AN EMERGENCY MEDICAL SERVICE SUPPORT SYSTEM FOR PATIENTS IN RURAL AREAS - AN EXAMPLE FROM TAIWAN

LI-LIN CHEN
Department of Electronic Engineering, Oriental Institute of Technology, New Taipei City, Taiwan
E-MAIL: lilin@mail.oit.edu.tw

Abstract:
Taiwan has steep landforms. In addition to the aborigines, forest workers, and farmers who live and work in mountainous areas, tourists often visit these areas during the weekend and holidays. People have experienced injury or sudden health conditions in mountainous areas; however, because of inconvenient transport or traffic controls, some of the injured people could not reach hospitals promptly, eventually dying. To reduce the time required for people in rural areas to reach emergency care services and prevent the above tragedies, an “Emergency Medical Service Support System for Patients in Rural Areas” was developed. This system is aimed at support the current emergency and rescue command center (119 units). During emergencies in rural areas, the command center can authorize nearby vehicles with the rights to perform as an ambulance to transport emergency patients to hospitals promptly. This prevents treatment delays caused by waiting for an ambulance to arrive from a distant location. Additionally, the emergency and rescue command center can coordinate with the units responsible for the sections of road under construction to assist emergency vehicles in traveling through these areas smoothly. Finally, an ambulance can be sent to a relay station to transport patients to a hospital rapidly. This support system effectively transports emergency patients in rural areas to hospitals promptly to receive appropriate medical treatment.

Keywords:
Emergency medical services; Rural areas; Mountain travel; National park; Delayed treatment

1. Introduction
Taiwan comprises steep landforms and is 395 km long and 144 km wide. The tallest peak of the Central Mountain Range of Taiwan is approximately 3,952 m high. Mountainous and hilly areas account for approximately two-thirds of the land area of Taiwan. Frequent earthquakes and typhoons in Taiwan often cause landslides on roadways; thus, roadways in mountainous areas require frequent repair and maintenance. Therefore, travel through a number of road sections in rural areas is often controlled [1].

Besides the aborigines, forest workers, and farmers who live in rural mountain areas, tourists often visit the scenic spots in mountainous areas during the weekends and holidays. Consider a previous incident, where a resident experienced a health emergency and his/her family attempted to transport them to a hospital outside the mountainous area. However, the family was hindered by road construction; eventually the resident died because of the delay in receiving treatment [2].

Currently, the most efficient emergency care service for rural mountain areas is the emergency air ambulance service [3][4][5]. However, this system can only be used in serious emergencies and its use is limited by the location. To date, efforts to develop an emergency care service system for rural areas have been focused on improving communication systems. However, the impact of transportation has been ignored. Thus, although resources are available, the emergency and rescue command center is unable to integrate the resources and provide prompt rescue because of regulations [6][7]. To reduce the time required to transport patients from rural areas to emergency care services and prevent tragedies caused by treatment delays, the “Emergency Medical Service Support System for Patients in Rural Areas” was developed.

Figure 1. System framework
2. System Functions

The route support system for emergency medical services contains five subsystems, including an emergency support center, emergency departments, patient information, traffic control center, and ambulances. Figure 1 displays the complete framework of the system; the functions of each subsystem are described below.

2.1. Emergency support center

As shown in Fig. 2, the system interface of the emergency support center enables data entry, mapping, and confirmation. The system employs GPS to identify the patient’s location. Staffs at the center then obtain the patient’s condition and his/her license plate number and enter these data into the system. By pressing the “confirm” button, the system plans a route considering the latest traffic information, including controlled roads and traffic issues, provided by the Ministry of Transportation and Communications. Under normal traffic conditions, only the standard tasks, such as sending an ambulance to the relay station, are performed. If a patient in a mountainous area is transported by his/her family or friends, the emergency support center ensures their arrival at the relay station and subsequent rescue is conducted efficiently and promptly. When traffic controls are encountered on the planned route, the system automatically searches for an alternative route, displaying the results on the map. However, when an alternative route is not available, a warning message is generated that shows which road sections are controlled. Then, the emergency and rescue command center has to accomplish the following procedures: (1) requests permission from the unit responsible for controlling the road to transport the patient through the area; (2) informs the person transporting the patient of the most efficient route to the hospital, traffic control information, contact details of the unit responsible for traffic control, and the location and contact details of the relay station; (3) notifies the hospital of the patient’s condition to enable rescue preparation; and (4) sends an ambulance to the relay station to transport the patient from the mountainous area. The emergency support center should ensure that all associated information is communicated to the four other subsystems to ensure the patient is successfully transported from the rural area to an emergency department.

2.2. Patients rescuing unit

As shown in Fig. 3, the system interface for the patient side is based on cell phones. Residents of rural mountain areas can enter their personal information into this program in advance. Therefore, when they require emergency services, if they dial 119, an application on their cell phone automatically transfers their information to the information interface of the emergency support center. Then, the emergency support center returns the following information to the person’s cell phone: (1) the most efficient route to a hospital. (2) Contact details of the unit responsible for traffic control. This information enables the person transporting the injured person to inform the unit responsible for traffic control of the injured person’s location and time of arrival in the controlled region, reducing the time required to transport the injured person through the controlled region. (3) The location of the relay station where an ambulance and rescue professionals are waiting.
2.3. Traffic control center

Referencing the real-time traffic information database, which contains public information provided by the Ministry of Transportation and Communications, the proposed system can search for the optimum route for medical rescue. This system considers road repairs and traffic jams when selecting an appropriate route, prioritizing the most efficient route to a hospital. After evaluating every alternative, the system may still select a route that travels through roads with traffic controls. In this situation, the emergency support center contacts the unit responsible for controlling the road to inform them of the emergency, providing the patient’s information, departure location, the license plate number of the emergency vehicle, contact information of the person transporting the patient, distance between the patient’s location and the controlled section, and when the patient is estimated to arrive at the controlled section, as shown in Fig. 4. The traffic control center acts immediately after receiving a request from the emergency support center. The traffic control center organizes the evacuation of machines on the roads under construction or traffic control and enables the vehicle transporting the patient to travel through the area easily and receive prompt emergency care.

2.4. Ambulances

A sample of emergency request received by the ambulance side is shown in Fig. 5. With this system, an ambulance is not required to travel back and forth over the rough mountain roads, which not only saves time but also guarantees the safety and efficiency of the rescue because the ambulance driver may be unfamiliar with the road conditions. To save time and prevent rescue failure, the proposed system sends an ambulance to the relay station as a patient is being transported from the mountainous area. Because the ambulance side also receives the patient’s information, first aid professionals can understand the patient’s condition in advance to prepare for providing emergency care and coping strategies.

2.5. Emergency ward

Emergency departments and ambulances require the same rescue information. When an emergency department receives information regarding an emergency patient, health care professionals confirm the information and then contact the patient side and the ambulance to provide timely assistance, including providing simple first aid instructions. Additionally, the ambulance staff notifies the hospital emergency department of the patient’s condition to ensure that the patient receives appropriate treatment upon arrival at the hospital. Finally, the emergency department contacts the emergency support center when the patient arrives at the hospital.

3. System Characteristics

The main characteristic of this system is that it enables the emergency and rescue command center to integrate resources and manage any medical emergencies promptly and efficiently to achieve the goal of successful emergency rescue. The “Emergency Medical Service Support System for Patients in Rural Areas” is based on the existing emergency medical services system but also incorporates the real-time traffic information database maintained by the Ministry of Transportation and Communications. Upon receiving an emergency care request from a rural area, this
support system begins planning the optimum rescue route.

Under normal traffic conditions, the emergency and rescue command center authorizes the vehicle transporting the patient with the rights of an ambulance to ensure that the patient can be brought outside the mountainous area rapidly. An ambulance is sent to the relay station to collect the patient. The location of the ambulance and emergency department are provided to the person transporting the patient. Additionally, to reduce the rescue time, the emergency support center notifies the ambulance and emergency service system to minimize the time required to reach the hospital and complete the emergency rescue.

Two traffic conditions that require additional procedures are described below: The first condition is the encountering of traffic controls, and the second condition is the encountering of obstructions.

3.1. Traffic control

When encountering traffic controls because of traffic congestion or a narrowed road, the emergency support center informs the unit responsible for controlling the area of the emergency situation, enabling the responsible unit to contact the patient side directly to assist in transporting the patient through the controlled regions successfully.

3.2. Obstruction

When encountering road sections that are under repair or maintenance, the emergency support center requests that the unit responsible for the construction region move any obstructing machines. This ensures that the patient can be transported through the area successfully to avoid delayed treatment.

4. Techniques for System development

This system contains five subsystems; the systems of the emergency support center, emergency departments, and ambulances are conducted on computers installed with a program designed by C# [8]. The systems for the patient side and the traffic control center were designed with a cell phone interface as an Android application [9]. The system at the emergency support center is responsible for route planning and integration. The system adopts a webpage framework that is integrated with the Google Map application to display the route. The route planning capability of Google Maps, and its ability to display coordinates, is used by this system to display information on the map. The system is also connected with the real-time traffic information database maintained by the Ministry of Transportation and Communications to identify real-time road conditions and further integrate this information to plan the optimum route. Service population and system environment

The health care services system in Taiwan has comprehensive emergency services. Although several domestic researchers have proposed strategies to improve emergency service systems and even recommended innovations, they primarily focus on improving the comprehensiveness of the services provided and the communication system in specific areas such as national parks and scenic spots in the mountains[10][11][12]. Therefore, in non-scenic rural areas, no systematic improvement has been implemented.

The service population of the system developed in this study is the residents and tourists who experience an accident or sudden health emergency in rural mountain areas. This system reduces the rescue time because an ambulance is not required to travel back and forth between the hospital and the location of the incident. Furthermore, appropriate management of transportation issues, such as traffic controls or road constructions, reduces the time spent waiting to transport the patient through specific road sections. Considering the above two characteristics, this system is can be used in any rural mountain area in Taiwan.

Currently, helicopters are commonly used to conduct rescues in mountainous areas. However, several factors, such as the weather and landforms, limit the use of helicopters. This support system can be used to rescue patients from any rural mountain area or scenic spot providing roads are available. Unlike helicopters, this system is not limited by the weather or landform factors and can manage most road conditions. In addition, the integration of this support system in the operations of the emergency and rescue command center increases efficiency because it eliminates the time wasted applying for a rescue helicopter.

5. Outcomes and Future development

The “Emergency Medical Service Support System for Patients in Rural Areas” presented in this study combines the existing emergency medical service systems and the real-time traffic information and communication system provided by the Ministry of Transportation and Communications. Furthermore, because the emergency
support center can provide vehicles in rural areas with temporary road passing priority and integrate various resources, including the vehicles transporting patients, ambulances, units responsible for traffic control, and emergency departments, the time required to transport a patient from a rural area to a hospital is reduced significantly. Therefore, this support mechanism enhances not only the efficiency of the current emergency medical service system but also increases public safety.

Future studies can incorporate the telemedicine system in this support mechanism. For example, devices for measuring blood pressure, heartbeat, pulse, and body temperature can be provided to the patient side. Then, this physiological data can be transmitted through cell phones and integrated in the emergency medical service system, facilitating remote consultation by physicians to improve the survival rate for the patients.

References


Organizing Committee

Honorary Conference Chairs

Hongrui Wang
President, Hebei University, China

Michael Smith
Past President, IEEE Systems, Man & Cybernetics Society, USA

William A. Gruver
Simon Fraser University, Canada and Past President, IEEE Systems, Man & Cybernetics Society

Szu-Wei Yang
President, National Taichung University of Education, Taiwan

General Co-Chairs

Daniel Yeung
South China University of Technology, China and Junior Past President, IEEE Systems, Man & Cybernetics Society, USA

Xizhao Wang
Hebei University, China

Program Committee Chair

Shyi-Ming Chen
National Taichung University of Education, Taiwan

Xuelong Li
Xi'an Institute of Optics and Precision Mechanics of CAS, China

Publication Co-Chairs

Patrick Chan
South China University of Technology, China

Chunru Dong
Hebei University, China
Treasurer

Eric Tsang
Macau University of Science and Technology, Macau

Local Arrangement Co-Chair

Robert P. Woon
IEEE Systems, Man, & Cybernetics Society, USA

Conference Secretaries

Patrick Chan
South China University of Technology, China
Wing Ng
South China University of Technology, China

Web Master

Patrick Chan
South China University of Technology, China