ISSN: 0128-7702
Pertanika J. Sci. & Technol. 6(1): 81-93 (1998)

A GIS Support System for Road Safety Analysis and Management

Ahmad Rodzi Mahmud, Radin Umar Radin Sohadi and Shattri Mansor
Road Safety Research Centre
Faculty of Engineering
Universiti Putra Malaysia
43400 UPM Serdang, Selangor, Malaysia

Received : 15 May 1998

ABSTRAK

Dalam mengenalpasti punca kemalangan jalan raya, jurutera, perancang dan penentu polisi sering memerlukan maklumat terperinci untuk menentukan langkah rawatan cegah yang diperlukan. Selain dari analisis statistik, ia juga memerlukan maklumat geografi yang berkaitan. Kertas ini membincangkan sistem maklumat pakar yang sesuai. Kajian ini merangkumi daerah Majlis Perbandaran Seremban Negeri Sembilan dengan kerjasama Polis Di Raja Malaysia dan Majlis Keselamatan Jalan Raya Malaysia.

ABSTRACT

In diagnosing the cause traffic accidents, traffic engineers, planners and decision makers often need as much information as possible before deciding the appropriate countermeasure. In road safety analysis apart from producing the most accurate prediction from statistical figures, the need to visualize information geographically is always essential. This paper describes the implementation of SMKJ2, the method used to provide multiple ways of visualising accident data based on certain set of criteria, and the plan to incorporate multiple experts and knowledge base in to the system. The project, presently confined to the area of Seremban City Council of Negeri Sembilan, has been carried out in collaboration with The Royal Malaysian Police and The Road Safety Council.

Keywords: GIS, Road Safety

INTRODUCTION

Advances in information technology have brought with them a number of new information systems in Malaysia. One of the most popular systems is the Geographical Information System (GIS). Since the early nineties, a sizeable number of public and private agencies have started to use GIS in managing their information.

Developments in local GIS applications have created a new avenue for managing traffic accident information in Malaysia. One of the pioneering GIS researches in traffic safety was a study on linking the flexible Microcomputer Accident Analysis Package (MAAP) data to a DOS version of the MAPINFO package (Ahmad *et al.* 1993). A study conducted by the Road Safety Research Centre, Faculty of Engineering, Universiti Putra Malaysia was aimed at encouraging GIS users in Malaysia to use the accident data that have been compiled nationally in MAAP since 1992 (Radin Umar and Baguley 1994). This approach was taken in view that (i) some geographical and spatial data had already been customized in their respective GIS systems and (ii) general reluctance to change to types of information systems other than that already used by the respective organizations.

With the increasing popularity of the Windows application in Malaysia in early 1992, many software users had switched from the DOS version to the Windows application. Unfortunately, new routines need to be rewritten to cope with this trend. As a result, the ARC/INFO system was chosen as it offers more features and can easily be linked to other department as the package is being widely used in Malaysia.

This paper presents some preliminary results on presenting and incorporating heterogeneous outlays for road safety analysis and management. The system was developed based on the ARC/INFO package and run on the UNIX environment. Accident data were extracted from the pilot project in Seremban (Radin Umar and Aminuddin 1992) and were used for demonstrating the prototype version of the information system.

DEVELOPMENT OF ROAD ACCIDENT ANALYSIS AND MANAGEMENT SYSTEM

The initial system was designed with the intention to display the various sets of road accident data in the form of a thematic map. Besides encouraging the GIS users to use the accident data compiled in MAAP, this research was also aimed at supplementing the output of the customized version of the Microcomputer Accident Analysis Package (Radin Umar *et al.* 1993). Tools for the system have been designed to give the easiest displaying mode for the most frequent query by the decision maker during the accident investigation processes. Outputs, either in the form of figures, diagrams, graphs or maps can be retrieved without having to issue a long list of commands.

For visualising the detailed situation leading to an accident, a special tool was created for processing and presenting the accident situation at a certain location within a specified period. This was achieved by (i) developing some analytical routines, (ii) redesigning a special menu and (iii) integrating them as an integral component of the base system. For future development, a knowledge base information will be incorporated to produce an intelligent system. This will allow for an automatic judgement in the diagnosis and proposing of an engineering remedial treatment. This full system is in line with the concept of a "true GIS" application system (Vrana 1989) which is capable of performing a variety of statistical analyses and overlay processing that integrate information on several spatially-distributed variables at once.

Source of Accident Data

This study was based primarily on a specially created accident form POL27(Pin 1/91) collected by the Royal Malaysian Police (PDRM) in the pilot areas

Seremban and Shah Alam (Radin Umar and Aminuddin 1991,1992). The form was designed for easier completion and is fully compatible with the TRL's (Transport Research Laboratory) accident analysis package MAAP (Radin Umar *et al.* 1993). The person filling in this form simply needs to circle the relevant value for each accident parameter, which has been conveniently classified into various sections. In a few cases where figures such as year or age are required, the officers needs to fill up the relevant boxes. This information is manually keyed in into MAAP using the programme option available in MAAP.

Classification of Textual Data

In order to optimize the storage space, the MAAP data were structured in a "flexible" format. The arrangement and the amount of each data set depend on the number of vehicles, passengers and pedestrians involved. To make it readable in the GIS system the data have to be converted into a tabular form. This was achieved by transforming and classifying each data set (*Fig. 1*) into five tabular databases; location, main, vehicle, passenger, pedestrian and driver.

Location Coding of Traffic Accidents

In order to link files, each accident record was given a unique identification number based on the states, districts, police stations and record number. Each record was also given the appropriate link, node or cell number (*Fig. 2*). A node is the point location to represent a junction. Any accident that occurs within the radius of 20 m from the junction is given a node number to represent the position of occurrence. A link, on the other hand, is a line to represent a route connecting one node to another node. An accident that occurs on a link is therefore given the two node numbers that connect the link. The area defined by a polygon bounded by a series of links is known as a cell. This coding system is used to represent an accident within an area where no nodal or link number can be assigned to identify the accident location.

On rural roads where the kilometre post system is installed, the location coding is based on the kilometre post installed along the route. The best accuracy of this system is to the nearest 0.5 kilometre (Baguley and Radin Umar 1994). Although the accuracy is not quite precise it is still possible to pin point the hazardous locations along the route. This type of data classification is very useful for making comparisons with the attributes of the road and its environment where a process called 'dynamic segmentation' can be used to display data for routing analysis.

Classification of Spatial Data

Spatial data were obtained by digitizing topographical and road maps. This was achieved by the use of the AutoCAD drafting package. The digitized data were edited and converted to ARC/INFO environment in different set of layers

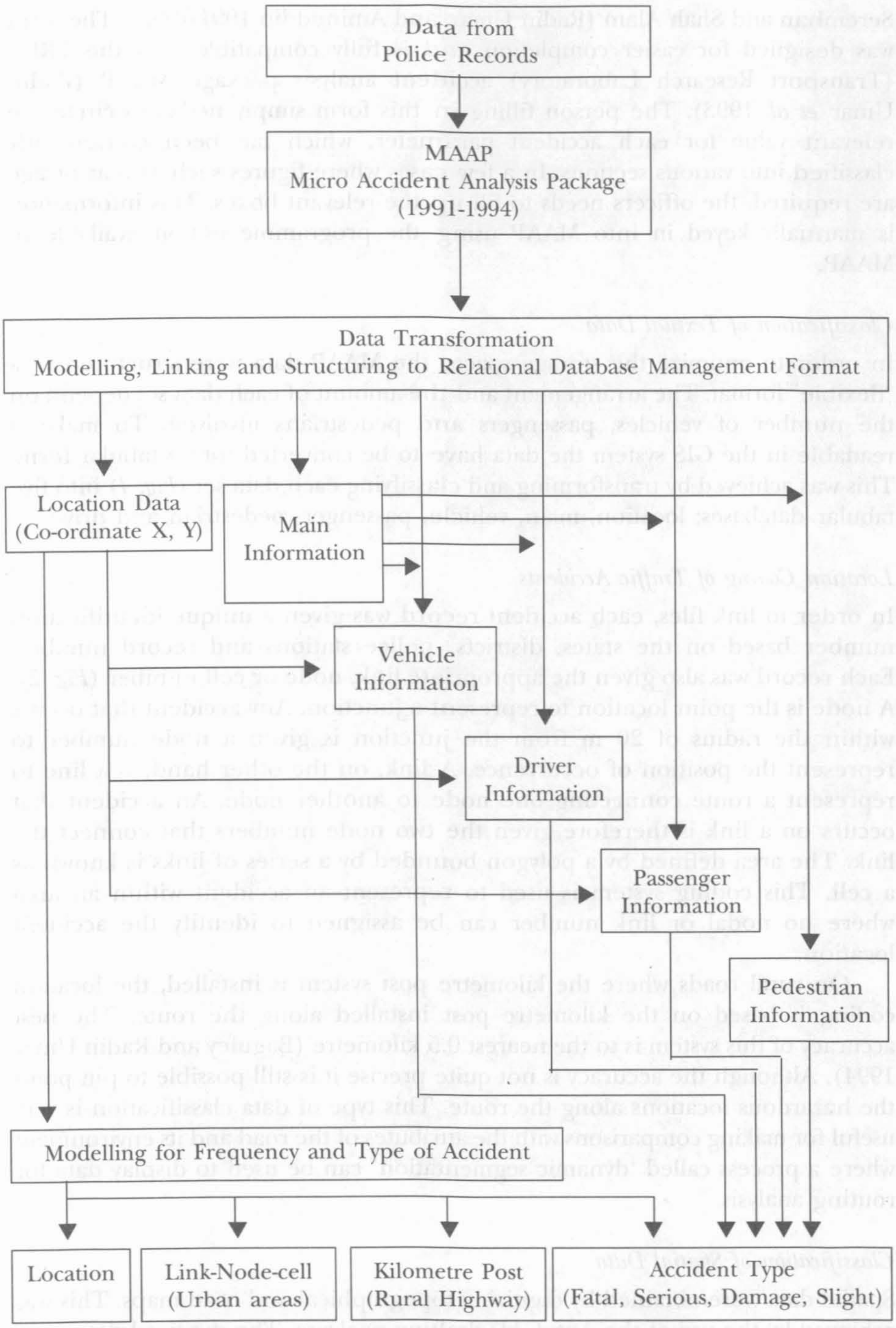

Fig. 1. Data transformation and modelling to relational database format

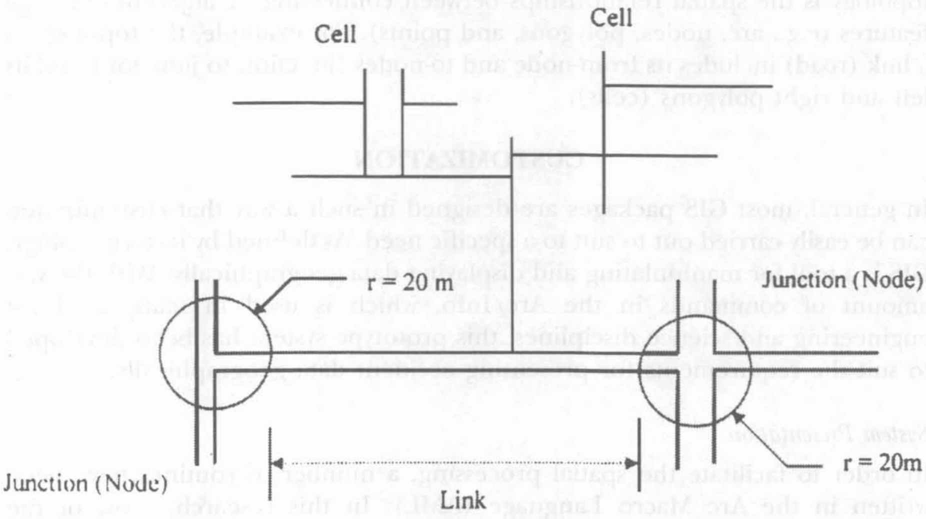

Fig. 2. Location classification for outlay (link, node and cell)

called "coverages" (Table 1). Further screen digitizing for the road centre line, cell and node definition was carried out to create coverages. The topology for each coverage was then built to be made it linkable to textual information. A

TABLE 1
Classification of spatial data

Feature Type	Data Type	Coverages Description	File Type
Points	Coordinate X–Y	Accident location	.PAT
Arcs	Series of line – link	Road, river, boundaries, railway, etc.	.AAT
Nodes	Coordinates of intersection of roads centre-line intersection	Road junction	.NAT
Polygons	Cell	Area covered by a pre-defined section	.PAT
Route	Segmented and measured arcs	A pre-defined route (consist of a series of arcs or part of an arc) - main road	.RAT .SEC

Note: PAT – Point of Polygon Attribute Table, AAT – Arc AttributeTable,NAT – Node Attribute Table, RAT – Route Attribute Table and SEC – Section Attribute Table topology is the spatial relationships between connecting or adjacent coverage features (e.g., arc, nodes, polygons, and points). For example, the topology of a link (road) includes its from-node and to-nodes (junction to junction) and its left and right polygons (cells).

CUSTOMIZATION

In general, most GIS packages are designed in such a way that customization can be easily carried out to suit to a specific need. As defined by its terminology, GIS is a tool for manipulating and displaying data geographically. With the vast amount of commands in the Arc/Info, which is used in many fields of engineering and science disciplines, this prototype system has been developed to suit the requirements for presenting accident data geographically.

System Presentation

In order to facilitate the spatial processing, a number of routines have been written in the Arc Macro Language (AML). In this research, most of the relational processes between the tabular databases were "hiddenly" done in the background. The process of relating the tabular databases is quite complicated and one needs to have some understanding of the database structures. A menu was created as an interface to make it user-friendlier and to protect users from giving faulty commands that may damage the database.

Visualising Data Geographically

From the menu design, the user has the opportunity to view data heterogeneously on the particular area of study. This information can be visualized in several perspectives and therefore can assist the professionals to suggest the appropriate remedial works. This can be achieved by analysing the evidence given not only from the statistical figures but also from various presentations of thematic maps.

Among the presentations that have been made possible are: -

a) plotting the distribution of accident bases on their location, which is determined by their co-ordinates (*Fig. 3*),
b) the frequency and distribution for different criteria in every cell (*Fig. 4*), and at specified links (*Fig. 5*);
c) presentation of occurrences along the route in the form of dynamic segmentation (*Fig. 6*).

Dynamic Segmentation

Apart from displaying the search output base on their coordinates, a method known as dynamic segmentation in the system has been exploited to visualize the distribution of the accidents. This method allows users to analyse and predict accurately the safety situations along a particular route. This segmentation was carried out by defining a series of arcs that represent a particular route. Each arc has its own attributes, which reflects different segments of information along the route. The distribution along the route can then be mapped along

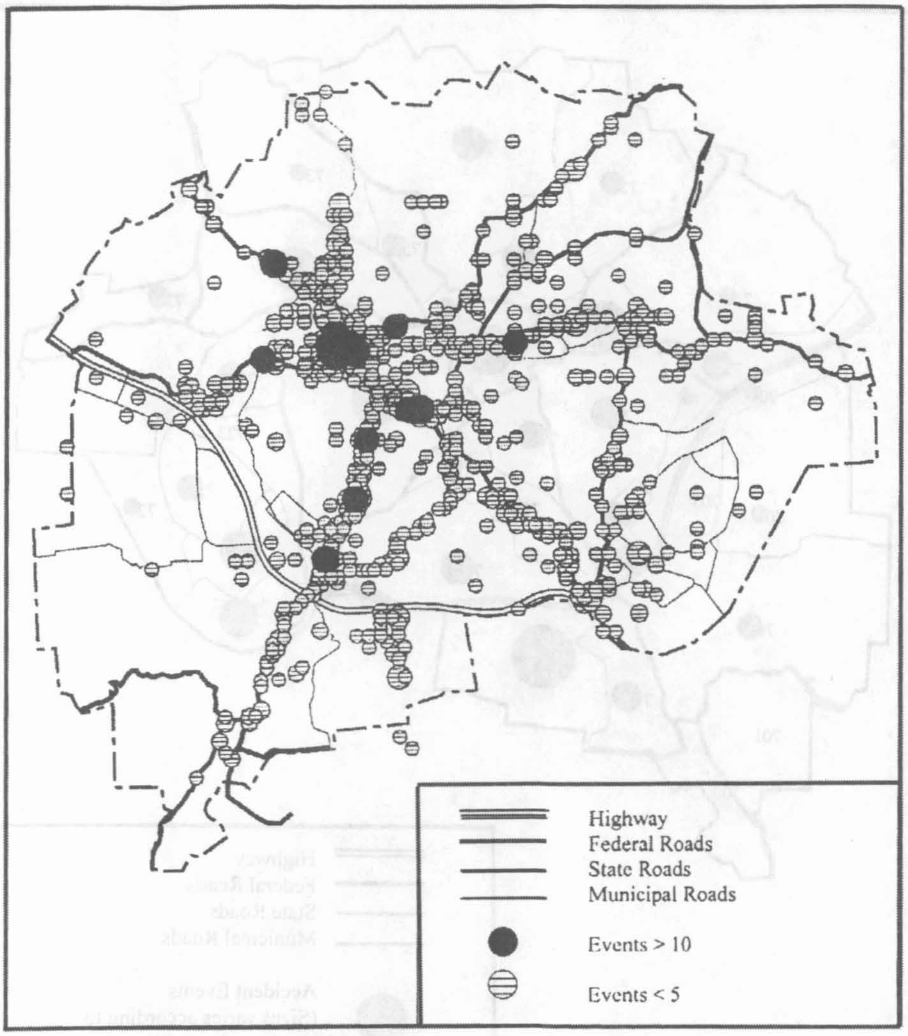

Fig. 3. Accident distribution based on recorded co-ordinates

the route. Each segment has different attributes such as pavement material, road sign and road furniture, traffic volume, surface condition, etc. and can be differentiated by displaying them in different symbols. This method of presentation can be visualized either in its true form or in the form of graphs.

Query by Example

One of the important features of this system is that it has extensive capabilities to facilitate users in making queries and can send the output to a plotter or a

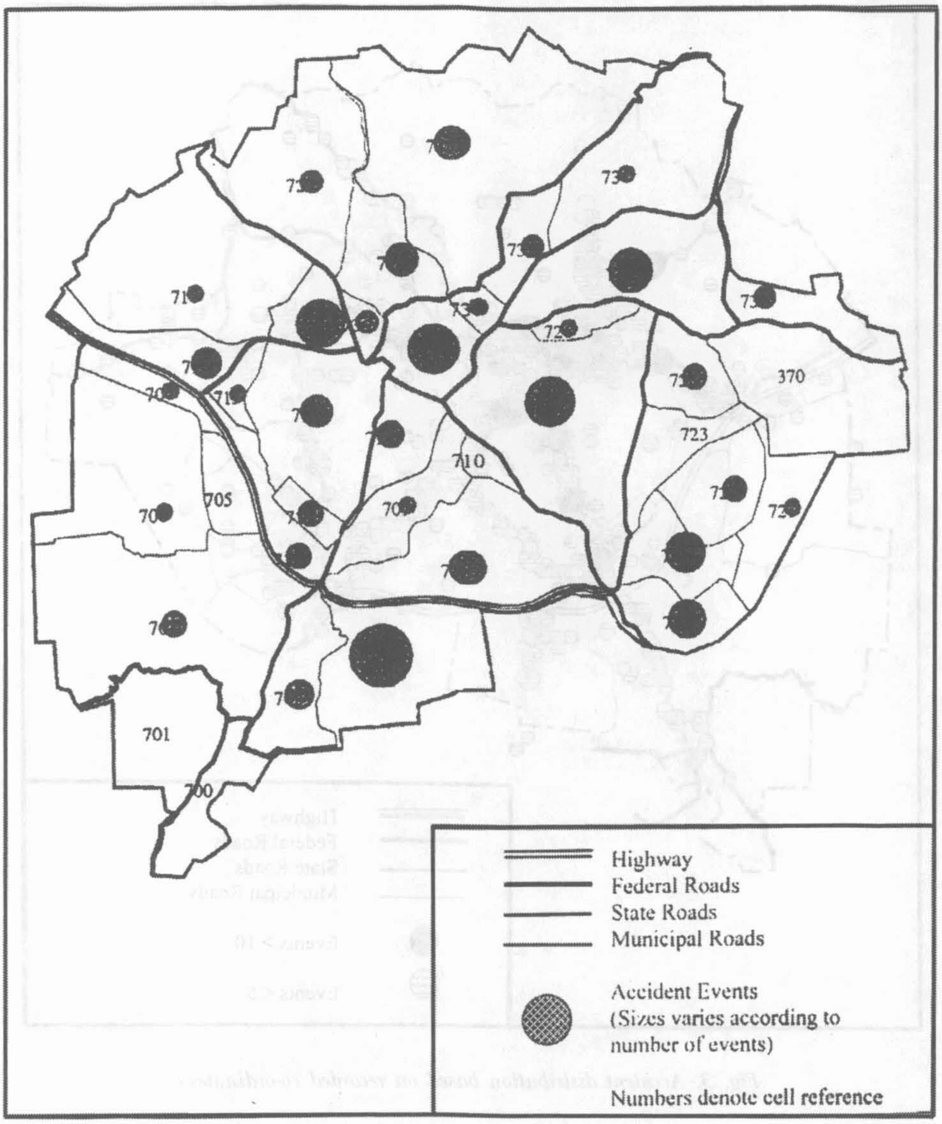

Fig. 4. Accident distribution based on defined cells

printer. The users therefore do not need to have an extensive knowledge of the operating system or knowledge of the GIS package. As an example, a user may need to identify all entities in a database that meet his specifications such as display all accidents occurring after midnight on rainy days. The system will check through the database to match the criteria and will display it on the screen.

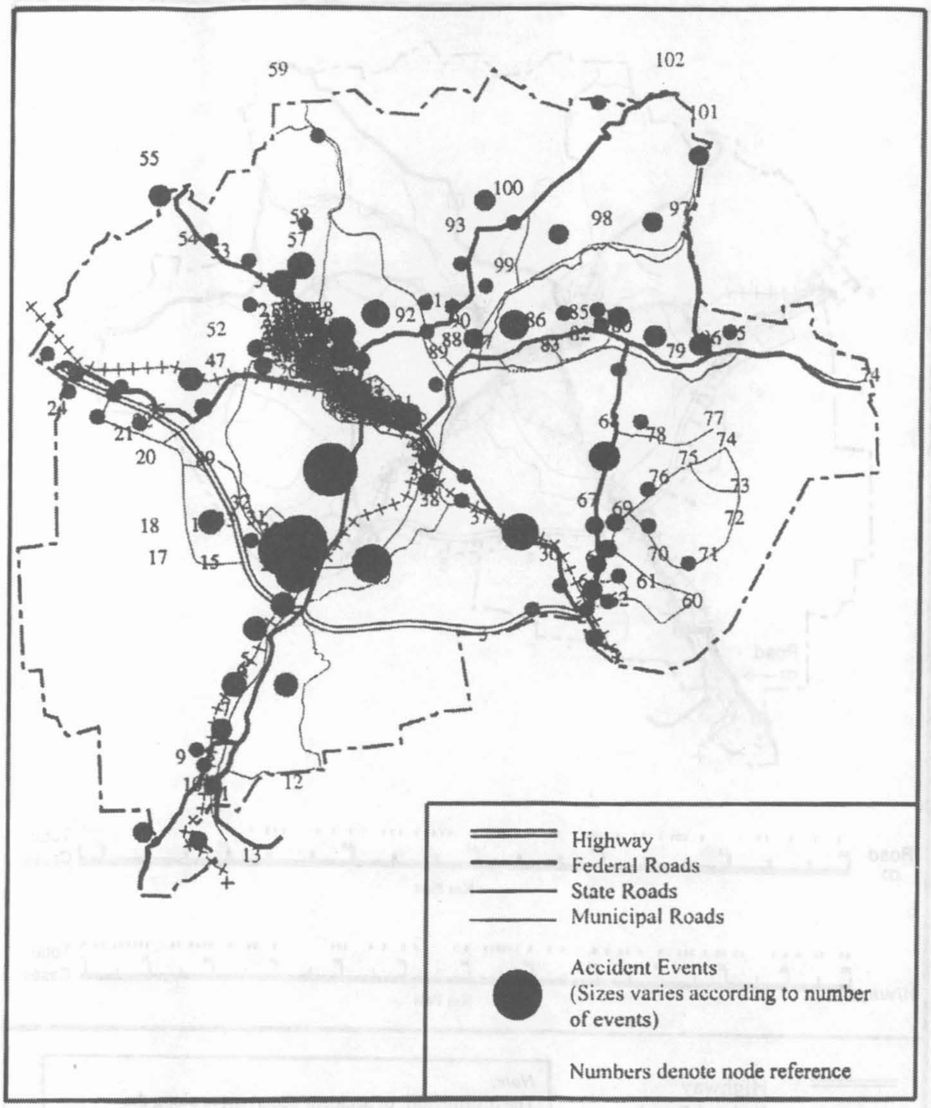

Fig. 5. Accident distribution based on link

INCORPORATING AN EXPERT SYSTEM IN THE ACCIDENT INFORMATION SYSTEM

In diagnosing and treating hazardous locations, engineers are sometimes ill-equipped with the necessary information for a "direct" and a cost-effective treatment. As a result some assessments are rather subjective and may be drawn

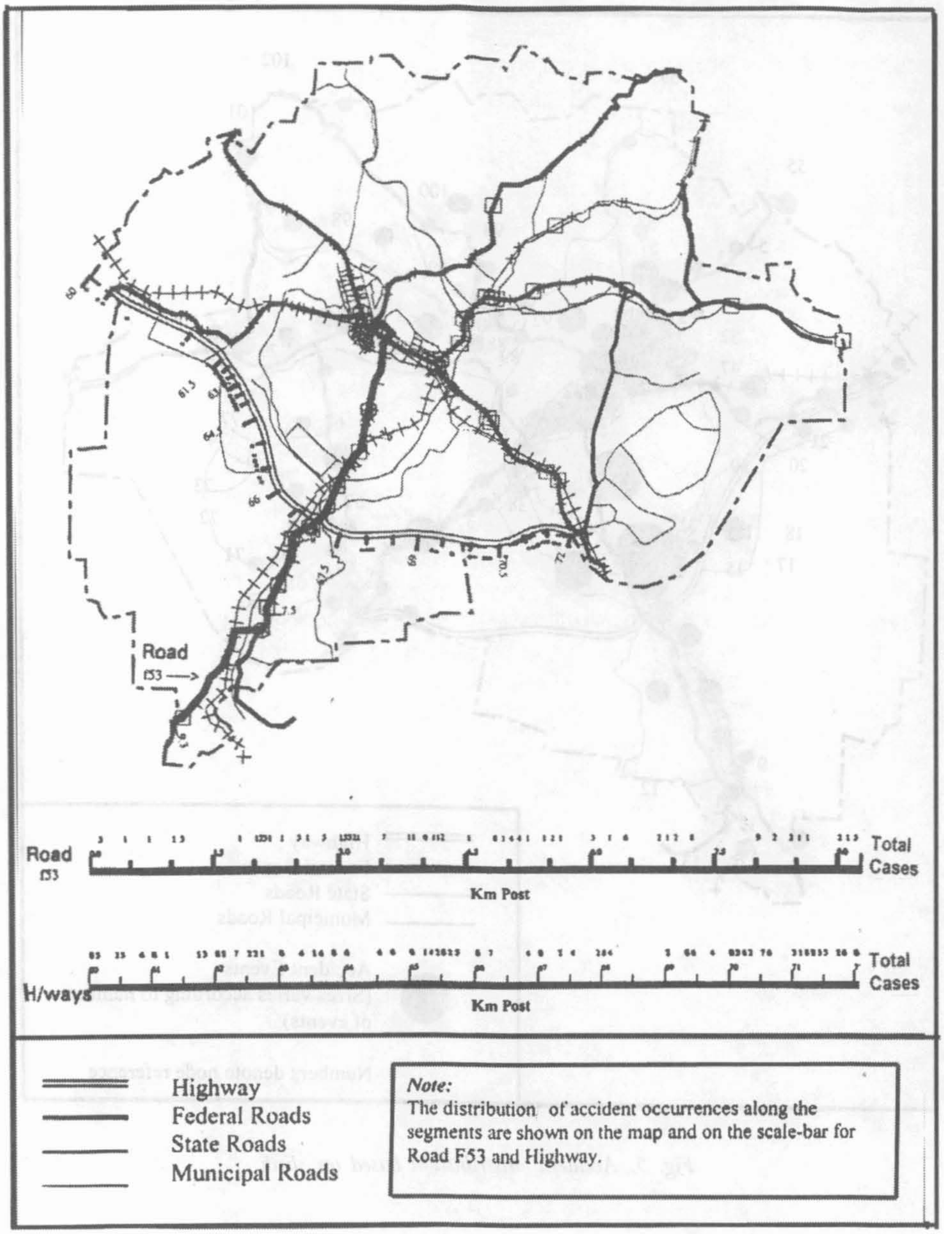

Fig. 6. Accident distribution based on dynamic segmentation

from some uncertainty due to uncertain evidence. In this situation, the decision always depends on the skills and the experience the engineers (Wu and Heydecker 1993). This phenomenon suggests the need for an expert system to infer and interpret figures based on a certain set of rules.

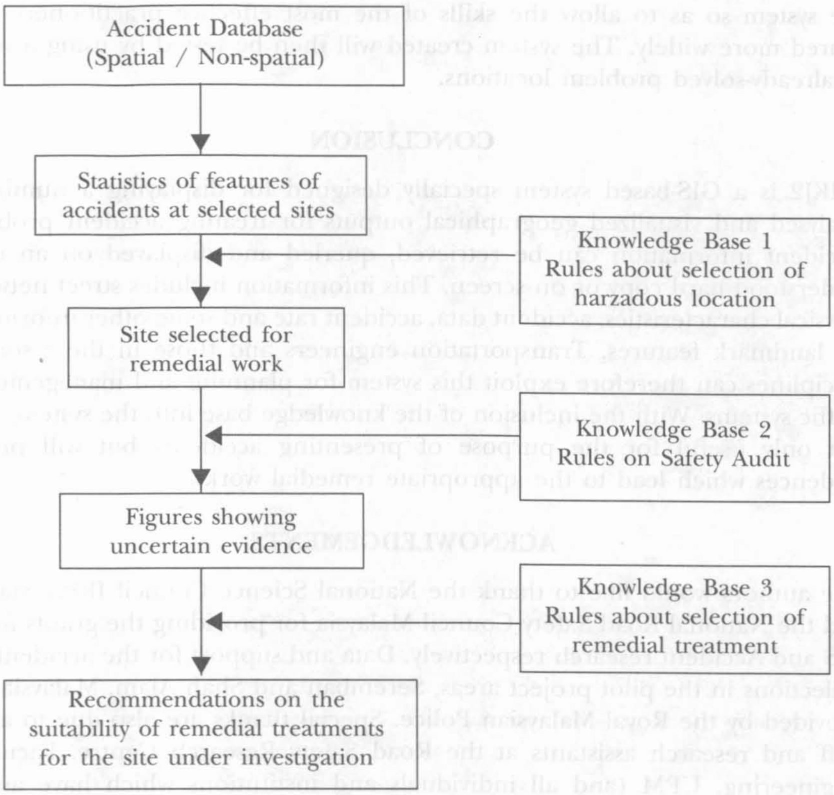

Fig. 7. Structure of the expert system for remedial work

An important feature to be integrated is the use of a knowledge-based system. Special tasks which are still under development will enhance the system to automatically and intelligently identify hazard locations. One approach is to study the prioritization system either based on accident frequency and rates or other techniques such as PAR (McGuigan 1986). In addition, a study of the formal can be made and this includes the guidelines and code initiated and published by the British Institution of Highways and Transportation (IHT 1990) and the local authorities. A collection of remedial work undertaken at certain high hazard locations will be investigated. This requires a good and thorough set of accident data and statistical models to predict the influence of various explanatory variables in explaining traffic accidents.

Based on the previous remedial work done, algorithms for developing the intelligent system can be formulated. This implies that diagnosis and treatment knowledge has to be acquired as an input to the inference engine. The inference engine will manipulate the knowledge base for presentation and problem-solving. Relevant expertise and experience will be incorporated into the system so as to allow the skills of the most effective practitioners to be shared more widely. The system created will then be tested by using a library of already-solved problem locations.

CONCLUSION

SMKJ2 is a GIS-based system specially designed for displaying a number of analysed and visualized geographical outputs for treating accident problems. Accident information can be retrieved, queried and displayed on an easily-understood hard copy or on screen. This information includes street networks, physical characteristics, accident data, accident rate and some other information on landmark features. Transportation engineers and those in the associated disciplines can therefore exploit this system for planning and management of traffic systems. With the inclusion of the knowledge base into the system, it will not only useful for the purpose of presenting accidents but will provide evidences which lead to the appropriate remedial works.

ACKNOWLEDGEMENTS

The authors would like to thank the National Science Council IRPA Malaysia and the National Road Safety Council Malaysia for providing the grants for the GIS and Accident research respectively. Data and support for the accident data collections in the pilot project areas, Seremban and Shah Alam, Malaysia were provided by the Royal Malaysian Police. Special thanks are also due to all the staff and research assistants at the Road Safety Research Centre, Faculty of Engineering, UPM (and all individuals and institutions which have assisted directly or indirectly in the course of the research).

REFERENCES

AHMAD RODZI, M., R.S. RADIN UMAR and S. SALIHA. 1993. Persembahan maklumat kemalangan dengan sistem maklumat geografi. *The Surveyor, The Professional Journal of Surveyors Malaysia* **28(3)**:

BAGULEY C.J and R.S, RADIN UMAR. 1994. The improvement of accident data quality in Malaysia. In *Proc. 1st Malaysian Road Conference, Kuala Lumpur.*

Institution for Highways and Transportation. 1990. The Safety Audit of Highways. London: IHT.

MCGUIGAN, D.R. 1986. The use of relationships between road accidents and traffic flow in blackspots identification. *Traffic Engineering and Control* **22(8,9)**:448-453

RADIN UMAR, R.S AND C.J. BAGULEY. 1994. The identification, prioritising and analysis of accident blackspots in Malaysia. *Journal of Road Engineering Association of Asia and Australasia* **January 1994**: 20-28. Vol. 3

RADIN UMAR, R.S., M. AHMAD RODZI AND A. AMINUDDIN. 1993. Model diagnosis dan rawatan kemalangan jalan raya di Malaysia. *Pertanika J. Sci & Technol.* **1**: 125-151.

RADIN UMAR, R.S. AND A. AMINUDDIN. 1991. Sistem diagnosis kemalangan jalanraya. In Seminar Tahunan ke 32, Majlis Keselamatan Jalan Raya Malaysia, Kuching, Malaysia.

RADIN UMAR, R.S. AND A. AMINUDDIN. 1992. Sistem Diagnosis Kemalangan Jalanraya, Laporan Penyelidikan No 1, Majlis Keselamatan Jalanraya, Kementerian Pengangkutan Malaysia.

VRANA, R. 1989. Historical data as an explicit component of land information systems. *Int. Journal Geographic Information System* **3(1)**: 33-49.

WU, J. and B.J. HEYDECKER. 1993. A knowledge-based system for road accident remedial work. *Computing Systems in Engineering* **4(2-3)**: 337-348.