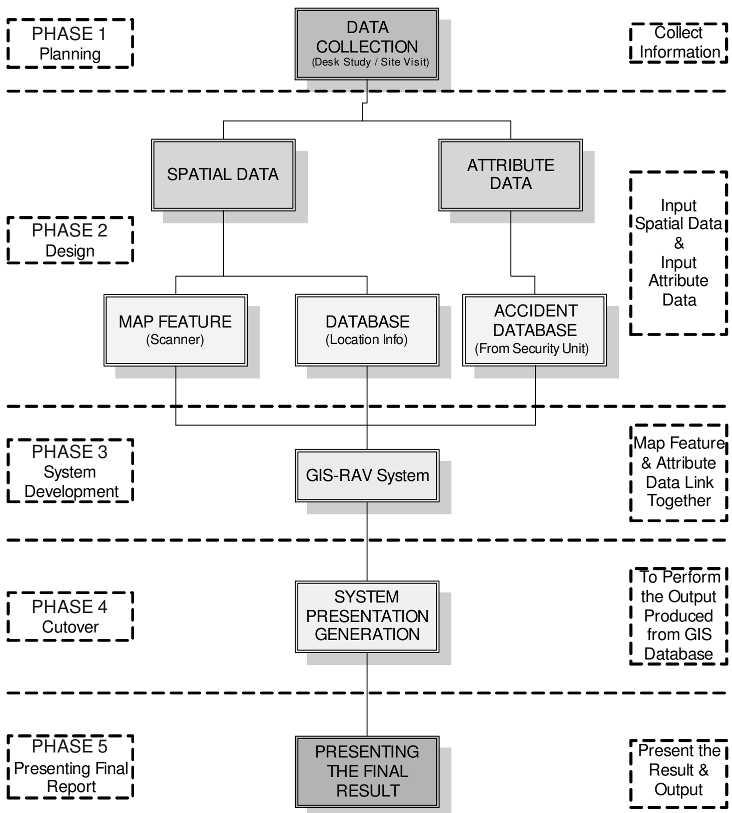

Figure 1. Study Overview

Phase 1: Planning

The planning stage is an accelerated phase that is similar to the project initiation and planning of the standard methodology. The GIS-RAV System is very feasible in terms of financial resources used as it is designed for test-bed deployment without considering recurring cost of maintenance. Because the system is not actually deployed in a real-life environment, the only resources involved are those used for development and not deployment or maintenance.

In this planning stage, the useful information related to the study such as maps, traffic accident statistic, the GIS-RAV system application, application of Visual Basic 6.0, and literature review was collected. Then, site visit was conducted with the main purpose to familiarize or visualize the actual layout of the study area and to obtain useful site information, such as name of the road, length and width of the road, and location indicator.

Phase 2: Design

The design stage is an accelerated stage that corresponds to the analysis and logical design phases. The database design is done in a detailed manner to identify all the data that is needed for the system, either internally for its own use or storage for the user. Four databases (in textual format) are used for data storage of the GIS-RAV System; two of the databases are used for the main function; Node Analysis and Distribution Plot. The other two databases are used for Geo-referencing and Accident Ranking.

At the beginning, the spatial data was obtained by scanning the UPM map. The next step was converted the scanned UPM map into RAV environment. Subsequently, geo-referencing procedure is carried out to obtain the coordinate for each link and node. Geo-referencing was done by mouse-click on the particular node or link. The coordinate of each node and link appeared in a sub-window called *Node System Development* as can be seen in Figure 2.

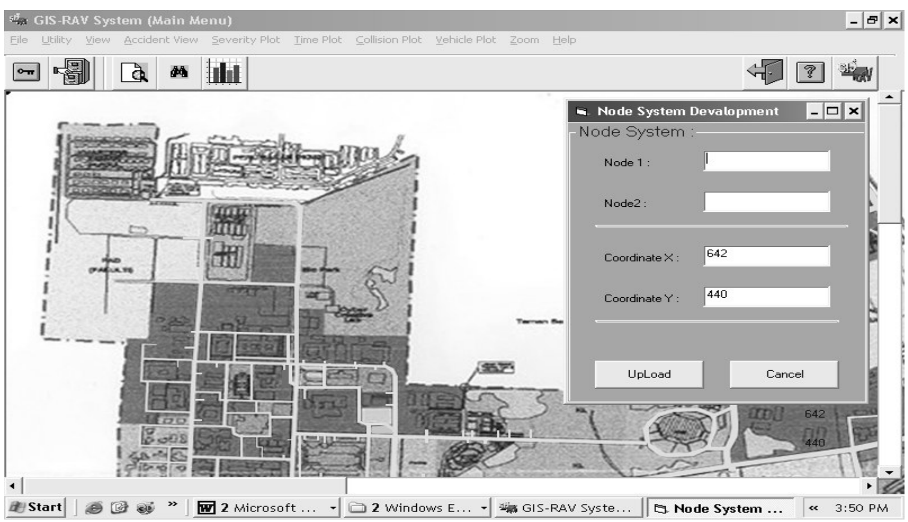

Figure 2. Geo-referencing of Spatial Feature

Attribute data is an information that can answer the question, such as *where*, *when*, *what*, *who* and *how*. For example, where and when is the accident happened, what severity and collision type and who involved. In this study, UPM Security Unit and UPM Medical Center provided the accident data. All accident data (attribute data) needs to be converted into textual format.

A Data Entry for traffic accident in UPM had been created to store the data (Figures 3 - 6). All accident data needs to be keyed into this Data Entry to form a more systematic database. This database will be used for GIS-RAV System application. The Data Entry is consisting of four forms named form ABC (which contained general accident information), form DE (form Driver and Vehicle), form F (form Passenger) and form G (form Pedestrian).

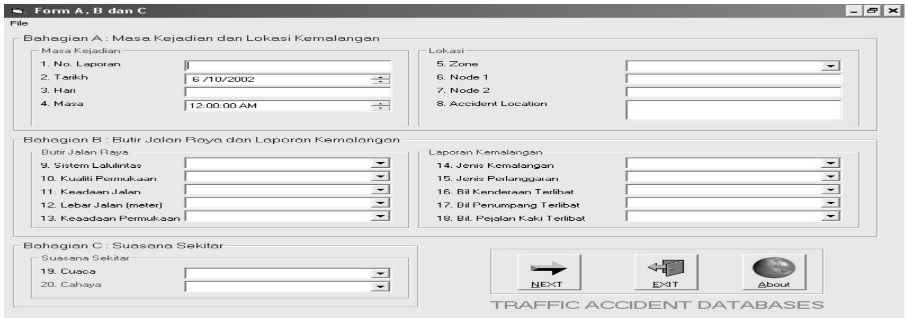

Figure 3. Data Entry (Main page)

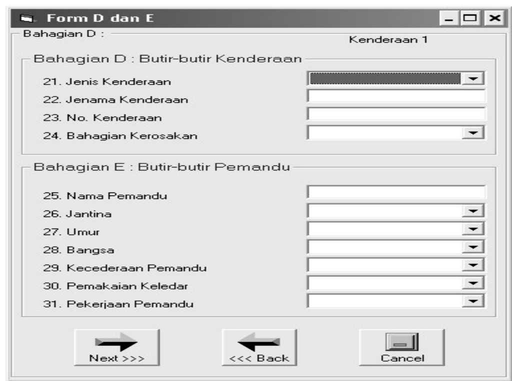

Figure 4. Form D and E (Vehicle and Driver Information)

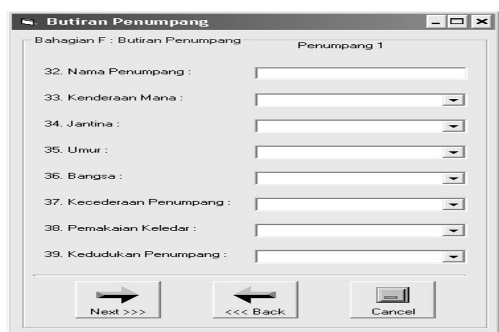

Figure 5. Form F (Passenger Information)

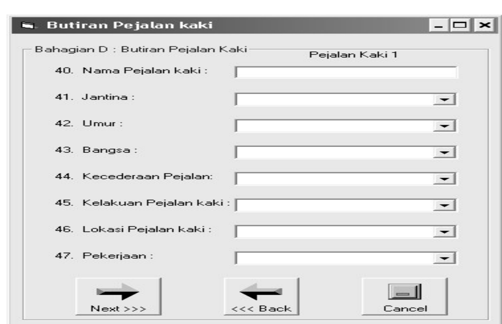

Figure 6. Form G (Pedestrian Details)

The quality of the system input gives direct impact on the output of the system. It is a vital that input forms and screens should be designed with this critical relationship in mind. A well-designed input forms and screens meet the objectives of effectiveness, accuracy, ease of use, consistency, simplicity, and attractiveness. Most of the objectives are attainable through the use of basic design principles, knowledge of what is needed as input for the system, and an understanding of how user should respond to different elements in the forms and screens. Figure 7 below is one example of the interfaces in GIS-RAV system application:

Figure 7. Start up Interface

Phase 3: GIS-RAV System Development

Because of the speed of system planning and design in GIS-RAV, the development of the system is, therefore, a crucial stage. The main method of development is through prototyping. Prototyping can be defined as designing and building a scaled-down but functional version of the desired system. The product of prototyping, the prototype itself, is then tested thoroughly and redesigned to correct any flaws discovered. This is an iterative process that goes on until a satisfactory version of the system is developed. The prototyping methodology can be shown more comprehensively in Figure 8 below.

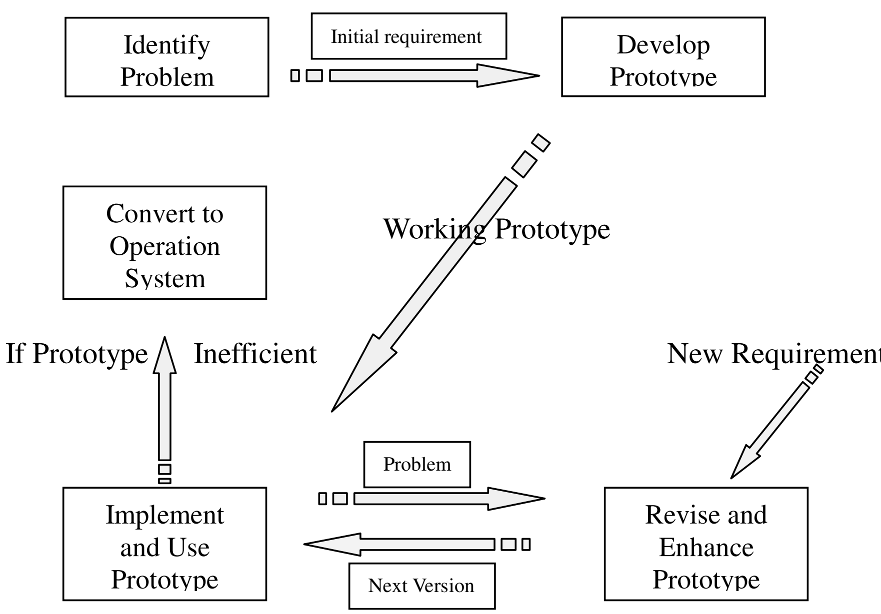

Figure 8. Steps in Prototyping Methodology

Phase 4: Cutover

The cutover stage is the last stage where the system is actually deployed and use throughout the organization. The cutover stage corresponds to the implementation and maintenance phases. In this stage, the steps are usually taken as: Installation of the system, Further testing of the system, Documenting the system, Training and supporting users, Managing and maintenance of the system, and Estimate cost and develop budget for maintenance.

Phase 5: Presenting the Final Report

The last part of the methodology of the study is to present the output, whether in terms of paper work or softcopy. In addition, a short presentation was carried out in explaining the whole process of the project.

4. GIS-RAV SYSTEM

The system is divided into two main functions and two minor functions in four different modules (Figure 9). There are Node Analysis, Distribution Plot, Accident Ranking and Search Engine. In handling transactions in the Node Analysis, the database of the Location Information and Accident Data are used. Similarly, in handling transactions in the Distribution Plot, there are Accident Database and Node System database. There are also two minor functions, the Search Engine module, which is a browser for the particular location and the Accident Ranking, which rank the ten of the most dangerous junction in UPM.

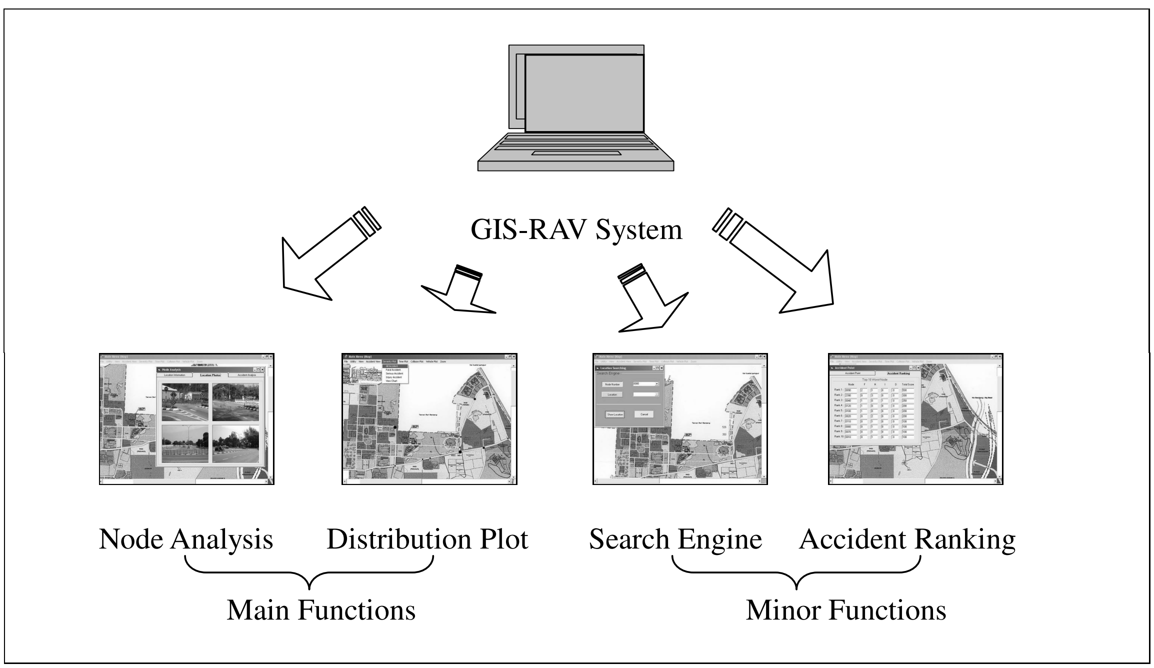

Figure 9. GIS-RAV System functions

Geo-Referencing.

First step before conducting four functions is to analyze Geo-referencing. This analysis can be done by mouse-click at the selected node, for example Node 0090. The sub window; Geo-referencing (Figure 10) will be displayed for analysis selection. In this window, the Coordinate X, Coordinate Y, Node1 and Node 2 are represented to identify the location of the junction. Three command buttons; *Add Node System* button, *Add New Accident Data* button and *Accident Analysis* button were appeared for user selection.

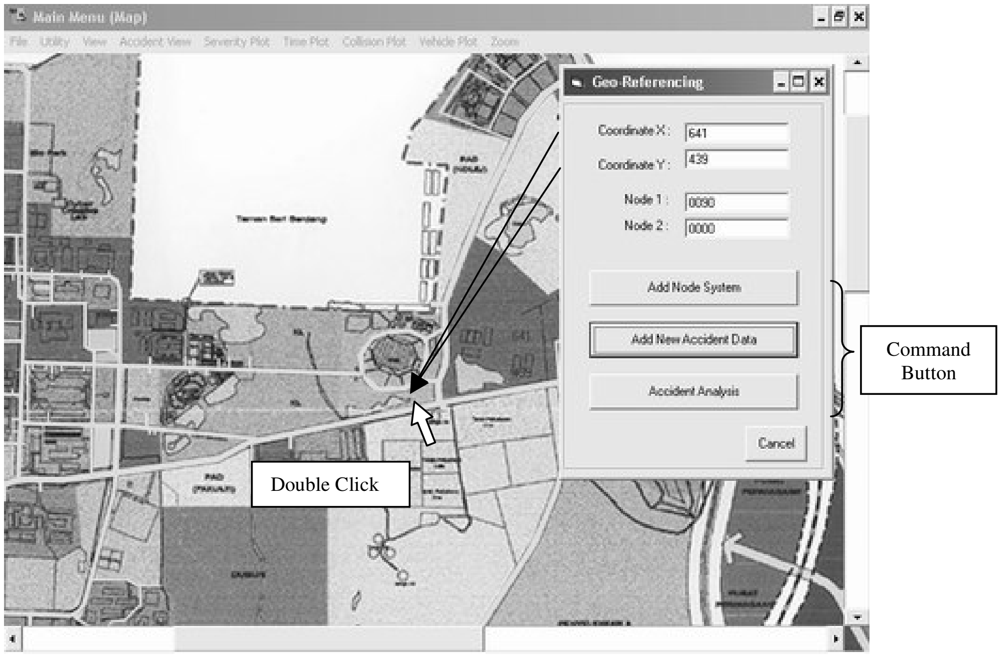

Figure 10. Geo-referencing

Node Analysis

Figure 11 - 13 shows the output of the node analysis. The *Node Analysis* can be done by selecting the *Accident Analysis* button. This followed by appearing of the Node Analysis windows. In this window, it will show 3 sections: (i) Location particular or information, (ii) Location photos and, (iii) accident analysis. At section 1, the Node Analysis window exhibits some location information, for instance, the name of the intersection, Node numbers, Zone, road system, nearest indicator, road condition and the width of the width (Figure 11).

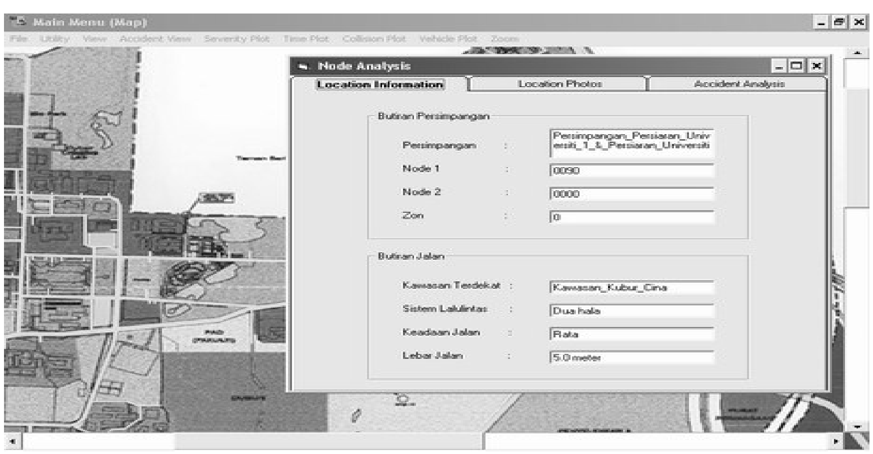

Figure 11. Node Analysis (Location Information)

At section 2, four of the particular location/junction photos are display (Figure 12). The purpose for displaying the photos is to give the visualization at particular site. Then, at section 3, the accident analysis was exhibited (Figure 13). Four graphs (in term of bar chart) are available in visualized the severity analysis, time analysis, collision analysis and vehicle analysis respectively. The *severity analysis* performs the accident severity at that particular location. The severity types are in term of fatal accident, serious accident, injury accident and damage accident. The *time analysis* was shown the daytime and nighttime accident.

The *collision analysis* performs the collision type that happened at the particular location. The *vehicle analysis* performs the type of vehicle that involved in accident at the selected location. Types of vehicles are car, heavy vehicle, motorcycle, and pedestrian.

Figure 12. Node Analysis (Location Photos)

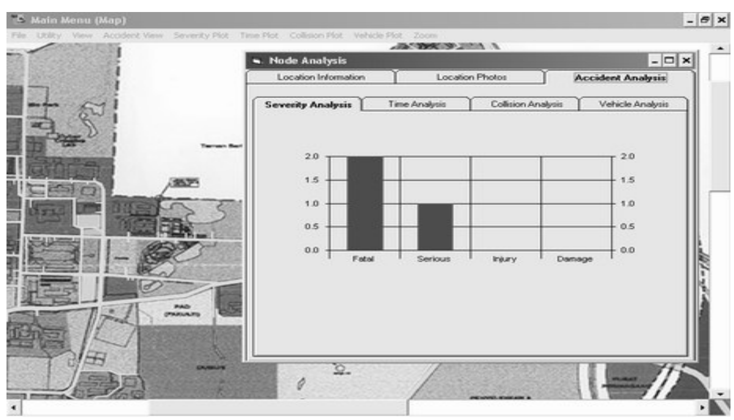

Figure 13. Node Analysis (Accident Analysis)

Distribution Plot

Distribution plot is another option of analysis (Figure 14), which is used to plot accident distribution, display and overview the overall accident cases in UPM. There are a few of distribution plot such as severity plot, time plot, collision plot, and vehicle plot. All type of the distribution plot is based on the user requirement, and this function can be considered as part of the query system provided by GIS-RAV System.

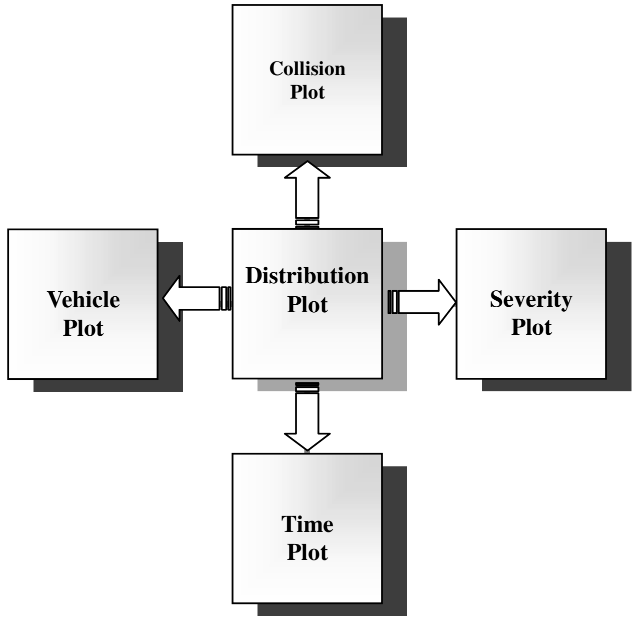

Figure 14. Distribution Plot

The accident distribution can be visualized by using any plot. For instance, if the user desires to view fatal accident in UPM area by severity level, the user can click on the "*Severity Plot*" menu and choose the "Fatal *Accident*", and the result as displayed in Figure 15 below.

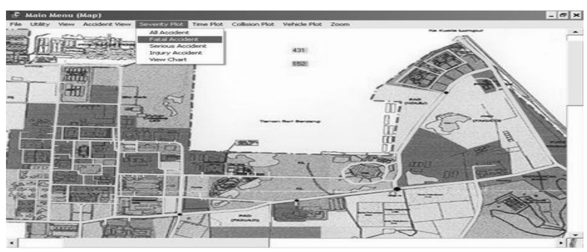

Figure 15. Sample output in fatal accident plot

The accident distribution can also be visualized by using the accident Day Time or Night Time Plot. For Instance, if the user desires to view the total accident that happened at daytime, just click on the "Time Plot" menu and choose the "Day Time" as displayed in Figure 16 below.

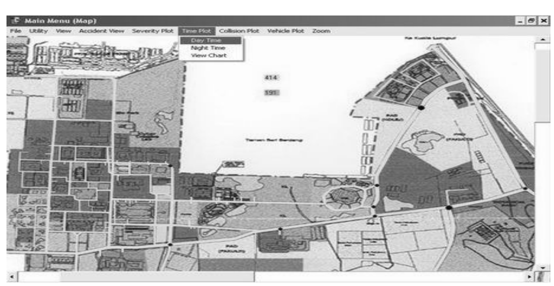

Figure 16. Sample output in Day time Accident plot

The functions under the Vehicle Plot are in term of motorcycle, heavy vehicle, car and pedestrian. One of the sample outputs can be seen in Figure 17 below.

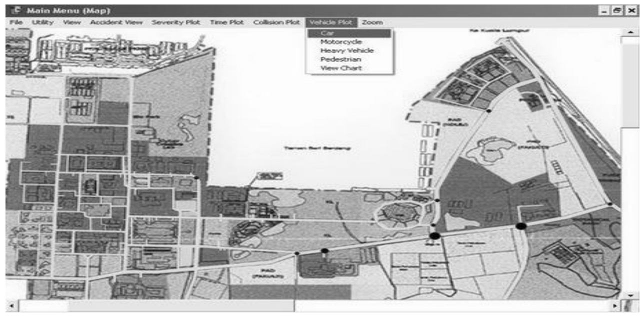

Figure 17. Sample output in Vehicle Plot (car plot)

Similar to the function that has been mentioned above, the Collision Plot is another powerful function for traffic accident investigation. The accident investigator can easily obtain the information of the collision type that happened at a particular location/junction. One of the sample outputs by using the function of Collision Plot can be seen in Figure 18 below.

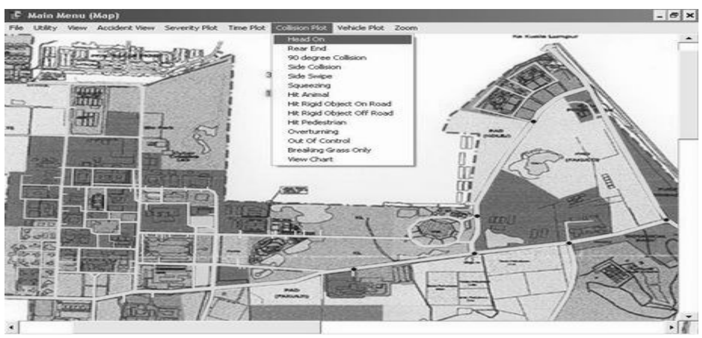

Figure 18. Sample output in Collision Plot (Head On Collision Plot)

Search Engine

Search engine is one of the powerful tools that help user to locate or search a particular location and accident data. Basically, the Search Engine is divided into two parts, which are Search Location and Search Accident data. The Search location can be done in two ways, either search by node number or location name. Some examples can be seen in Figure 19 - 20.

Figure 19. Location Search

Figure 20. Accident Data Search

Accident Ranking

The ranking function will list out the 10 most serious node or link in the study district by using Highway Planning Unit (HPU) frequency as indicated in Table 1 and one of the sample outputs can be seen in Figure 21

Table 1. HPU Frequency

Accident Severity	HPU Frequency (Point)
Fatal	200
Hospitalized (Serious)	100
Slight Injuries	50
Damage Only	10

Figure 21. Accident Ranking

5. CONCLUSIONS

With the proper setup of GIS-RAV System, the user or decision maker can retrieve, analysis, and display database on its spatial characteristics. GIS-RAV System is developed to provide the following functions:

i) The core functions are entering, searching and retrieving information from database.
ii) Main supportive functions are Node Analysis and Distribution Plot.
iii) Minor functions included are Searching Engine and Accident Ranking

GIS-RAV System comes with a lot of advantages, such as quick access for obtaining information and able to store a wide range of spatial information. It is purposely design for non-computer expertise, for instance security stuff in UPM.

The development of the GIS-RAV System has been tested thoroughly and all major flaws have been weeded out. Basically, this project has described a framework for prototype in establishment a GIS-RAV System for traffic accident application in UPM campus. The system is able to retrieve, process and analyze the study graphically and thus the diagnosis rules in a more systematic and realistic ways.

GIS offer an advanced engine to drive, both area-wide and location-oriented investigation. A GIS based application was chosen as the best alternative to improve the accuracy and timeliness in priorities accident location. The initial advantages are its' user friendly software interface, ability to locate locations quickly and accurately on a map, database setup is inexpensive and ability to find out the accident prone area quickly.

The user can retrieve accident information through the node analysis or the distribution plot. The Node Analysis is a function, which able to visualize road accident on the selected location with maps, photos, and simultaneously, further information such as site information and accident data will be display statistic graphically. The Distribution Plot is another function, which provides a better query system in priorities and identifies the accident-prone area and thus presents the overall accident location in general.

5. SUGGESTIONS AND RECOMMENDATION

As for future works, however, the system can be enhanced to provide more features in the following ways:

- ✓ Adding multimedia capabilities such as the ability to store digital photographs.
- ✓ Adding printing function which ability to print out the accident information.
- ✓ Adding a function which able to capture the collision diagram of the accident.
- ✓ Change the database in term of textual format to tabular format.
- ✓ Security guards co-operation is very important especially for the duty officer.
- ✓ The co-operation from the person who involved directly or indirectly is very important too.

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