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Smart Mobile-based Emergency Management and Notification System

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***Abstract*—Mobile government is an innovative research area where efforts are made to advance governmental and public services. As such, in this paper, we propose a crisis management system for real-time emergency notification of users using mobile applications and smart watches. We develop an intuitive web portal using a client server architecture for governmental agencies to easily and efficiently notify users within the range of danger in the occurrence of a disaster through SMS or push notifications to the mobile application or the smart watch, if the latter is available. Moreover, real-time mapping for indoor localization systems are utilized for user navigation to the nearest exit with the added feature of floor plans for public locations that may be accessed offline for the convenience of the users. The system is also designed for instant emergency aid assistance in case of a medical personal difficulty through the use of the developed dedicated bilingual multi-platform mobile application.**

***Keywords*-Emergency; Crisis; Mobile Application; Smart Watch;**

I. Introduction

Mobile Government (m-Government) is an emerging field where mobile technologies are used in governmental institutes to facilitate public services. m-Government plays an important role in many fields such as m-Health [1]. As such, providing m-Government services is an interesting research area. Moreover, according to the EM-DAT, the international disaster database provided by the Center for Research on the Epidemiology of Disasters (CRED), the number of technological disasters have decreased between 2010 and 2015 as shown in Fig. 1a [2]. However, the total number of deaths accompanied with those disasters that include industrial, miscellaneous, or transport accidents, have increased as seen in Fig. 1b. Moreover, natural disasters occurrences such as hurricanes, floods, and earthquakes follow the same trend as that of technological ones as shown in Fig. 2a. On the other hand, the total number of deaths caused by these natural disasters has decreased over the past years until it became almost stable between 2013 to 2015. This can be seen in Fig. 2b. In addition to the human losses, these disasters may lead to economic losses and losses accompanied with infrastructure destruction.

For a couple of decades, natural disasters have been monitored using the wireless sensor network (WSN) technology. The augmentation of various sensors along with mobile computing and telecommunication systems provide a cheap, quick, and a flexible WSN that closely monitors the natural disasters operating on low power consumption [3], [4]. Its utilities cover different purposes including disaster prevention and post-disaster search and rescue missions [3], [4]. However, utilization of wireless sensors brings forth a challenge of transmitting and storing huge amounts of data to be readily available for the search and rescue teams when needed [5].

Although natural disasters have a great impact on human population and society, technological disasters, or man-made disasters, are prevalent and their effects are just as crucial as the natural ones. Thus, managing those hazards is vital. The utilization of Information and Communication Technologies (ICTs) can enhance the effectiveness of disaster management [7].

Mobile Government (m-Government) is the use of mobile technologies within the government administration to deliver public services to citizens and firms. It is quickly emerging as the new frontier of service delivery, and transforming government by making public services more accessible to citizens. Governments in developing countries are increasingly making efforts to provide more access to information and services for citizens, businesses, and civil servants through wireless devices.

The usage of smart phones and other devices that are well equipped with sensors is widespread. For instance, from sensors, including Global Positioning System (GPS), accelerometer, and cameras, built in such devices arise a wide range of sensing applications [8], [9]. Therefore, smart phones supports the capability of disaster management through its sensors [10]. In addition to the effective disaster management feature smart phones are capable of, they tend to increase the resilience after undergoing disasters by engaging the citizens in the process of managing the disasters [7]. The incorporation of social media and smart phones have resulted in the exchange of information regarding the ongoing disasters and safety precautions. Moreover, people started reporting their safety conditions throughout the emergencies and after their incidence [10].

For instance, [13] tracks all the natural and technological disasters occurring globally, so affected users may only find out about the disaster if they attempt to search for disasters in

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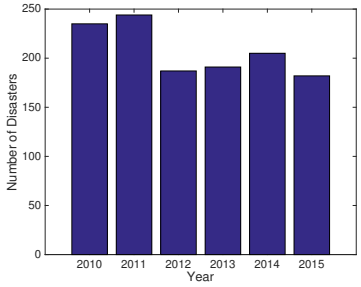
a particular area. This is not efficient and does not alert users of a disaster. Consequently, our proposed system reduces the amount of stress and anxiety caused by the lack of awareness of real-time disasters. Furthermore, the American Red Cross developed an application for first aid with instructions of the different emergencies a person might suffer from [14]. This application assumes that the injured user or the witness is aware of the medical condition the injured person is suffering from, and thus only provides instructions to a predefined list of emergency diagnostic cases. On the other hand, our proposed system provides the users with sets of instructions to follow based on the gender, age group, state of consciousness, and symptoms the injured person is suffering from.

In this paper, we propose a convenient crisis and emergency management mobile application. A wide range of users with different age groups can utilize the proposed system for relief in various emergency situations; both on large and small scales that range from personal emergencies to community disasters at their time of occurrence. Consequently, real-time mapping for outdoor and indoor localization systems are integrated to locate the area of the disaster. Furthermore, it is incorporated with a system to provide the user with the right course of action to be taken in case of several personal emergency cases, whether the user is experiencing it firsthand or just as a witness. Moreover, users who are in the vicinity of the disaster receive real-time notifications either through push alerts or Short Message Service (SMS). In addition, we employ smart watches to notify the users about the disasters at their time of occurrence [11], [12]. Furthermore, our proposed solution includes floor maps of frequently visited public places in case of building evacuations that can be accessed offline through Global System for Mobile communication (GSM).

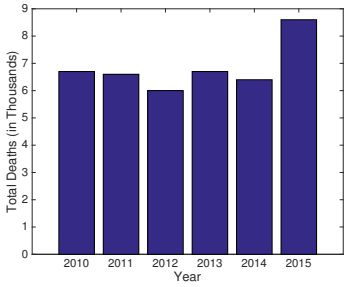
Our proposed system's main contributions include: indoor localization and offline-activated floor plans through the use of GSM, instant emergency aid system, and a dual-end real-time alert system. The remainder of the paper is organized as follows: Section II presents the proposed system, Section III discusses our results, and Section IV concludes the paper.

II. Proposed System

We propose a convenient and user-friendly disaster and emergency management system that includes a server, a mobile application synchronized with a smart watch, and an accompanying website designed for disaster relief authorities, such as the concerned governmental agencies. Our proposed web portal enables governmental agencies to alert users immediately of emergencies as well as maintain the credibility of the alerts. That is because the web portal allows the agencies to view alerts about possible emergencies from users for further investigation about their seriousness. It also enables the notification of all users within the affected radius

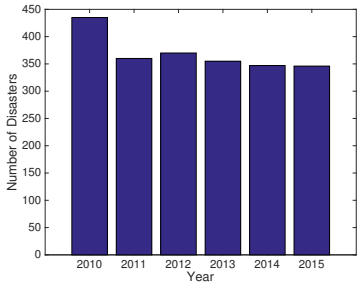


(a) Total number.

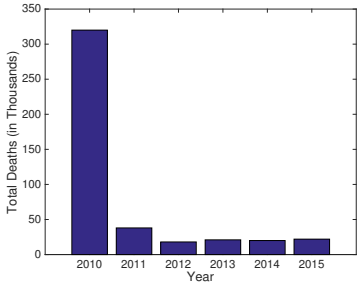


(b) Total number of deaths related.

Figure 1: Technological disaster trends over the past five years in all continents [2].



(a) Total number.



(b) Total number of deaths related.

Figure 2: Natural disaster trends over the past five years in all continents [2].

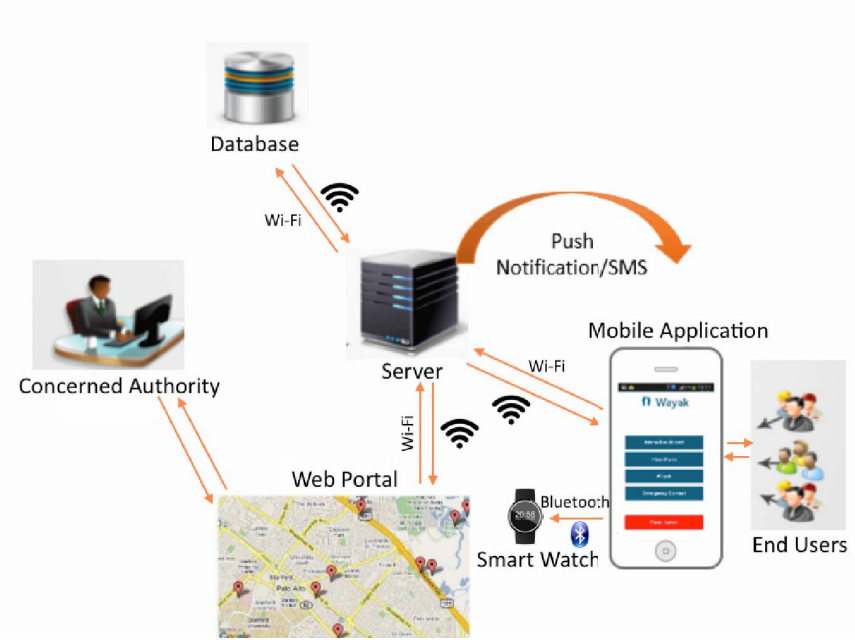


Figure 3: Overall proposed system architecture.

of an emergency incident. The overall system diagram is shown in Fig. 3.

Once a crisis occurs, the concerned disaster management authority, such as the local police, can locate the affected region on the map using the proposed accompanying web interface for governmental agencies. On the other hand, when the user downloads the application and accesses it for the first time, the unique International Mobile Station Equipment Identity for the smart phone is stored in our server's database. This is applied to distinguish each user, and set as his/her ID in our database. Location of the users are updated in real-time through the incorporation of GPS and pushed to the server. Only the users who are located within the region of the disaster or emergency are notified using push notifications or SMS, as appropriate. Moreover, users with smart watches receive a notification on them with the message the authorities have provided. Furthermore, the proposed system enables users to alert the authorities about an emergency. This alert report is first studied by the authorities to ensure its reliability to avoid misleading or false information.

Consequently, the smart phone application of the proposed system includes several useful features such as the alert system explained in Section II-A, instant emergency aid discussed in Section II-B, indoor localization and offline accessible floor plans as in Section II-C, and the emergency contacts list and the panic button as elaborated on in Section II-D.

A. *Alert System*

We propose an emergency alert system for users for reporting of community technological emergencies. The user reports the incident using our proposed smart phone application with the date and the particular event description. The location of the event is detected via GPS and is pushed to the server.

The report is then immediately displayed to the authorities in our system's web portal to notify them of the emergency. We also retrieve from the server the user's personal identification information, collected using our secure and easy to use registration system, and attach them to the aforementioned report. This information includes first and last name, national ID, and telephone number. The information is kept confidential, and is only used to keep track of the user in case of an emergency, or alert reporting. The authorities are then able to confirm the occurrence of the emergency, and notify the users within that region to take specific action, if required.

B. *Instant Emergency Aid*

The proposed system also aims to minimize the negative consequences that proceed a personal emergency through supplying an instant emergency aid feature. This feature provides the user with both written with illustrative images and audible instructions. It facilitates the users to assist in case of a personal emergency incident to themselves, if they are able, or to others. As such, it is convenient, fast, and easy-to-use. Personal emergencies include choking, bleeding, bone fracturing, difficulty breathing, heart

attacks,.. etc. Our proposed solution aims to deal with these urgent situations. This reduces the chances of death and other subsequent terminal conditions, for it helps relieve the affected party till specialized people arrive on scene.

Our proposed system considers gender, different age groups, whether the affected party is conscious or not (in case of the user being a witness to the incident), and the fact that non-medically trained users are not able to accurately diagnose a case of emergency. Therefore, the proposed mobile application also allows the users to select all that applies from a list of most common symptoms to various emergency cases. The system then diagnoses the emergency case based on the symptoms chosen.

The user is immediately presented with the needed information of the best course of action to be taken. This might include the instruction not to move the affected party to prevent further injury, or detailed description of the applicable first aid procedure to be taken in a particular situation. In both cases, and upon the completion of the first aid instructions, the related emergency authority number is automatically dialed for the user to communicate the situation in case that there were no other witnesses. The proposed system uses the National Emergency Crisis and Disasters Management Authority (NCEMA) emergency instructions to provide to the user [15] to ensure the credibility and reliability of the course of action suggested.

C. Floor Plans and Indoor Localization

Technological or man-made disasters such as accidental fires may take place in public areas. Since such areas are usually crowded, it is crucial to ensure the people's safety in case any emergency takes place. Our smart phone mobile application system provides the users of indoor floor plans for frequently visited locations in UAE such as malls, and large amusement parks. The floor maps can be accessed offline through the use of GSM.

On the other hand, we require Wi-Fi connection for the enabling of indoor localization feature. That is because we store a pre-collected robust Received Signal Strength (RSS) database from all the access points on our server for Wi-Fi fingerprinting, the method used for our proposed system's indoor localization. As such, a live RSS from the system is matched with the RSS database on the server [16]. The matching between the live RSS and the database ones is performed for localization every five seconds using the k-Nearest Neighbor (k-NN); an efficient algorithm for such a paradigm [17]. Consequently, once the user gets a notification through their mobile phones or smart watches about a certain emergency in a public location, our indoor localization algorithm defines a path to the nearest exit. This path is shown on the floor plans to help with fast evacuation.

D. Emergency Contacts and Panic Button

In our proposed system, we provide the users with an intuitive list of the most important emergency authorities contact numbers. The users are presented with a list buttons that directly link them to the police, ambulance, fire department, or the civil defense. This is particularly important since in a stressful situation such as in an emergency, a person might forget the emergency contact numbers, or even might not be aware of them. Moreover, while these contact numbers feature is presented separately, it is also incorporated within the instant emergency aid feature as discussed in Section II-B.

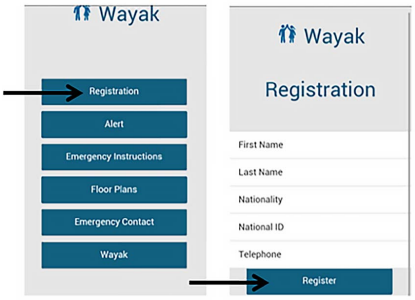
Furthermore, in case of an extreme emergency, such as when the user is on the verge of passing out, or a heist or a robbery are taking place, the user can just press on the panic button. This button directly connects to the police with the personal information of the user and the GPS location as to enable rescue as soon as possible of the user. This button is strategically located in the bottom center of the application such that it is easily accessible. As a result, an immediate emergency is just a click of a button away from the user.

III. Results

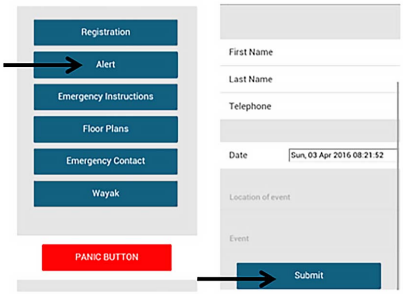
Our proposed mobile application is multi-platform, easy to use, and bilingual (Arabic and English languages) for the convenience of the users. Moreover, our proposed application is a dual-communication one between the citizens and the authorities, so that users may notify authorities of any possible emergencies such as robbery. This alert feature requires the user to be registered in our database for the authorities verification of the identity of the user, and to motivate vigilant actions and reduce false alarms. Fig. 4 shows the work flow of the alert system.

First, the user registers in the proposed smart phone application by filling out a small form. A user may then click on the *Alert* button in order to report the incident's details. Upon submission, the information is sent over Wi-Fi to the server and the authorities are notified for checking the suspicious event. If confirmed, all the users within the area to be affected are notified through push notifications or SMS, as appropriate. As such, the web portal includes control of messages sent to the user by providing an interface developed using Google Maps API for setting the message to be sent to users (in Arabic or English), a Google map of the country that can be zoomed in or out to set the center of the emergency location, and the radius that the message should be sent to the people in. Upon sending, the location with the radius are highlighted in red with the ability to show the message sent to the users by a click for later reference as needed. This interface can be seen in Fig. 5.

Our proposed instant emergency aid system provides users with instant and intuitive personal emergency relief instructions in audio visual format. Thus, our application reduces misdiagnosis of personal emergencies for the first



(a) User registeration.



(b) Alerting authorities.

Figure 4: Alert system workflow.

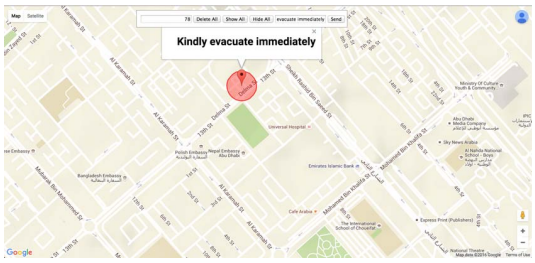


Figure 5: Accompaying web portal interface.

respondents, the emergency witnesses or the affected party themselves, by presenting a user-friendly system that diagnoses personal emergencies and provides first aid instructions. Fig. 6 showcases a demonstration of the system with a user witnessing an unconscious citizen suffering from a personal emergency.

Upon choosing *Emergency Instructions* button, the user selects the gender, the age group, consciousness, and visible symptoms that the affected party is suffering from. Age groups include infants, children, teenagers, adults, and elderly. Once the diagnosis is completed, the user is instantly presented with the aid instructions. Our proposed system also aims to further facilitate the helping of others with verbal recordings of the instructions to minimize the time needed to read the instructions while performing them.

Additionally, the users are presented with floor plans of a selection of frequently visited public areas. Our proposed solution caters for all the citizens in the UAE, therefore the floor plans are provided as a mean of facilitating finding the nearest exits in case of any evacuation of the buildings. Fig. 7 shows the workflow to access the floor plan of a certain mall.

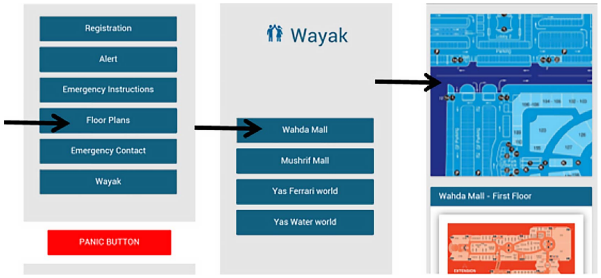


Figure 7: Floor plans workflow.

The proposed system provides the users with several emergency contacts. To avoid dealing with major personal emergencies, the user can simply click on the *Ambulance Emergency* button to call the concerned authorities to send an ambulance to the location. This can be seen in Fig. 8. As such, the user may also alert the authorities by simply clicking on one of the emergency contact buttons to inform the related authorities of the crisis.

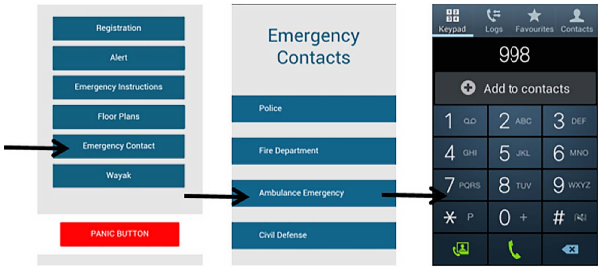


Figure 8: Emergency contact workflow.

IV. Conclusion

In conclusion, this paper proposes a real-time emergency management and notification system using mobile applications and smart watches. This is a direct implementation of m-Government services to better governmental and public facilities offered. Governmental agencies can use our dedicated web portal to immediately notify users with the danger zone of an emergency. Users may then use our developed mobile application to locate the nearest exit route through Wi-Fi fingerprinting indoor localization technique. Users can also alert the authorities of suspicious behavior or possible emergencies that warrant further investigation. The multi-platform bilingual mobile application also provides instant aid instructions to users in case of personal emergencies. Our future plans for the proposed system include automatic personal emergency efficient aid through the storage of the user's medical information and automatic diagnosis of personal emergencies through smart watches.

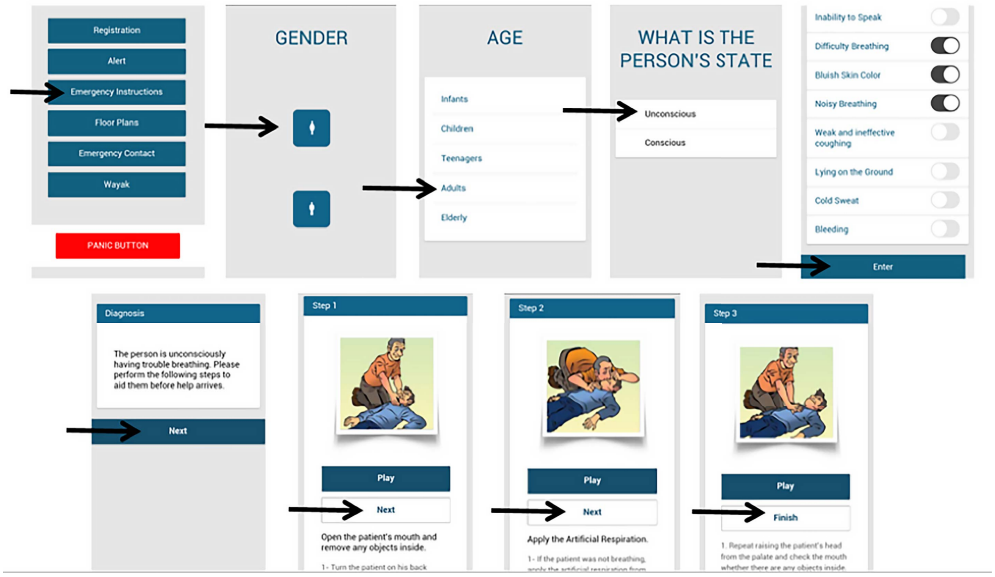


Figure 6: Instant emergency aid system workflow.

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