A GIS SYSTEM FOR AMBULATORY TRANSPORTATION

Birsen Gülden, Erkan Mumcuoğlu, Nazife Baykal
1METU, Informatics Institute, Information System, 06531, Ankara, Turkey

Abstract

In public safety, geography plays a significant role. One of the most important front-line elements of public safety is an efficient emergency transport and care system. The capacity to access and process information rapidly and organize resources where needed can be critically important in an emergency situation. Information about the locality of an event or a disaster is often vital in knowing how to respond. A significant operation for the handling of emergency incidents is the routing of ambulances to incident sites and then to the closest appropriate hospitals [1]. One of important steps to surviving in an emergency is a quick response time [3].

The aim of this study was to build an immediate, rapid and efficient emergency medical transport system prototype, called AML, to be used in Middle East Technical University (METU) Emergency Service, Ankara, Turkey. In the study, geographical information systems (GIS) technology is used as they assist in the development and implementation of an emergency medical service (EMS) response system.

Key Words

Health Informatics, Emergency Medical Service, Geographical Information Systems, Arcview

1. Introduction

1.1 Features of GIS

Geographical information system can be defined as an organized collection of computer hardware and software, geographic data, and personnel to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information [4]. A GIS is designed where geographic location is an important characteristic or critical to the analysis [5]. GIS stores two types of information:

- Geographic coordinate data (spatial data), representing features that have a known location on the earth.
- Attribute data linked to the geographic features (spatial data) that describe the features.

GIS has a topology, the way in which geographic features are related to one another and where they are in relation to one another. Topology is the critical aspect that distinguishes a GIS from a graphics or automated cartography system. Topology builds on two notions. Absolute location, the actual location of a geographic feature is one of them. The second one is relative location, position in relation to another feature or features [5].

The design, construction, and confirmation of the digital database are the most difficult and lengthy GIS tasks in the putting them into practice. GIS control data by themes, usually data layers consisting of a collection of logically related geographic features and their attributes. They analyze the spatial and attribute data. This analysis, in some cases, is based on the querying the spatial or attributes data to obtain new data. In other cases, it is the overlaying the divided data layers or objects on top of each other so that each position in the area covered can be analyzed in terms of these data [5].

A GIS may well be used merely as a storage, retrieval, and display system for geographic data. However, the actual value of GIS lies in their capabilities to generate new data by manipulating existing data or evaluating the relationships among different sets of data. Spatial analysis is done by programs which use data retrieved by database management systems (DBMS). The GIS data management is handled by a DBMS, a group of computer programs. DBMS puts in order and manages the spatial database, and controls the way the data are stored and retrieved, so that relationships among data are kept up or can be restructured. Presentation and output of GIS data are achieved by both printers and computer screens. These output devices need software to arrange text. The graphics software is used to convert data into drawing instructions if a map is to be drawn [5].

1.2 Emergency Patient Transportation

Emergency medical service (EMS) is important to community as the police or fire department services. EMS provides care for victims of sudden and serious diseases or injuries.
An EMS system is an organized and also synchronized arrangement of resources, including personnel, vehicles, equipment, and facilities, which are coordinated to respond to medical emergencies, irrespective of cause [9]. Improvements in the provision of emergency medical care are closely related to the EMS system quality and effectiveness.

Emergency patient transportation, at first sight, seems quite simple. An emergency call comes into emergency medical services headquarters or into emergency communications center and then it is directed to the appropriate EMS, an ambulance is dispatched, emergency medical technicians arrive on the scene, and the patient is transported to a suitable medical facility. In general, patients are transported to the closest hospital with a basic emergency department permit that is staffed, equipped and prepared to receive emergency cases and manage emergency care proper to the needs of the patient. This chain of events is the result of a complex system, in fact. This system preferably combines technology, strategic planning and clinical proficiency to ensure an immediate, efficient response to each and every call for help [7].

Ambulance services have traditionally constructed stations at one or more than one location where possible within their service areas, with each station staffed 24 hours a day to handle calls. Staffing levels generally remain constant, with the same amount of ambulances vehicles and staff available at the same locations at the same times.

Emergency care begins the moment a call comes into a dispatch center. Using a set of advanced protocols, dispatchers ideally walk callers through a phone-based triage system to determine the scope and severity of the emergency situation. These calls can be monitored, working with the dispatchers to ensure that they follow all protocols while providing the highest level of clinical skills and customer service possible [7].

The first step to surviving an emergency is a quick response time. The second and perhaps most important step is receiving expert emergency medical care. Basic life support usually provided by emergency medical technicians. They provide first aid treatment and transportation to the hospital, but do not provide advanced life support. Every ambulance should ideally be staffed and equipped with advanced life support levels with at least one member of the medical team certified in advanced life support [7].

1.3 GIS for Emergency Medical Services

A geographical information system can considerably add value to public health. It can offer cost effective tools for evaluating interventions and policies potentially affecting results [6].

A well-organized emergency transport and care system is one of the leading elements of public safety. Reducing damage in an emergency situation to the lowest level is a very significant matter. An immediate, rapid and efficient emergency medical care system can allow emergency medical technicians use the technology, in order to save the valuable human lives. The development and implementation of an EMS response system should be supported by a geographical information system. An emergency management system assisted by computer technology can save time by demonstrating possible travel routes to the incoming call, and displaying travel routes from the call to the hospital, or other medical care facility. A powerful, easy-to-use tool that brings geographic information to the desktop is ArcView [8].

ArcView allows an authority to merge information from multiple sources and plot that data on a map—a technique called spatial representation—which makes it easier to view and analyze data. It is a technologically advanced geographical information systems program that processes all the data received and assigns it geographical attributes. ArcView GIS is sophisticated desktop geographic information systems software that gives the power to present, visualize, explore, query, summarize, and analyze the data geographically.

Network analyses are one of the basic operations for GIS spatial analysis. Network analyses are the techniques for routing resources along a set of linked linear objects. Optimal path routing predicts the best route between two or more points based on distance, time, effort, or another measure. Optimal path routing is often used for routing emergency response vehicles [5].

A quick response time to the emergency call can be achieved by trying to minimize the travel times from the ambulance location to the emergency call and from the call to the suitable medical care facility. The correct choice of suitable free hospital can also save time by not allowing carrying the patient to a full capacity medical care facility.

In AML, while choosing proper facility, the quantity of beds in hospital's intensive care room, respiratory equipment needed and the best traffic routes to hospital in hand are also considered. Therefore, AML is expected to shorten delivering time, reduce the damage to the patient to the lowest level and allow the ambulance stuff perform their task better.

2. Materials, Methods and Results

In this study, the data from the thesis study done by K. Ertuğay [2] and raw data from “Ankara Metropolitan Office of Information Systems” were used. The needed corrections and additions were done during development of the system. ArcView GIS 3.2, a technologically
advanced GIS program, and ArcView Network Analyst extension were used to process all the data.

ArcView GIS 3.2 allowed merging information from multiple sources and made it easier to display, organize and analyze plotted data in a map with a technique called spatial representation. (Figure 1)

The ArcView Network Analyst extension added additional functionality to ArcView and Avenue (ArcView's robust object oriented scripting environment). It enabled to solve a variety of problems based on geographic networks (e.g., streets, highways, etc.). The complete customized solution was build using the power of Avenue and the ArcView Network Analyst for METU Emergency Service.

The ArcView Network Analyst can use any cost field for its calculations. This means one can solve the questions based on drive time, street length, or any of a number of criteria. This allowed moving beyond simple distance based routing and making use of the additional information available.

The efficiency of the emergency operations was aimed to be improved by finding the best routes around town. The problems such as finding the most efficient travel route across district or quarter to an emergency incident and then to a suitable hospital were solved by using the ArcView Network Analyst extension based on travel time. The best routes in emergency cases can be found based on the shortest distance or time between where you are and where you want to go. In an emergency situation time is most important criterion to save human lives. Therefore, in the study, the time was used as transportation cost that was used by the network. The transportation cost referred to how expensive it is, typically in terms of time, to travel from one point to another.

Network analysis, which is a function of ArcView GIS 3.2, has been used to realize whole situation, and then, to find the most suitable hospital for patient have been decided. Ambulance location was assumed as the starting point and emergency call address and suitable hospital were taken as destinations, respectively.

The study was based on the use of GIS in emergency patient transportation of METU Emergency Service. In the system AML, information about incoming emergency calls is stored. Whenever the emergency call information is required to be saved for later uses, one click on “Save Record” button in emergency call dialog box will be enough. In order to save time the system allows the emergency medical technician(s) to specify address of emergency call by only entering name and surname information. If the automatically retrieved address information is different than the stored one in the system, emergency medical technician(s) can correct it using the related line(s). The date and call number of emergency call are also specified by the system automatically. (Figure 2)

The system AML is intended to be mostly used in the METU Emergency Service Ambulances while they are on move. Therefore, AML try to minimize wrong click(s) due to vibration on the way. The confirmation is expected for every button click in the dialog box before starting the avenue script to function so as not to lose time with any unwanted process. (Figure 3)
The district information of an emergency call is highlighted in a separate view of districts of Ankara. This property is added to AML with the aim of allowing the system to be used for city wide applications. (Figure 4)

Figure 4: The view for the district information of an emergency call.

Emergency medical technician(s) can locate the street/main street information of an emergency call according to the position of METU Emergency Service by using AML. The “Locate Street” option is added to the dialog box in case the technicians do not know the location of the street/main street of the emergency call. (Figure 5)

Figure 5: The location of the main street of an emergency call according to the position of METU Emergency Service.

The building of an emergency call is highlighted from a dialog box button of the system AML. This feature intends to assist emergency medical technician(s) to locate the incident spot along the street/main street. For this purpose the view is zoomed in to the street/main street. (Figure 6)

Figure 6: The highlighted location of the building of an emergency call.

ArcView GIS 3.2 offered algorithms to query and analyze spatial networks, in the study. It assisted to get more from data by using the data in new ways. Working geographically enabled to understand and make better decisions about an emergency situation and get the power one need to solve problems faster. Presenting the solution results of emergency case was also easy with ArcView. It is found that communicating geographically was a powerful way to inform and motivate emergency medical technician(s).

The interfaces and complete applications were developed by using Avenue, ArcView software's scripting language. So it was appropriate to put ArcView to work in emergency medical cases.

The address information, ambulance and hospital locations are coordinated to present obtained results on the user interfaces. The suitable hospital for the emergency circumstance is selected by using the quantity of beds in hospital's intensive care room, respiratory equipment needed and the best traffic routes to hospital in hand. In an emergency situation where the time is treasure for saving human lives, AML allows emergency medical technicians to decide on appropriate free hospital for the emergency patient. The personnel in ambulance can perform their task better with this valuable [3].
The cost of time of transportation path from the ambulance location to the emergency call and from the call to the suitable medical care facility is estimated by the system to inform the emergency medical technician(s). Figure 7 shows the estimated cost of time of transportation path from the emergency call location to the suitable hospital. Accepted emergency medical standards call for the provision of basic life support to the scene in four to six minutes, advanced life support to the scene within six to eight minutes and transport capability on the scene within eight to ten minutes [10].

**Figure 7:** The information box for time cost of the path from the ambulance location to an emergency call.

The prototype system, AML, can also displaying the route having minimum travel time from the ambulance location to the emergency call and from the call to the suitable medical care facility, mostly an emergency service of a hospital. (Figure 8)

**Figure 8:** The system generated path from the ambulance location to the emergency call position.

### 3. Conclusion

Emergency transport system cooperating with a GIS shortens delivering time and reduces the harm to patient to the lowest level. Developing map based applications give emergency medical technician(s) the power to work geographically. The developed prototype system is expected to offer speedy transportation in an emergency situation that occurs in the responsibility area of METU Emergency Service and save valuable human lives. This prototype can also be used for city wide applications if the whole city street network, hospitals and building data are integrated into the system.

### 4. Acknowledgement

We want to thank METU Emergency Service for their cooperation and help.

### References