DEVELOPING A GIS-BASED METHODOLOGY FOR MANAGING AND ANALYZING ROAD TRAFFIC ACCIDENT DATA IN GREECE

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ABSTRACT

This study aims to develop a Geographic Information System (GIS) based methodology for managing and analyzing Road Traffic Accident Data in Greece, in order to resolve the current data management problems, and to support the decision making process, in the field of Road Safety. In Greece, Road accident data are being collected by many different entities such as Local Road Traffic Police Departments, Hospitals, Organizations or Insurance Companies. Databases are not linked to each other, leading to mismatches, re-collection of the same data, and loss of time and information. Furthermore, Road Traffic Accident Data usage in Greece is limited to mainly serve statistical purposes only, while its contribution in decision-making process is narrowed. Taking into consideration these facts, GIS were accounted as a proper tool to manage the road accident data, and support the decision making process in the field of Road Safety, in Greece. In order to implement the methodology, the city of Veria was chosen as a case study area.

Key Words: GIS, Road Safety, Accident Analysis

INTRODUCTION

Road Safety is considered as a significant topic worldwide, both at national and international level. Simultaneously, due to the evolution of Geomatics in recent years, considerable number of studies has been carried out, focusing on the development and implementation of geographic information based tools, in the field of Road Safety.

The consequences of Road Traffic Accidents are significant for the social, economic and political level of a city or a country. The importance of Transport Safety, especially Road Safety, is stated clearly in the latest White Paper of the EU, for the future of Transportation in Europe (European Commission, 2011).

The national efforts of nation, to address the problem, more or less systematical, aim the reduction of the number of road accidents and the severity of their impact. An important step towards this direction is the investigation the causes of accidents, and the identification of possible differences according to
the location of an accident. Some of the strategies are common in many states, but it is clear that each country adapts and refines the above mentioned, based on the local characteristics, culture and needs.

At this point, it should be noted, that Road Accidents are a result of the combined effect of three factors, which are:

- The User of the road, which is the most important factor
- The Vehicle
- The Environment, which includes the Road Environment and the Supervision (Policing) of the System.

(World Health Organization, 2004)

The stakeholders involved in Road Safety, are illustrated in the literature as «three e's» (enforcement, engineering, education), which are: the Enforcement or Road Traffic Police, which is the authority responsible for controlling and policing the system, the Engineers, who are responsible for the design and construction of road infrastructure and environment, and, ultimately, Education, which plays the most important role in cultivating the driving culture and behavior (Khan & others, 2004). It is obvious, that there should be a mutual collaboration between these sectors, in the direction of improving the level of Road Safety.

GIS allow today the concurrent management of large amount of spatial and attribute data, and provide a variety of processing capabilities and spatial data analysis tools, while offering prospect for standardization and automation of various processes. According to the above mentioned, GIS can contribute accident reporting, data analysis, and especially to the investigation of factors affecting the level of road safety. Particularly, the use of GIS contributes to the identification of factors that would not be noticeable using other conventional methods of statistical analysis (not location based).

In general, it is established that GIS is a reliable decision-making and prioritizing tools, supporting more focused interventions and leading to better use of available resources. Also, GIS can enhance interactivity between all the involved sectors/ stakeholders in road safety, setting a "common language", taking advantage its data representation and illustration abilities.

SIMILAR STUDIES – INTERNATIONAL PRACTICES

Internationally, spatial analysis of road traffic accidents draws major concern from all stakeholders. For this reason, various studies and applications have been carried out in the last fifteen years, from universities or official authorities. In these studies, simultaneous management of spatial and attribute data is being achieved, focusing on the spatial approach of Road Safety. Also, most of these studies are trying either to discover specific correlations between road accidents and various location attributes (land uses, demographics) or to identify which GIS methodology-tool is the most appropriate for analysis.

Erdogan and others, examined the differences between fixed distance accident density and Kernel density analysis, in a motorway located in Turkey. Kernel density leads to more reliable results (Erdogan 2008). Anderson, in 2006, has presented a study in which, a comparison between three spatial GIS based methods (Kernel density estimation, network analysis and area wide analysis) for road accident hot spots identification in urban areas, is demonstrated. The case study area was North London, and the results showed that network based tools can illustrate hot spots in more realistic way (Anderson, 2006). Larsen came up with similar outcomes, examining the results of applying planar-based tools in accident analysis in Philadelphia. The results showed that the use of planar methods lead to more clustered accident locations than it is in reality (Larsen, 2010). The source of the problem, as it was illustrated in two latter studies, is that accidents occur in a network, and the tools for analyzing the phenomenon are identifying the incident space as continuous.

Mitra in 2008 performed an accident analysis in Inland Empire (Region of California State) using spatial and socio-economic data. The output indicated that there are certain correlations with specific locations such as schools, bars or pubs and high-density population areas (Mitra, 2008). Additionally, Truong presented a methodology, based on spatial autocorrelation analysis of pedestrian-vehicle accidents to identify and rank unsafe bus stops, in the Adelaide metropolitan area. Results indicate that the proposed methodology is able to detect spatial patterns of crash data and reasonably identify and rank unsafe bus stops in pedestrian-vehicle crash hot spot areas (Truong, 2011). Wang, in his doctoral
thesis, investigates the relationship of traffic accidents and traffic congestion. The results are mixed, but seem that traffic congestion may lead to more accidents but reduced accident severity (Wang, 2010).

Except studies from universities, many authorities have developed their own specialized GIS systems, for managing and analyzing road traffic accident data. The US Federal Highway Administration has initially developed a GIS analysis system, in 1999, with several tools for analyzing accidents that occur in highways (FHA, 2001). Furthermore, the “Metroplan Orlando” has developed a GIS system for observation of road accidents in three jurisdiction counties, including urban areas (Metroplan Orlando, 2009). In Finland, the “Statistics Finland”, has developed a GIS based application called “Map Application”, that is using the existing road accident database. The “Map Application” is used to assist the site accident identification, to support road accident analysis and to improve road safety (Tormanen, 2010).

PRESENT SITUATION IN ROAD ACCIDENT DATA MANAGEMENT IN GREECE

In Greece, the entities, which officially and systematically collect Road Accident Data, are the Road Traffic Police Department, the Hospitals, and the Insurance Companies. Though, the kind of data being collected, as well as the method and the time of collection, differ from case to case. More over, the databases created by each party, are not linked to each other, leading to mismatches, re-collection of the same data, and loss of time and information. In the following figure, the entities that collect Road Accident Data, are being presented, together with the forms used in any case, as well as the databases and the final outcomes from each one.

![Figure 1: Present situation in road accident data collection in Greece, (Palaskas S., 2005)](image)

From the figure, it is obvious, that for every accident, there are many forms filled by different entities. As is was stated above, many information are being recollected, while the same time, the results may differ from case to case, due to the different methods followed in any case.

METHODOLOGY – PROPOSED SYSTEM – CASE STUDY

The methodology developed, aims firstly the exploitation of available road traffic accident data and the illustration of current trends, and secondly, the possibility of adding new data, so that the system is always up to date. The update feature is crucial, as road traffic accidents is a phenomenon that is expressed dynamically in space and time.

The approach which was adopted, can be divided in three steps, which are:
1. Data processing
2. Provision of digital cartographic features
3. Geocoding

The update and analysis processes are not considered in the three steps of the methodology, as the former is not necessary for the application, and the latter can be implemented in many different ways.

Thus, at the first step (data processing), the available data has to be imported into a manageable database. At this point, it should be underlined, that in the case of Greece, the road traffic accident data is available in printed form. To enable data processing and exploitation, a database has to be created, based on the relevant official form, which is used for the data collection.

The basic accident data parameters in all the accident forms can be summarized in the following broad categories (Khan, 2004):

- General information: Year, Month, Day of the week, Hour etc.
- Location: Street Number, Intersection No, Geographical/GPS co-ordinate, Milepost, Area Name etc.
- Road user: Age, Sex, Road user type, Alcohol consumption, Seat belt use, Car passenger position, Driving license category, Date of Issue, etc.
- Injury details: Extent, No of persons Injured, Injured Person Details, Evacuation means etc.
- Road environment: Road type, Road category, Weather conditions, Lighting conditions, Road surface, Road surface conditions, Traffic control etc.
- Vehicle: Vehicle type, Vehicle age, etc.
- Accident: Accident type, Maneuver type etc.

The imported data should be coded, in order to be able to perform any kind of manipulation process. The coding has to be based on the fields of the official form, in order to be compatible with existing data. During the import process, attention should be paid in order to avoid errors or omissions that could lead to unreliable results. For this reason, tools for input check on the database, like acceptable values or drop down lists, are highly recommended.

Concerning the presented system, the most important data element is the location of the accident. And the exploitation of this information consists the main difference between the solely statistical analysis and geographical and geostatistical analysis. The location reference of an accident can be recorded in several ways, according to the authority that collects the accident data. In Greece, the Traffic Police, stores the location of an accident, based on the postal code, given that the accident occurred in urban environment, or based on the kilometric point, if the accident occurred in regional road. Therefore, the use of geocoding tool is required. Nevertheless, in other countries, the location reference can be given by the coordinates of the accident, simplifying the procedure.

In the next step, the available digital features of the study area are examined, in order to identify if they meet certain conditions. The conditions are:

- The road network should be linear and geometrically correct
- The data must contain road numbering or kilometer pointing, so the address locator can be created
- If multiple data features are used, they must be in the same reference system

Ultimately, using the geocoding tool that combines the address locator with the stored data, each one of the accidents is placed to the incident location point. Each accident point contains its attribute data, in order to perform further analysis. In this way, accident data import process, and generally data management, is being systematized, and moreover, the spatial dimension of the accidents, is emphasized, something, which until now was not examined, or it was partial and empirical.
To perform further analysis, it is necessary to apply some spatial analysis tools, which are contained in GIS software. For the analysis of road traffic accidents, there are not any specific tools established yet, because it is a relatively recent approach to the problem, in comparison to the spatial analysis of crime that exists for many years (Anderson T., 2006). Only the last fifteen years, many studies were carried out, examining which methodology is the most reliable, in order to draw safe conclusions. The methodologies or tools, which are commonly used for road traffic accident spatial analysis, are:

- Accidents per km
- Aggregated Accident Rate
- Central Feature
- Kernel Density Estimation
- Spatial Autocorrelation
- Spatial Correlation

In order to assess how the developed methodology can be applied, a case study area was chosen. The case study area consists of two separate spatial levels, which are the city of Veria (urban road network) and Egnatia Motorway (district road network), so to investigate the outcome of the methodology in urban and non-urban environment. Based on the methodology presented, the steps for the application, in the case study area were:

1. In collaboration with the local Road Police Authority, the road accident data that have injuries and deaths were recorded. Accident data were derived from the “Abstract Forms”, which are generally filled within three hours from the accident, for the years 2006, 2007 and 2008.
2. Thereafter, because the data was in handwritten form, it was imported in a database that was designed. The data was coded. The coding that is used, is the same that the Road Police Authority uses to compile the monthly road accident reports.
3. The digital background used was from Urban and Regional Planning and Development Engineering Department, Faculty of Engineering, Aristotle University of Thessaloniki that is based in the city of Veria.
4. Then, two Address Locators were created. One for the city of Veria and one for the Egnatia motorway.
5. Ultimately, the procedure is finalized applying the geocoding tool, to place each accident to each location based on the address or the kilometric position.

The software that is used for the application of the methodology was ArcGIS 9.2. The results of the geocoding procedure are presented in the following figure. About 2% of the data were not geocoded because their location was not recorded.
In the next two figures, the application of two different tools is presented, in the city of Veria. On the left, accidents within 50 meters were collected to a single point in order to count the accidents that are close to each other, and on the right, Kernel density is applied within 150 meters. It is obvious that the two methods highlight similar locations, more in the case of Kernel density because of the larger radius space.

Regarding the Egnatia Motorway, in the next three figures, is presented the application of three methods. In the first, the accidents within 2 kilometers, were collected to a single point, and were classified into 3 classes. In the second, a Kernel density estimation method was applied, in order to estimate the accidents density within 2.5 kilometers. In the last figure, the black spots in Egnatia motorway were calculated. To estimate the black spots, firstly the kernel density within 2.5 km, was calculated, separately for each type of accident (Fatal, serious injuries, slight injuries). Then, each density layer was reclassified into 10 classes. In the final step, the three layers were combined into a single one, using the “Weighted Overlay” tool, using this equation: \( P = X + 3Y + 5Z \) (X: slight injury accident, Y: serious injury accident, Z: Fatal Accident) (Geurts K., Wets G., 2003).
It is illustrated that there is a single location that in all figures is emphasized. Actually, this location proved to be problematic and in the last two years, some countermeasures have taken place.

CONCLUSIONS

The current Road Accident Data Collection and Elaborating System in Greece, is related to several weaknesses. For instance, there are many different entities collecting the same data, using different methodologies in order to achieve that. These entities maintain different databases, which are not linked to each other. All the weaknesses mentioned above, lead to re-collection of the same data, loss of data and mismatches of results (due to the different methodologies), resulting to low reliability of the Data Collection Process.

Regarding the utilization/usability of the collected data, their digital import and analysis, is narrowed to serve statistical purposes, and especially for showing the tendencies throughout the years. As for the spatial reference of the accidents is concerned, according to the current structure of the Road Accident Data Form, and the current Data Processing Procedure, it is not easy to be examined. It is being underlined, that practically, non specific methodology for finding the Black Spots is being followed. As a result, during the procedure of setting priorities by the Authorities, the Prioritization Procedure of the Authorities, does not take into consideration spatial factors, spatial factors either are not taken systematically into consideration at all, or, when they are, the criteria are mainly empirical (due to the Authorities’ good overview of the Study Area).

By using GIS tools, and specifically the proposed methodology, many of the problems, mentioned above, can be managed. The implementation of the methodology can contribute in many levels. First of all, the Road Accident Data Collection and Elaboration Procedure can be standardized. Secondly, the spatial dimension of the Road Accidents can arise into a major factor, for analyzing the facts and setting priorities. In such a way, Spatial Analysis can be implemented and Black Spots can be pointed out, supporting more reliable and focused surveys. More over, all of the resources can be managed in a more efficient way, reducing the time needed to process the data.

In the following figure, the current procedure and the proposed one are being presented and compared. It is obvious that, due to the proposed methodology, the procedures were simplified, and the cooperation between the different parties involved, can be implemented in a more harmonic way.
Finally, regarding the future aspects of the proposed methodology, there are several improvements that can be implemented in order to have a more user-friendly and automated system and to make data accessible for all the interested parties.

First of all, for the import of data, configured forms can be used, while for the process of the data, specific tools, based on the local needs, can be developed. More over, a web-based platform can be created, in order to give the users the ability to fill in the forms via Internet, and also provide accessibility to all the interested parties, enhancing the cooperation between them and making the data and the results visible to the public. In that way, the new technologies can be used in order to improve the analysis of Road Accident Data, a phenomenon with profound effects on the Society.

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