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ANDROID BASED REMOTE FALL MONITORING AND GENERATING LOCATION ALERT

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Abstract- The development of a remote fall monitoring system on an android operating system is built for M-Health (mobile healthcare) purposes, for example to monitor people who are epileptic, amputees and the elderly etc. The sensors embedded in the smart phone device can be exploited to perform healthcare monitoring. There is no additional hardware involved other than the device itself, making it a light, powerful, easy to use remote monitoring system. The system remotely monitors the device for any fall and if fall has occurred, it automatically sends an alert message to the data centre along with the location details. The application is easier to use and no additional training is required.The eclipse integrated development environment (IDE) used to develop the application enables the developer to code in java and xml with its various tools. In order to obtain the location of the android user, the code accesses the hardware sensors and the location sensor. The latitude and longitude extracted from the GPS (Global Positioning System) is added to the SMS which is then sent to the data center. Medical assistance is then dispatched to the required location. The inbuilt accelerometer of an android device is accessed for fall detection. An emergency button is also available in case the person requires medical assistance. Pill dosages and doctor appointments are managed and updated by the data center regularly. An ROC (Receiver operating characteristic) curve is plotted in order to fix the optimal threshold for the fall detector system.

Keywords: Android, Eclipse IDE, Accelerometer, Location Manager, Fall Detector, M-Health

Introduction

The human life expectancy has increased over the past few years [1], [2]. This has been possible by the substantial progresses in health monitoring technologies. Due to better healthcare services, the rate at which the aging population has been growing has led to an elevation in the number of medical staff [3], [4]. Elderly people are the most vulnerable in the society necessitating a continuously monitoring their health especially if they live alone [5], [6], [7]. Technological advances have helped to alleviate these problems, and patient monitoring can be done directly from home [8], [9]. As a consequence, there is a need of flexible and efficient method to improve the medical monitoring at home.

Android smartphone devices have helped to attend patients who need medical assistance [10]. Android platform is becoming more and more popular in the medical field, and shows great effectiveness when it comes to sending information from remote areas [11].This project involves the use of this telemedicine system to dispatch an ambulance or medical help to the patient's current location using the inbuilt location sensors of a smartphone device in emergency cases and when a fall is detected [12]. It has been reported that around 11 million people fall every year. Injuries due to fall can have serious consequences if no help is provided at the right moment [13]. In this case, there will be a data centre that will transmit the patient location to the nearest hospital, therefore ensuring immediate response. Additional help features have been programmed in this android application to medically support the patient [14]. These comprise of calling the help centre directly for assistance, reminding the patient of when and what pill to take and all health related appointments [15], [16].

These are the new trends consequent to the development of smartphones. Nowadays people have become more conscious about their health. Therefore most mobile manufacturing companies are striving really hard to integrate more sensors into the mobile devices, namely heart rate monitor, temperature sensors and pedometers [17-40].
This paper discusses the application developed using telemedicine concept to dispatch an ambulance or medical help to the patient's current location using the inbuilt location sensors of a smartphone device. The developed application monitors the fall using only the inbuilt sensors present in a smart device [41-45].

Methodology

The remote monitoring system consists of the development of a mobile application that makes use of the array of inbuilt sensors such as location sensor and accelerometer, which are used to obtain the patient's location when a fall is detected.

The data centre will have a database which will have a record the patient's details and medical history as seen in figure1. The IT service provider will give technical help if require whereas the medical service provider will inform the nearby hospital or doctor if medical assistance is required.

Tools used

Eclipse IDE that is designed to provide a powerful integrated environment is used to build android applications. ADT extends the capabilities of Eclipse to set up new Android projects, create application user interface, debug applications and add packages based on the android framework API [32], [34-36].

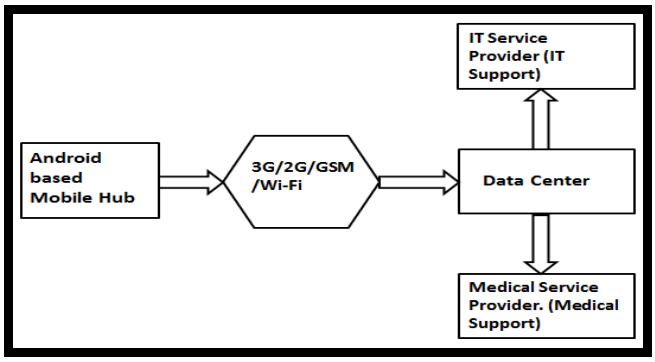

Fig. 1. Project overview on how the remote smart device is linked to the data centre.

The fall detector is a module which gets initiated as soon as the application is opened. It is a java program which exploits the inbuilt array of sensors to detect a rapid motion thereby detecting a fall. Shown in figure 2 is the flow chart describing the working of fall detection in the android device.

The module first detects the presence of an accelerometer in the smart phone device. Then the accelerometer is accessed using a sensor manager. Sensor event listeners keep track of changes in the accelerometer values. The timestamp is used to keep a real time track of the accelerometer readings. In case a change is detected, the program checks the time at which the change has occurred. The reading is then passed through the fall detector algorithm.

Once the above criterion is fulfilled, the fall detector algorithm is implemented. It calculates the net acceleration of the device and compares it with the threshold value which was decided empirically. If the algorithm detects a fall, then the help activity begins and if not, it goes back to detecting changes in the values of the accelerometer reading.

Once a fall is detected the location manager and the geo-coder are used. By making use of location sensor and location manager, latitude and longitude are extracted. Using these coordinates the address is extracted by making use of geo-coder.

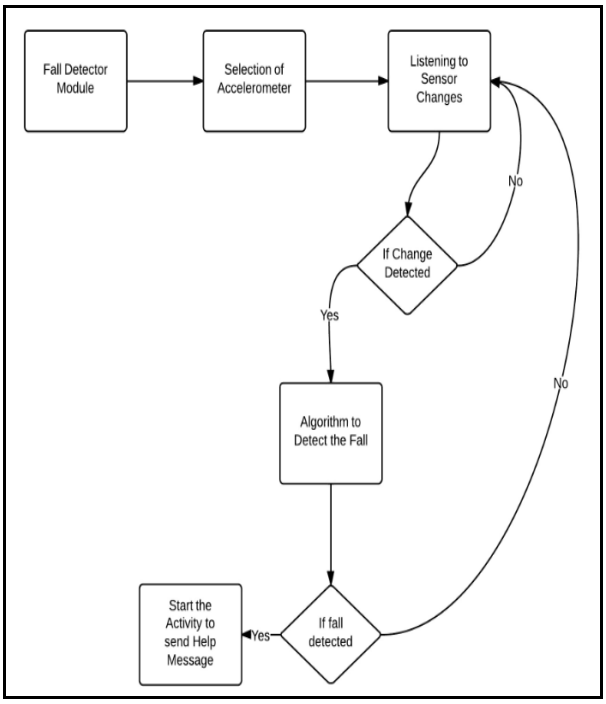

Fig.2. Flow chart describing the working of fall detector in the android device.

The next step involves sending the message to the data-centre. This is done by accessing the SMS manager. This builds a string with the appropriate text involving the latitude longitude coordinates and the approximate address. The message is finally sent and home screen is loaded before the activity ends. Shown in figure 3 is the block diagram of processes involved in sending alert message.

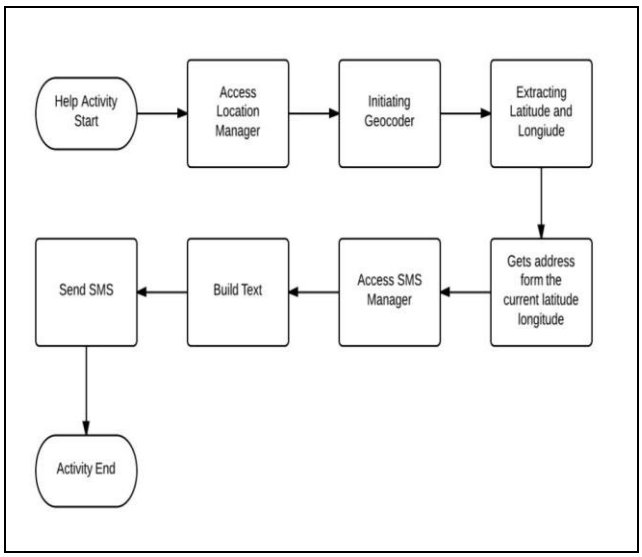

Fig.3. Block diagram of processes involved in sending alert message.

The algorithms implemented to develop this application are giving promising outputs. The fall detector is still in

prototype stage. The location sensor gives output of location with the accuracy of twenty meter radius. Pill reminder and the Appointments are maintained by cloud services so they can be modified wirelessly. The IT service and the customer care will be managed by the data centre. The data centre is responsible for collaborating with different hospitals in the region to provide better health care services. A sample user interface of the android based remote health monitoring mobile device is shown in the figure 4.

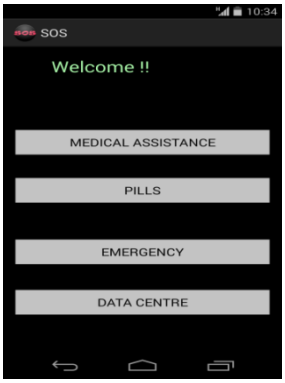

Fig. 4. The user interface of the android based remote health monitoring

Results

For complete analysis of fall threshold a total of 130 experiments were conducted. A receiver operating characteristic (ROC) was plotted. The ROC curve for 25 threshold values is represented in figure 5. ROC analysis provides an approach to selecting an optimal threshold for the system developed. ROC analysis is related in a direct and natural way to analyze diagnostic decision making. This involves the counting of the number of falls (1) detected (true positives TP) (2) not detected (false negatives FN), and number of activity of daily living (3) detected (false positive FP) (4) not detected (true negative TN) as fall events [18], [19], [20].

The Figure 5, describes the ROC analysis of the fall. The various important parameters involved in this analysis are as follows:

1. Sensitivity: is the true positive rate of the system [39]
2. Precision: is the positive prediction value [39]
3. F1 score: is score is the harmonic mean of precision and sensitivity [18].

The ROC curve was plotted by using the fraction of true positives with respect to the fraction of false positives. Drawing an ROC curve involves plotting sensitivity (on the y-axis) versus specificity (on the x-axis).The diagonal of the ROC is termed as the "random guessing line". Threshold values that are above the diagonal line represent good classification results i.e. they are better than random classifications, threshold values below the diagonal line provide poor classification. Based on the above analysis we were able to obtain an optimum threshold for classification of a fall.

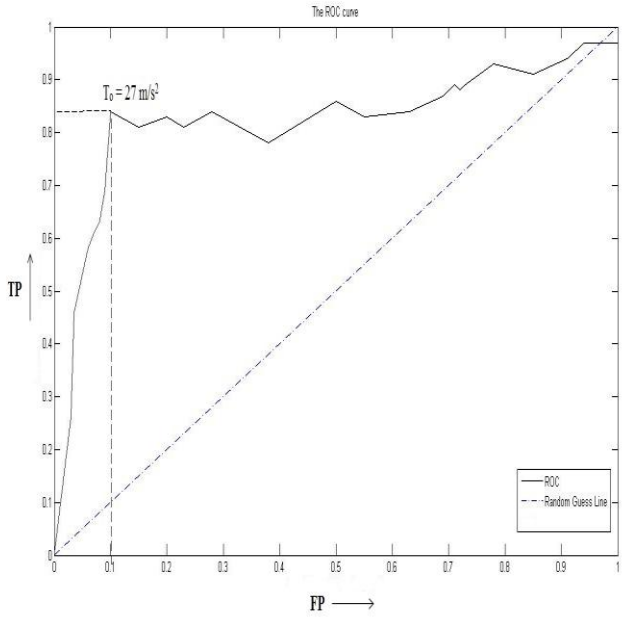

Fig.5. The ROC curve obtained during the optimization of the fall detector system where TP and FP are the true positive rate and false positive rate (false alarm) respectively

ROC analysis provides important information about diagnostic test performance: the closer the apex of the curve, towards the upper left corner, the better the threshold value, that is, the true-positive rate is high and the false-positive rate is low. Therefore thresholds with high true positive rate and high false positive are and those below the threshold are unsuitable. It can be deduced from the ROC curve that the most optimal threshold value lies at (0.1, 0.84). This optimal threshold for the fall detector system turns out to be 27 m/s2.

Location manager and the geo-coder are used to extract approximate location. The location feature is used in both the fall detector and the emergency module. The alert message is sent with the details shown in the figure 6. Shown in table I, details of fall detection at various locations tested near Manipal.

Fig. 6. Alert message seen at receiver end of the data center

The pill reminder and Doctor Appointment are additional features implemented in the development of the application. Choosing these options results in opening of a web service that downloads the data from cloud services. These data can be modified and updated on a regular basis without any changes made to the application.

TABLE I. Accuracy of the estimated location

Coordinates of latitude and longitude From Alert Message	Location Name	Coordinates of latitude and longitude From itouch Map[46]	Difference in location	
13.3516882, 74.7932122	Workshop road Manipal	13.352024, 74.793311	0.0003358	0.0499012
13.3535396, 74.7940737	MIT inside road	13.355351, 74.793575	0.0018114	0.0004987
13.3536562, 74.7945528	Udupi Agumbe highway	13.353629, 74.794176	0.0000272	0.0003768
13.3516542, 74.7826401	End point road	13.352136, 74.782600	0.0004818	0.0000401
13.3521332, 74.7820758	Aditi Parva Apartment	13.352104, 74.781994	0.0000292	0.0378642

Conclusion

An android application was developed for remote health monitoring. This application is able to detect a fall and send appropriate alert message to a data centre along with the client's location. The application is developed using Eclipse IDE. The development process involves accessing lot of inbuilt sensors and testing them on an android smart device. The device used during this process is LG Nexus 5. The fall detector is a module which gets initiated as soon as the application is opened. It is a java program that exploits the inbuilt array of sensors to detect a rapid motion thereby detecting a fall. The fall threshold was set after extensive testing and statistical analysis. The ideal threshold which was required was the one which did not affect the daily utility of the smart device and did not trigger a fall while walking, sitting or even while using the device to perform other tasks. The accelerometer is accessed using a sensor manager. Sensor event listeners have been used to keep track of changes in accelerometer values. The location sensor and location manager extracts latitude and longitude. The output of the location sensor is accurate as observed in Table 1 with average difference of 0.001453 and 0.0186 for latitude and longitude respectively. Using these coordinates the address is extracted using geo-coder.

Smart devices are becoming more popular every day. There is a vast potential for these devices to be implemented as portable health care devices. During the four month development process of this application we were able incorporate a fall detector, a location monitor, pill reminder and appointment scheduler. These results in such a short period of study proves that there is a huge scope for future development and this area of study should be closely followed as there might be some ground breaking discoveries happening in the coming future.

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