Rescue of Traffic Accident Injuries to Nearest Hospital Using Vector GIS

Conference Paper · October 2005

CITATIONS
0

READS
142

1 author:

Mohammed Taleb Obaidat
Jordan University of Science and Technology; Jadara University
99 PUBLICATIONS **376** CITATIONS

SEE PROFILE

RESCUE OF TRAFFIC ACCIDENT INJURIES TO NEAREST HOSPITAL USING VECTOR GIS

Dr. Mohammed Taleb Obaidat
Associate Professor of Civil Engineering; Civil Engineering Department
Jordan University of Science and Technology (J.U.S.T.); Irbid, JORDAN
Phone: 00-962-79-5604090 Fax: 00-962-2-7250222; E-Mail: mobaidat@just.edu.jo

ABSTRACT

An attempt to find automatically the nearest hospital to rescue injured people of accidents, and to send emergency medical service and care are demonstrated. Traffic and pedestrian accidents data used for the years 2001, 2002 and 2003 was obtained from the civil defense department (Rescue Department) at Irbid city, Jordan. Geographic Information Systems (GIS) themes and their associated databases were built using Arcview GIS software. Databases of themes contained types, causes, locations and time of accidents, call time, rescue departure and arrival time, required time to move injures to hospital, distance between accident and civil defense, distance from accident to hospital, accidents participants, and hospital name and location. Multiple regression analysis was used to model and predict the relationship between the previous database variables and the time duration required to rescue injuries from accident location to the nearest hospital. Results showed that GIS could be effectively used for this purpose by selecting the shortest path to the accident and thus rescue lives of injuries to the nearest hospital.

KEY WORDS: Vector GIS, Traffic and Pedestrian Accidents, Rescue, and Injuries.

1 INTRODUCTION

Nowadays, the merge of different technologies such as GIS, Intelligent Transportation Systems (ITS), Global Positioning Systems (GPS), and Computer Vision (CV) can make real-time response and measurement as a reachable task. In fact, the efficiency of transportation systems has been extensively increased through the usage of these advanced computer, electronics, and communication technologies.

As far as traffic accidents are concern, the rescue task of injuries is considered as one of the most important tasks that cause tremendous public concern. The reason behind that is the life survival of human beings whom are the most worthy thing in life. However, traffic congestion especially downtown urban areas would affect the rescue time required to send the injuries to the nearest hospital. Therefore, rescue vehicle and traffic routing as well as the selection of nearest hospital from accident location are essential in order to provide real-time response of rescue.

GIS has the advantage of using spatially referenced data that can strengthen the potential of routing functionality. Other advantage of GIS includes data management and manipulation capability as well as navigation potential. GIS time management capability is anticipated to easily control accident location. Therefore, GIS is expected to be a powerful tool for rescue routing.

In this paper, GIS queries and regression modeling will be used to select the shortest route from rescue department to accident's location, and the shortest route from accident's location to the emergency medical service center. Moreover, variables that affect the time duration from rescue department to accident location will be investigated.

2 LITERATURE REVIEW

The advancement of computer and communication technologies is anticipated to increase the transportation systems smoothness and efficiency. Therefore, the trend of research is going rapidly toward automation and real-time response. GIS, ITS, GPS, and CV are considered as the most powerful technologies used in the domain of emergency management, including traffic accidents and rescue task.

Medoza *et al.* (2000) targeted an efficient, reliable and automated GIS-based data management system for the purpose of processing and handling accident data on Federal Roads of the different states of Mexico. The system integrated GIS along with cartographic representation, classification and naming of roads, traffic characteristics, and accident information for vehicles and participant drivers. GIS queries made it possible to locate the most hazardous sites, classification of accident cost, distribution of medical centers, and the 95 percentile of the time period required to reach accident sites by emergency medical aid. According to international standards, the time required to reach accident location from rescue department shouldn't be more than 30 minutes in rural areas and 10 minutes in urban areas (OECD 1994).

Miller and Karr (1998) carried out a study about using GPS procedures to locate motor vehicle crashes and their impact on time and accuracy. They found that the GPS technology was promising to improve the accuracy of locating crashes rather than using hardcopy reports because they were difficult and time-consuming. However, they recommended to explore alternative procedure to speed the location process and improve its accuracy.

Duffell and Kalombaris (1988), Abdel-Aty and Jovanis (1997), and Wohlschlaeger (1997) studied the criterion affecting travelers' path choice. They concluded from their empirical studies that the minimum or shortest travel time, travel time reliability, number of traffic lights and stop signs, neighborhood security, congestion condition, and shortest travel distance were the most important criterion affected the drivers' path choice. Other factors could also affect the path choice including: personal characteristics (age, sex, education, profession, income level, etc), route attributes (travel time, travel cost, speed limit, waiting time, type of road, slopes, number of intersections, traffic density, number of turns, parking, probability of accident, bridges, environment, land use, etc), trip characteristics (trip purpose, mode use, number of travelers, time budget, etc), and general circumstances (weather condition, day/night, route and traffic information, etc).

In this paper, accident locations and characteristics in Irbid-city, Jordan were used for the period 2001-2003 in order to use GIS and multiple regression analysis to find the shortest path from accident location to both rescue department and medical center. Further, some factors affecting duration of time required from rescue department to accident locations were investigated. A regression model to predict the required period of time to reach the accident location from the rescue department was also developed.

3 DATA COLLECTION

A rescue database for traffic accidents in Irbid-city, Jordan was built for the period of 2001-2003. The data was obtained from the civil defense department (rescue department) in Irbid governorate. The database included:

-Accident type (Collision; vehicle-vehicle or vehicle-pedestrian; Rescue-collision; Tumbling; or Collision/Tumbling)

-Accident causes (Extra speed, tire explosion, no control, no attention, collision, tumbling, or tire problem)

-Accident location

-Call time to ask for rescue

-Rescue's team departure, arrival, and finish time
-Distance from civil defense department to hospital
-Distance from civil defense department to accident
-Distance from accident to hospital
-Participant in accident
-Hospital names (Military, Al-Amera Basma, Rosary Sister, or Ibn-An Nafis)

Basically, the previous database was the only data available in the reports of the civil defense department. The database was incorporated into their associated attributes and shapes into Arcview software. Table 1 shows an illustration of a selected portion of the database used in this research work for the year 2001. It has to be noted that the nearest rescue department usually send the rescue vehicle and not necessarily from the main rescue center. The study area digital map and vector shapes map of its roads were also obtained from Irbid great municipality.

Table 1: Sample Database of Accidents for Year 2001.

ID	Type of accident	Causes	Call Time	Departure Time	Arrival Time	Finish Time	Distance from Accident to Hospital (Km)	Hospital	Date
1	Rescuing	Tumbling	13.22	13.23	13.28	14.10	12	Military	2/8/2001
2	Rescuing	Collision	15.05	15.06	15.10	15.25	15	al-amira Basma	2/8/2001
3	Rescuing	Tumbling	11.12	11.13	11.14	11.45	9	Military	2/8/2001
4	Rescuing	Collision	18.06	18.07	18.10	18.40	12	al-amira Basma	11/10/2001
5	Rescuing	Collision	19.57	19.58	20.05	20.40	20	al-amira Basma	3/8/2001
6	Rescuing	Tumbling	19.06	19.07	19.11	19.40	17	al-amira Basma	7/8/2001
7	Rescuing	Tumbling	18.32	18.33	18.35	18.55	12	Military	7/8/2001
8	Rescuing	Tumbling	18.16	18.17	18.23	18.55	20	al-amira Basma	8/8/2001
9	Rescuing	Collision	18.40	18.41	18.45	19.20	12	al-amira Basma	15/8/2001
10	Rescuing	Collision	15.13	15.14	15.20	15.55	15	al-amira Basma	16/8/2001
11	Collision	Tumbling	13.50	13.51	13.55	14.10	3	al-amira Basma	26/6/2001
12	Collision	No attention	15.00	15.01	15.05	15.15	4	al-amira Basma	28/6/2001
13	Tumbling	Extra speed	9.42	9.43	9.50	10.15	5	al-amira Basma	21/5/2001
14	Tumbling	No attention	16.02	16.03	16.12	16.20	7	Rosary Sister	28/6/2001
15	Collision	Tumbling	0.42	0.43	0.47	1.15	3	al-amira Basma	17/5/2001
16	Collision	Extra speed	13.43	13.44	13.51	14.15	5	al-amira Basma	24/5/2001
17	Collision	Tumbling	5.48	5.49	5.50	6.30	6	al-amira Basma	24/5/2001
18	Collision	Extra speed	12.01	12.02	12.06	12.30	3	al-amira Basma	22/5/2001
19	Collision	Tumbling	18.06	18.07	18.12	18.35	4	al-amira Basma	24/5/2001
20	Rescuing	Tumbling	15.41	15.42	15.46	16.10	9	al-amira Basma	6/8/2001

4 GIS THEMES

Figure 1 shows the used themes (layers) in this research work. Five themes were used. They included Irbid base digital map, three layers for accident locations for the years 2001, 2002 and 2003 respectively, and hospital locations. The attributes of database for each layer were linked to shape files. The accidents elements for the year 2001, 2002 and 2003 were 64, 82, and 120 respectively.

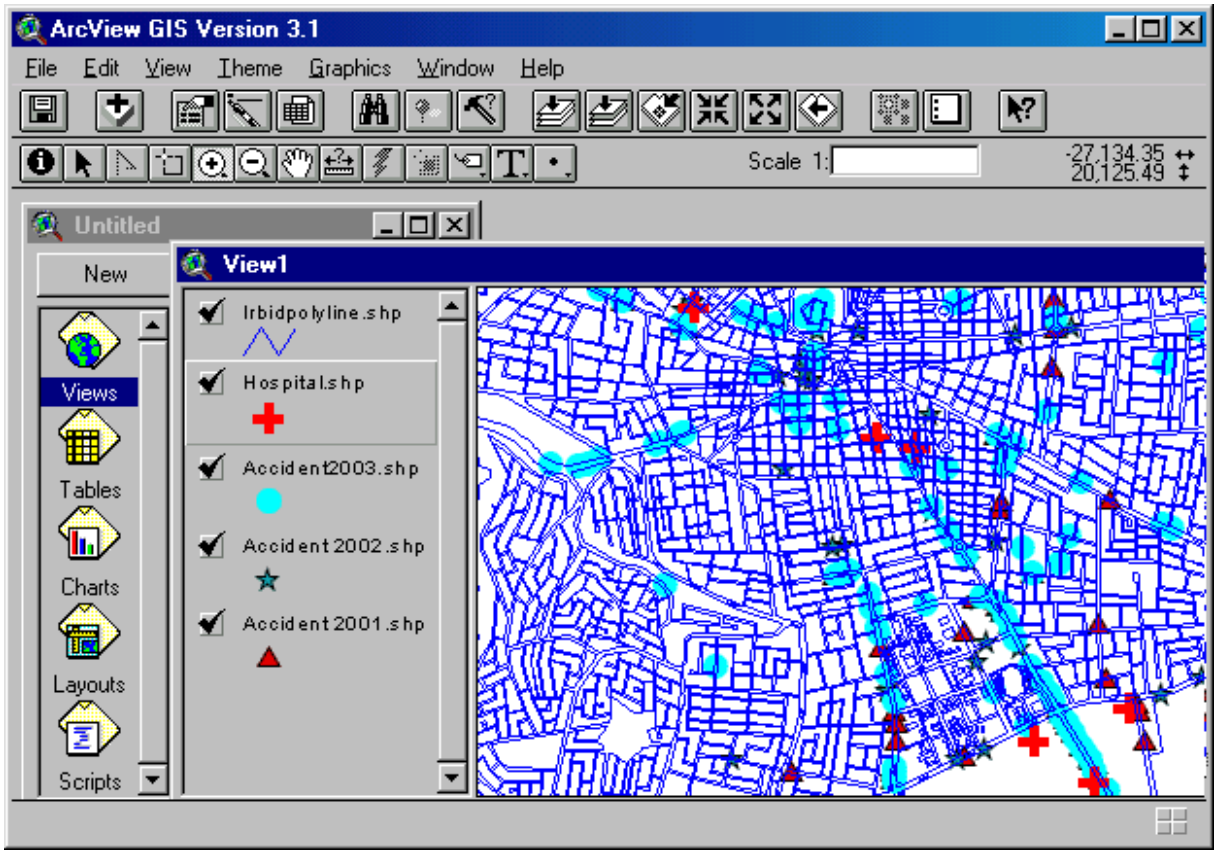

Figure 1: Five Themes Used in Research Work.

5 EXPERIMENTAL RESULTS

A scheme was developed to select the shortest route or path from rescue department to accident location and from accident location to the nearest hospital. The scheme uses the following steps:

1. Display the "accident theme" for the targeted year and the "hospital theme".
2. Use query builder to query for any particular "accident".
3. Make "hospital" theme as an active theme.
4. Use the "select by theme" option to query for the nearest "hospital" to select a feature of active theme using the option "Are within a distance of" the selected accident. The nearest hospital will be selected automatically.
5. Repeat steps from 1 to 4 to query for the shortest path from rescue department to the accident, except using the active theme having the rescue department instead of hospitals.

Figure 2 and 3 respectively show demonstrations for the previous scheme and a selection of the nearest hospital for a selected accident.

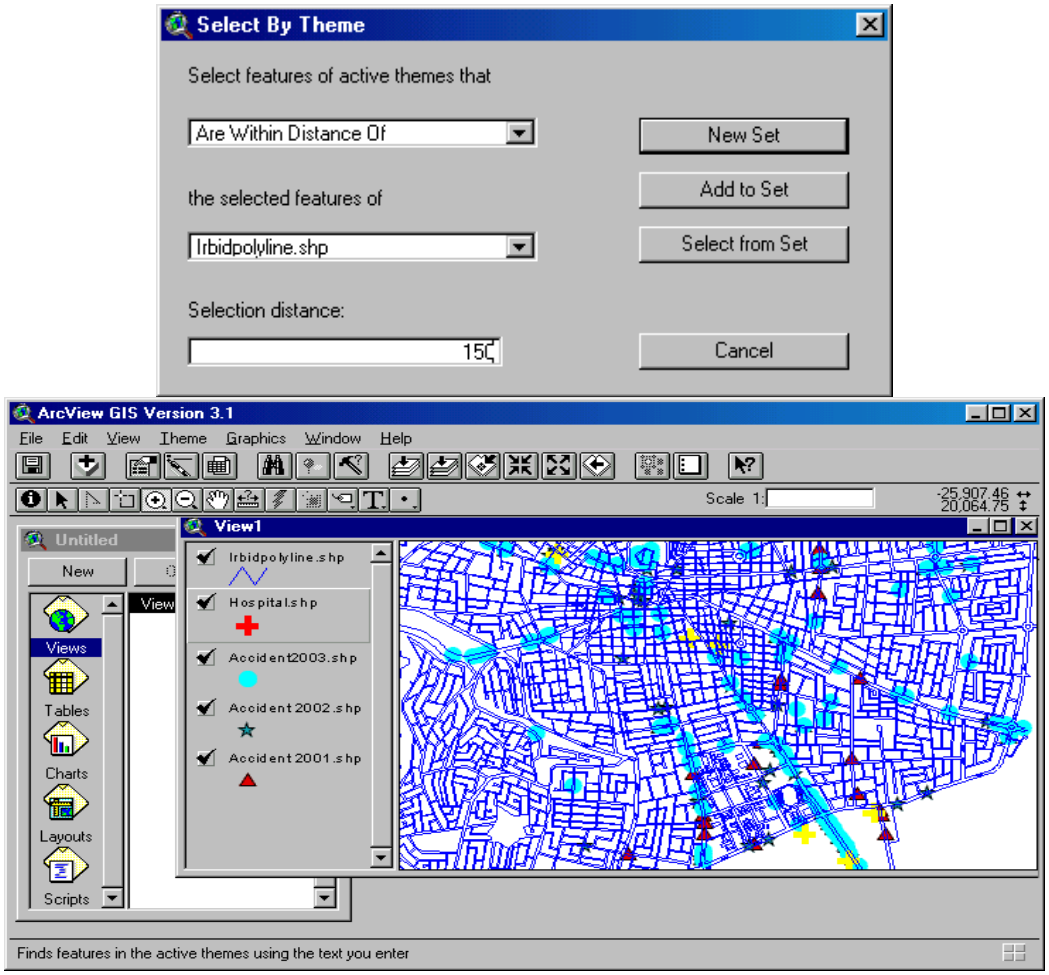

Figure 2: Demonstration for the Developed Scheme to Find Nearest Hospital.

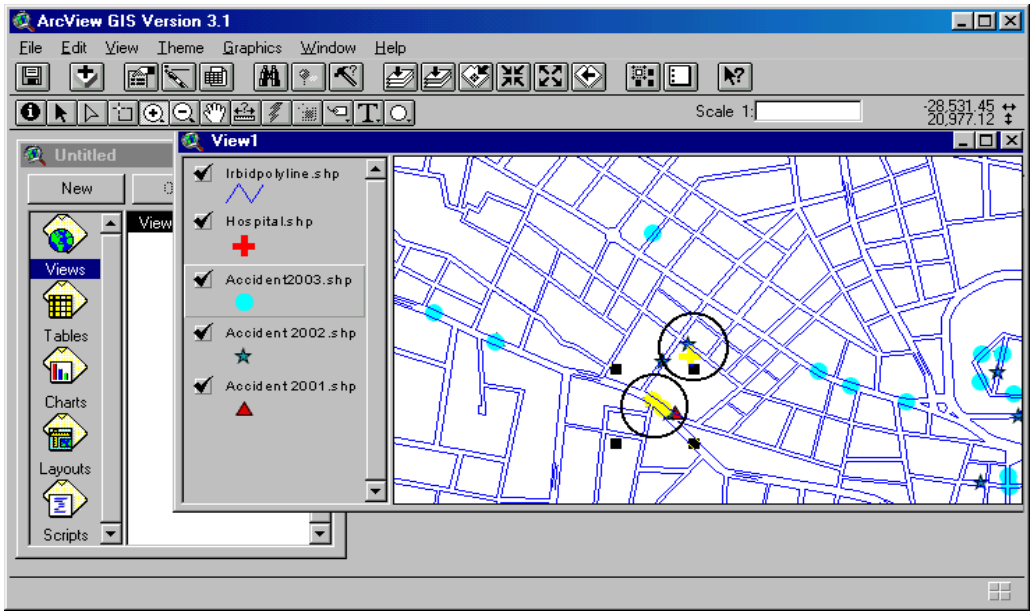

Figure 3: Nearest Hospital to the Selected Accident.

6 STATISTICAL MODELING

The basic goal of regression analysis is to predict statistical models that have the capability of determining the values of dependent variable using different observations of independent variables. In this work, multiple regression analysis was applied to find the relationship between several independent variables or predictor variables and a dependent or criterion variable. SPSS software package was used for this purpose.

The selection of best models used the general goodness of fit represented by coefficient of simple and multiple determination (R^2), general linearity by applying F-test, significance of individual variables through t- or F-test, normality of residual distribution and consistency of variance, and standard error of estimate.

The following variables were used:

Y= The dependent variable that represent the duration in minutes from civil defense to accident location;

X_1, X_2, X_3, and X_4 = Season of the year (Autumn, Summer, Winter and Spring, respectively).

X_5 = Distance from civil defense to hospital.

X_6 = Duration from accident location to hospital

X_7 and X_8 = Time (6 a.m.-12 a.m.) and (12 a.m.-19 p.m.), respectively.

For accidents of the year 2001, using stepwise regression method, all variables were not significant except variable X_3 (winter season). The final prediction model was:

$$Y=3.843+ 0.156\ X_3; \qquad R^2= 0.18 \tag{1}$$

For accidents of the year 2002, using stepwise regression method, all variables were not significant except variable X_3 (winter season) and X_7 (time 6-12 a.m.). The final prediction model was:

$$Y=4.62 + 3.1\ X_3 + 0.6\ X_7; \quad R^2= 0.39 \tag{2}$$

For accidents of the year 2003, using stepwise regression method, all variables were not significant except variable X_3 (winter season) and X_7 (time 6-12 a.m.). The final prediction model was:

$$Y= 3.98 + 1.2\ X_3 + 1.32\ X_7; \ R^2= 0.52 \tag{3}$$

For accidents of the three years (2001, 2002, and 2003), using stepwise regression method, all variables were not significant except variable X_3 (winter season). The final prediction model was:

$$Y= 4.2 + 0.98\ X_3; \qquad R^2= 0.52 \tag{4}$$

This gives a clear indication that winter season time is the most important contributor to the predicted time duration of which the rescue vehicle requires from the civil defense department to the accident location. The peak volume time (6-12 a.m.) is the second contributor variable. The two independent variables were most likely having higher contribution to rescue time duration due to wet pavement condition in winter and rush hour traffic congestion condition at that time.

Low values of R^2 indicate clearly that other variables should be included in this study. Probably the following variables might be included: region, number of injuries, type of injures, number of traffic lights and stop signs, etc.

7 ANALYSIS AND DISCUSSION

It was clear from statistical modeling that pavement surface condition and traffic condition were the two most important factors affecting the rescue time. The reasons of that were due to slippery pavement condition during winter season that might cause traffic accident for rescue vehicle and the traffic congestion time during the daytime (6-12 a.m.). Rescue time was also affected by number of intersections in the route and traffic volume in the path of rescue vehicle. In urban areas, the distance between the rescue departments to accident location was not that significant, therefore, it didn't affect the rescue duration time.

The developed GIS scheme to select the nearest hospital from the accident's location was a practical and effective approach. It was meant to minimize the procedure of selecting the nearest hospital in order to give the chance for non-experienced people to practice using this approach.

Nowadays, with the revolution of ITS and GIS, incorporating the presented scheme into Advanced Traveler Information Systems (ATIS) and Advanced Traffic Management Systems (ATMS) is anticipated to enhance the emergency management tasks. This would be possible in urban areas where vehicles are equipped with and logged to GPS and navigation systems. At that time, real-time response and decentralization of emergency management will be more efficient.

8 SUMMARY AND CONCLUDING REMARKS

Experimental results for rescue department reports along with developed GIS-based scheme showed a powerful and highly potential automated method to select the shortest distance to the nearest hospital from accident location. This implies better comfort and less travel time for the rescued people. However, extensive work is still required to ease and fasten the response methods for rescue department. Real-time response would enhance the rescue process to reach ideal response situation.

Analytical techniques results indicated that rescue time and time from accident to hospital mainly depend on season and time of the day. Of course, this does not mean that we can't explore the effect of other factors related to traveler, road, traffic, environment, trip generation, route, and others. Doing this is anticipated to enhance the statistical modeling reliability.

Incorporating GPS to the presented scheme would also add another dimension to the study to track rescue vehicle over the period of time while transporting injuries from accident location to the nearest hospital.

A possible enhancement for the presented system is to incorporate GIS task with up-to-date traffic information via automated communication with ITS traffic control centers and GPS receivers.

9 ACKNOWLEDGEMENT

The effort of engineer Alaa' M. Al-Sharoa in this research work is highly appreciated and acknowledged.

REFERENCES

Abdel-Aty, M., and P. Jovanis. (1997). Using GIS Capabilities to Improve the Understanding of Route Choice Behavior. ITS, *University of California*, Davis.

Arcview GIS 3.1. *Environmental System Research Institute (ESRI),* Inc., 380 New York Street, Redlands CA 92373, USA.

Duffell, J., and A. Kalombaris. (1988) Empirical Studies of Car Driver Route Choice in Hertfordshire. *Traffic Engineeing and Control*, Vol. 29, Printerhall, London.

Mendoza, A., A. Uribe, C. Z. Gil and E. Mayoral (2000). Development of a Rational Accident Database Management System for Mexican Federal Roads. *A paper presented during the 79th Annual Meeting of Transportation Research Board (TRB),* Washington, DC, USA.

Miller, J. S., and D. Karr. (1998) Experimental Application of Global Positioning System to Locate Motor Vehicle Crashes: Impact on Time and Accuracy. *In Transportation Research Record* 1625, TRB, National Research Council, Washington, D.C., pp. 41-49.

Standards for Evaluating Road Emergency Medical Services. (1994). *Organization for Economic Cooperation and Development (OECD),* Paris, France.

Wohlschlaeger, S. (1997). Factors Affecting Motorist Route Choice and Diversion Potential. *Presented at the 76th Annual Meeting of the Transportation Research Board, TRB,* Washington, D.C.