Location Aware Health Monitoring System For Emergency Cases

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Abstract: Patient monitoring system has drawn considerable attention of the researchers for the last few years. An effective patient monitoring system should be able to record, display, and transmit patients' critical physiological data to their healthcare service providers from anywhere at any time. Recently, mobile technology has led to significant innovations in this field ranging from implantable devices to smart applications. In this work, we present an innovative patient monitoring system that integrates an application and wearable devices to monitor the patients' critical physiological data. In addition, it uses the global positioning system (GPS) so that patients and healthcare service providers can track each other. We have field tested our system and the results show that our proposed system can send vital physiological data as well as the location information of patients to a remote healthcare service provider with a high precision. The system also generates alarm messages for the patients and it also assists the patients to locate the nearby healthcare service providers. The location information is automatically updated with the patients' movement.

Index Terms: App Inventor, Arduino, Bluetooth, GPS, health alert, patient monitoring, physiological data, sensors

1 Introduction

Monitoring the health status of patients is a very challenging issue. Remote healthcare monitoring can play an important role here. An effective remote healthcare monitoring system can reduce the workload on healthcare service providers. It can also reduce the workload on the public safety networks, charity, and governmental and non-governmental organizations. The ultimate goal of an effective healthcare monitoring system is to reduce healthcare cost, which is skyrocketing as shown in Fig.1. According to the Organization for Economic Co-operation and Development (OECD) healthcare costs have been growing at an unsustainable level in some developed countries as depicted in the Fig.1. For example, the per capita health expenditure in USA has increased from USD 27 (in 1960) to USD 2594 (in 2010). It is also projected that the same will increase to USD 4487 in 2020.

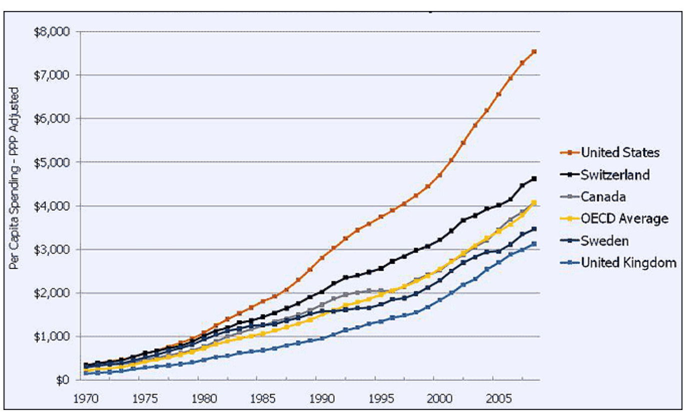

Figure 1. *The healthcare cost of some selected developed countries.*

Modern healthcare system has evolved and entered a modern arena over the last few years. However, it is still a common practice for patients to visit healthcare service providers for necessary diagnosis and advising. There are two basic problems associated with this common practice. Firstly, patients need to stay in a hospital for a period of time. Secondly, the healthcare professionals must be present onsite with the patients to assist them. To solve these problems remote patient monitoring system has been introduced. A remote patient monitoring system should be able to record, display, and transmit a patient's physiological data from anywhere at any time. These systems are usually equipped with an alarming system, which can send messages to patients and healthcare service providers about any abnormal physiological data that are outside the normal range [1]. Over the years, mobile technology has led to significant innovations in healthcare — from implantable devices to smart applications. Mobile device based healthcare system has become popular because of improved patient experience and cost effectiveness. In this work, we introduce a mobile device based patient monitoring system. We integrate an application, a mobile device, and a set of wearable devices to monitor the patient's physiological data and to share the same with the healthcare service providers. We integrate different modules into one Android application. The proposed system is able to measure the temperature, heartbeat rate, and blood pressure of a patient. The main objectives of our proposed healthcare system are as follows. The system can assist in monitoring the health of patients, who are living in remote areas. Hence, the system is able to reduce the back-and-forth travel of the patients from hospital to home (or workplace). In this work, we also use the Internet of Things (IoT) platform. The IoT offers a promising technology to achieve the aforementioned healthcare services, and can further improve the medical service systems [2]. We develop a software based on the MIT App Inventor 2 that is compatible with Android operating system. Our system also uses GPS technology. The GPS technology assists a patient to find the locations of the nearest healthcare service providers. At the same time, the healthcare service providers is also able to locate the patient. The rest of the paper is organized as follows. Some recent related works are presented in section 2. System model is presented in section 3. The hardware and software implementations of the system are described in section 4. The results are presented in section 5. The paper is concluded with section 6.

2 Related Works

The patient monitoring system, presented in [3], uses sensors to monitor the heartbeats, body temperature, respiratory rate, and ECG of a patient. It uses a microcontroller board to analyze patient's physiological data and to generate alarm message (if necessary). A hospital healthcare monitoring system, using wireless sensor networks, has been presented in [4]. The system has the ability to monitor physiological data of multiple patients admitted in a hospital. The systems uses a coordinator node attached on patient body to collect all data from the sensors and sends them to a base station. The attached sensors form a wireless body sensor network (WBSN). The sensors are able to sense the heart rate and blood pressure of the patient. This system can detect any abnormal conditions, issue an alarm to the patient and send a SMS/E-mail to the concerned physicians. In addition, the system consists of several wireless relay nodes, which are responsible for relaying the data sent by the coordinator node and forwarding the same to a base station. An automated wireless health monitoring system has been presented in [5]. The system measures a patient's body temperature and heartbeat rate by using embedded RF technology. The system consists of a power supply, an 8051-microcontroller, a temperature sensor, RF transmitter and receiver modules, and an LCD display. The 8051 microcontroller is used for collecting and displaying the patient's data. According to American Heart Association, $4 billion of unnecessary medical bills are paid each year on the assessment of non-cardiac cases in hospital emergency departments. To reduce these costs and the anxiety of people with known cardiovascular problems, a portable monitoring system has been presented in [6]. The system consists of smart phones and wearable sensors. This system monitors the heartbeats and notifies the person or external party in case of any abnormalities in patient data. As the World's population gets older, diseases directly related to aging are increasing and they are becoming the focus of technological effort and research. Alzheimer's disease (AD) is one of the common diseases among old people. A mobile device-based healthcare system, for monitoring the patients with Alzheimer's disease, has been developed and presented in [7]. The system enables the caregivers and medical professionals to monitor their patients all the time. Similar remote health care monitoring system (RHCMS) has been presented in [8]. The system emphasizes accuracy in measuring, recording, and analyzing patients' data. The results show that the RHCMS can be widely deployed to monitor the health condition of a patient inside and outside of the hospital. Patient parameter monitoring system, using Raspberry Pi, has been presented in [9]. The system is designed for measuring and monitoring various parameters like temperature, ECG, and heartbeat. The system can record data using Raspberry Pi and display the same on a LCD. The system also records the results in a server using GSM module so that the physicians can access the server to retrieve the patient's data. A monitoring and advisory system for diabetes patient management, using a rule-based method and K-Nearest Neighbor (KNN) classifier, has been introduced in [10]. The system can send physiological data namely blood sugar, blood pressure, and food consumption of diabetic patients, and can manage the treatment by recommending and monitoring food consumption, physical activity, and insulin dosage for the patients. Smart system for monitoring children's chronic illness has been presented in [11]. By using the system parents, teachers, and doctors can remotely monitor the health of children based on the sensors embedded in the smartphones and smart wearable devices. Cloud-assisted Internet of Things (IoT) enabled framework for health monitoring has been presented in [12]. The system uses the emerging IoT technologies for interconnecting medical devices and sensors. The system is able to monitor the ECG and other physiological data by mobile devices and sensors and securely send data to the cloud for seamless access by healthcare professionals. Cloud-supported cyber-physical localization framework for patient monitoring has been presented in [13]. The system facilitates the seamless integration of devices in the physical world (e.g., sensors, cameras, microphones, speakers, and GPS) with cyberspace. This enables a range of emerging applications, such as patient or health monitoring, to track the patient's location. The system integrates a large number of physical devices, with localization technologies (e.g., GPS, WLAN), to generate, sense, analyze, and share medical and user-location data for complex processing. To monitor the health of a pregnant woman with preeclampsia, a novel health monitoring system has been proposed in [14]. The system has been designed for the community-based health care providers so that they can collect symptoms and perform clinical measurements at the patient's home. The clinical data are used to predict the risk level of a patient. Based on the risk level, the system provides recommendations for treatment, referral, and reassessment. The proposed system also uses an oximeter to measure oxygen saturation level of a patient in order to predict her risk level. A wireless stand-alone portable patient monitoring and logging system has been designed in [15]. The proposed system monitors three biomedical parameters by a single personal medical device. These three parameters are: blood glucose level, heart rate, and pulse oximetry. The goal of the work is to build a compact and cost-effective device, which is capable of monitoring several medical parameters while patients conduct their normal daily activities and storing these parameters in an embedded system based portable device. Wireless electrocardiogram (ECG) monitoring system based on Bluetooth Low Energy (BLE) technology has been reported in [16]. The system consists of (i) a single-chip ECG signal acquisition module, (ii) a Bluetooth module, and (iii) a smartphone. The system is able to acquire ECG signals through two-lead electrocardiogram (ECG) sensor. The system is also able to transmit the ECG data via the Bluetooth wireless link to a smartphone for further processing and displaying the ECG signals. The results show that the proposed system can operate for a longer time due to low power BLE technology. Wireless medical sensor network has been used in [17]. It consists of a collection of biosensors connected to a human body. The system monitors patient's vital physiological data. The real-time medical data, collected using wearable medical sensors, are transmitted to a diagnostic center. The data generated from the sensors are collected aggregated at the center and then are transmitted to the doctor's personal digital assistant (PDA) for diagnosis. The system uses the symmetric algorithm and attribute based encryption to secure data transmission and access control system for medical sensor network. The work also addresses the advantages of the system over other systems in terms of encryption time, decryption time, and total computation time. A modular framework work is presented in [18]. The system uses a smart wearable system for ECG and health monitoring. The proposed framework is used for remote restorative frameworks to help the elderly patients, for self-testing diagnostics, or for doctors to analyze ailments of the circulatory framework. The proposed framework comprises of electrocardiogram (ECG), which evaluates the anomalies of heart and heartbeat. The system stores the data utilizing Arduino Mega. The framework is considered extremely useful as the patient's condition is routinely checked without the patient setting off to the clinic for standard check-up. The system is also associated with the cell phone through Bluetooth technology and the patient's data are shown in an application.

3 System Model

The system block diagram of our proposed system is shown in Fig. 2. The sensors are attached to the patient's body. These sensors measure vital signs including body temperature, blood pressure, and heartbeat rate of the patient. These sensors and the Bluetooth chip are attached to the E-health shield. The E-health shield is connected to the Arduino. The Bluetooth chip sends the data to an application resided in the patient's mobile device. The application analyses the sensors' data and determines any abnormality in the data. If the application finds some abnormality in data, it notifies the patient with a message. The application also provides the patients with data about the nearest healthcare service provider. The application is able to track the patient's location and send a message to a nearest healthcare service provider. The message contains data about the abnormality in the patient data so that the nearest healthcare service provider is able to track the patient's status and send an emergency team to the patient.

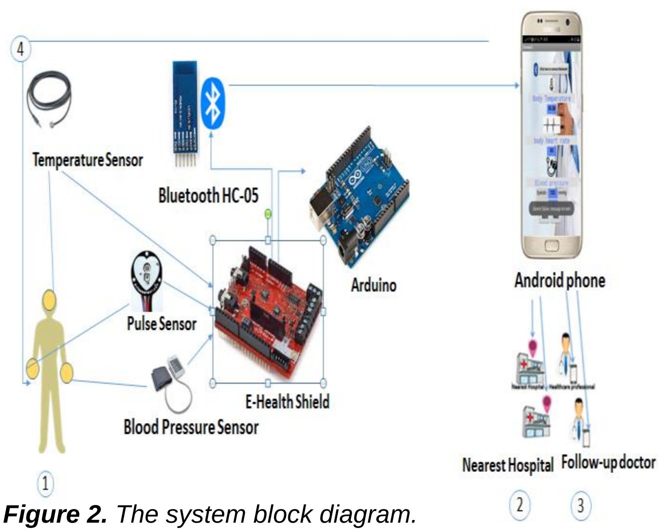

Figure 2. *The system block diagram.*

The program flowchart is shown in Fig. 3. The system starts working and receives the data from the sensors. The GPS provides data about the longitude and latitude of the patient's location. These two readings help the nearest healthcare center to find the location of the patient and dispatch an ambulance to her/him. The application displays data and stores the same so that the patient and the physicians can access the data at anytime from anywhere. During the movement of patient, the system recalculates relative distance between the patient and all the nearby healthcare centers and it compares these distances so that the patient knows about the nearest healthcare center. In case of emergency, the system sends two messages. The first message is sent to the patient herself/himself to inform her/him any abnormality in the physiological data. This message also contains location information about the nearest healthcare center so that she/he can visit the doctor for necessary diagnosis. The second message is sent to the nearest healthcare center to inform them the location of the patient and her/his status. Therefore, the nearest healthcare service provider can locate the patient and can judge the urgency. If the data is in the normal range, the system keeps working without sending any alarm message.

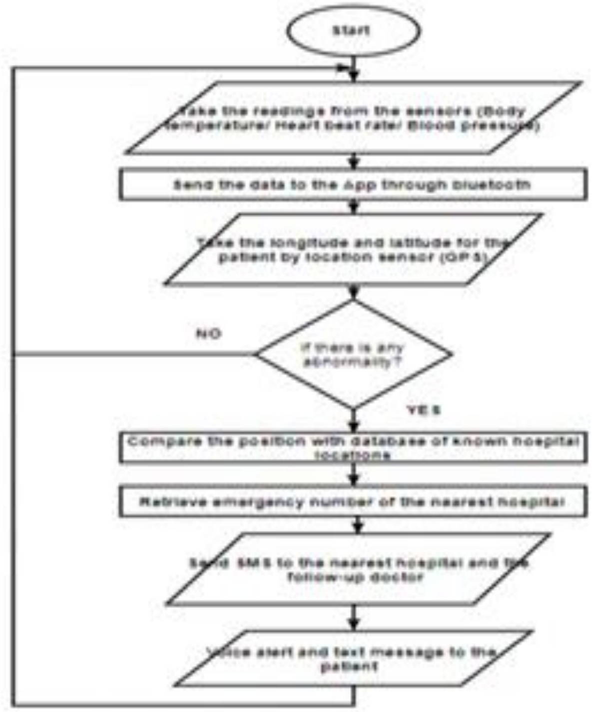

Figure 3. *The program flowchart.*

Both of these two parameters are measured in the scale of 0-360^0, symbolized by degree of a circle. Taking the earth to be perfectly spherical, one degree of latitude along a meridian (from one parallel to the next one 1° away) always measures the same distance because latitude measures distance. That distance amounts to about 111.1 km (69.1 mile) for the earth. One degree of longitude, on the other hand, measures angle so that the distance covered by 1° of longitude is a different distance at every latitude. Taking the earth to be perfectly spherical, then at the equator 1° of longitude is the same as 1° of latitude; at 60° north or south the distance is half of that (55.6 km or 34.5 mile). In this work, we use the following formulae to calculate the distance between two sets of coordinates:

$$x = 69.1(\emptyset_2 - \emptyset_1) \quad (1)$$

$$y = 69.1\ (\lambda_2\ - \lambda_1\ )*\cos(\frac{\emptyset_1}{57.3}) \quad (2)$$

$$D = \sqrt{x^2 + y^2} \quad (3)$$

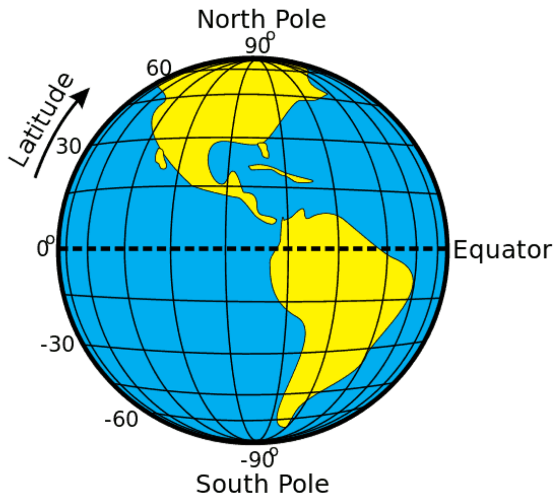

Figure 4. *The Geographical latitude and longitude.*

where x is the distance for latitude, y is the distance for longitude, D is the distance between the two points, and λ_1 and λ_2 are the longitudes of the point 1 and point 2, ϕ_1 and ϕ_2 are the latitudes of the points 1 and 2. To convert from decimal degrees to radian we should use a factor of $\frac{180}{\pi}$, or approximately 57. 296^0. This formula is very accurate enough for our system. However, there is more accurate formulae called Haversine formulae that are available to calculate the distances. The Haversine formulae are given by

$$hav(\theta) = \sin\left(\frac{\theta}{2}\right) = \frac{1-\cos\theta}{2}$$
(4)

$$d = 2r\sin^{-1}\left(\sqrt{hav(\varphi_2 - \varphi_2) + \cos(\varphi_1)\cos(\varphi_2)hav(\lambda_2 - \lambda_2)}\right)$$
(5)

where d=the distance between two points, r= the Earth's radius in meters, φ_1, φ_2 : the latitudes of points 1 and 2, λ_1, λ_2: the longitudes of points 1 and 2. We test our formulae with that of Haversine formulae and we discover that our formulae can measure the distances with an accuracy of 99.01%.

4 System Hardware and Software

In this section, we explain the hardware used to implement the system. Our system consists of Android's Operating System, BlueSMiRF, and Arduino as shown in Fig. 5. The system sends the data from the Arduino to a mobile application wirelessly. We use a Bluetooth chip for this purpose. Since the distance between the Arduino and mobile device is very short, we use the Bluetooth to send the data over short distances (less than 10 meters). We choose Bluetooth technology because it supports a high data rate and it is a low power wireless technology. We use an Android OS smart phone as the user interface device. We use the BlueSMiRF [19] as the wireless communication technology, and Arduino as the microcontroller. The Bluetooth protocol operates at 2.4 GHz band from 2400 to 2483.5 MHz. It uses 79 radio frequency channels in the band starting at 2402 MHz and continuing every 1 MHz.

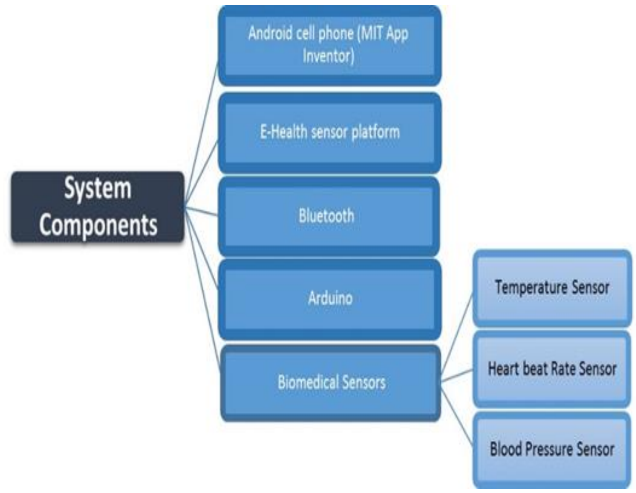

Figure 5. *The system component.*

The Bluetooth network is called Piconet [20], which consists of one master and one or more (up to seven) slaves. The master coordinates communication throughout the Piconet. It can send data to any of its slaves and request data from them as well. The slaves are only allowed to transmit to and receive from their master. They cannot communicate with other slaves in the Piconet. In our system, the master is the Arduino and the slave is the mobile. The Bluetooth Chip in our system is BlueSmirf. We connect the Arduino to the Bluetooth chip as shown in Fig. 6. We connect TX-O pin to D2 of the Arduino and the RX-I to D3. The CTS-I and RTS-O pins are left floating. We develop a program for the Arduino. This program collects data from the sensors and delivers the data to the mobile application via Bluetooth. In this work, we use a set of sensors namely temperature sensor, pulse sensor, and blood pressure sensor. The sensors are described in the following subsections.

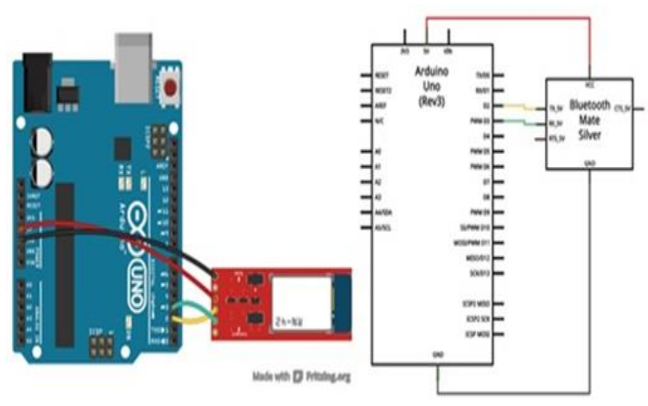

Figure 6. *The connection between Bluetooth and the Microcontroller*

A. Temperature sensor

A temperature sensor used in the work is shown in Fig. 7. The sensor measures the temperature of an object. In our project, we use this sensor to measure the body temperature of a patient. This sensor data depends on placement, the time of the day, and the activity level of the person. The normal body temperature is 37 °C of an adult and the healthy adult's temperature fluctuates about 0.5°C throughout the day. We use these data in our algorithm to detect any abnormality in patient's body temperature.

Figure 7*. The temperature sensor.*

We calibrate the temperature sensor before integrating it to the system. In most applications (including our system), the precision of this sensor is good enough. However, we improve the precision by using calibration. We use three resistances called R_a, R_b, and R_c in the E-health shield [21] for calibration. Each resistance has a certain value and this value is recorded in the accompanied software of e-Health board to do the calibration. These values can be varied. We calibrate the sensor by setting the resistances as R_a=4700, R_c=4700, and R_b=821 as shown in Figure 8.

Figure 8*. The calibration of the temperature sensors.*

The pulse sensor consists of two main components namely an LED and a circuitry. The LED is placed on the veins. These veins have the blood flow inside them when the heart pumps. Hence, the sensor monitors blood flow and measures heartbeat rate. Once the flow of the blood is detected, the ambient light sensor picks up more light. The change in the received light is analyzed to find the heartbeat rate. The circuitry side is responsible for canceling the noise [22]. We connect the pulse sensor with the e-health shield as shown in Fig. 10. We set normal rate of the heart bit rate for patients of different age groups in our applications. These ranges are listed in Table 1.

Table 1*: The heartbeat rate data*

Age	Heart rate (beats per minute)
Infant (6 months)	120-160
Toddler (2 years)	90-140
Preschooler	80-110
School age	75-100
Adolescent	60-90
Adult	60-100

Pin number	Pin name	Wire color	description
1	Ground	Black	Connected to the ground of the system
2	VCC	Red	Connected to +5V or +3.3V supply voltage
3	Signal	Purple	Pulsating output signal

Figure 9 *The connection of pulse sensors*

C. Blood pressure sensor

We use Arduino to connect the sensors. Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs easily since they are equipped with a set of digital and analog input/output pins that are interfaced to breadboards or circuits. We choose the Arduino because of the following reasons. Arduino boards are relatively inexpensive compared to other microcontroller platforms. The Arduino modules cost less than $50. The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems, whereas most microcontroller systems are limited to Windows only.

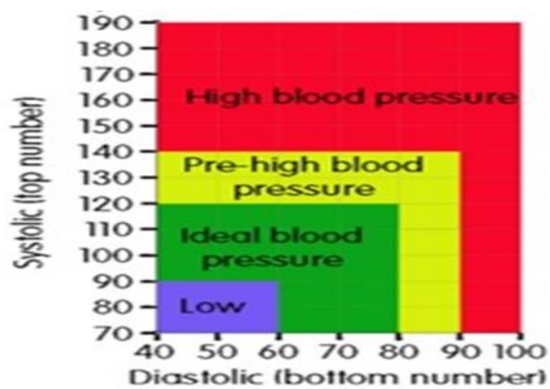

Figure 11 *The ranges of blood pressure.*

The Arduino Software (IDE) is easy-to-use for beginners who don't know much about programming. It is also flexible enough for advanced users. The Arduino software is an open source tools. We have used an Android operating system (OS) based Smartphone in the system. The Android system is designed based on the Linux Kernel and currently developed by Google. We use a mobile device in our project implementation. The reasons are as follows. We use smartphones in our system because it can fit in a purse or pocket. Smartphones can be connected to Wi-Fi networks for Internet access. It can also be connected to a mobile data network. We need a GPS system to provide the location of the patient continuously. The mobile phone has a built-in GPS. We need a GSM network to send an alarm message to the follow-up doctor and to the nearest healthcare service provider. The system sends the messages to their phone numbers by using the GSM system, which is already built-in the mobile. We use the MIT App Inventor to implement the mobile application of this system.

5. The Results

The screen shoot of the application is shown in Fig. 12. The display menu shows the physiological date of a patient. We develop this Android application for receiving the vitals sign and displaying on Android smartphone with the help of Bluetooth Module and record the data in an Android web server. After opening the Android application in mobile, it will show the list of Bluetooth modules as shown in Fig. 13.

Figure 12 *A screen shot showing the vital signs measured by the application.*

After connecting the BlueSmirf, the system receives data from Arduino. The patient receives an alarm massage when there is any abnormality in the patient's physiological data as shown in Fig. 14. The massage contains the patient data and name of the nearest hospital as shown in Fig. 14. At the same time, the system sends an alarm massage directly to the nearest healthcare center. The later message also contains the patient data. When one or more of the vital signs increase above the normal range, the system sends a message (see Fig. 15 and Fig. 16) to the nearest healthcare service provider for necessary advising. Fig. 17 shows the longitude and latitude data for the patient. Based on this information the application determines the current location of the patient. If she/he moves from one place to another, the longitude and latitude data will change, and the system will determine the location of the patient. Then, the system determines the distance between current location of the patient and the location of hospital by using the equations mentioned in section 3.

Figure 13 *The list of nearby Bluetooth devices.*

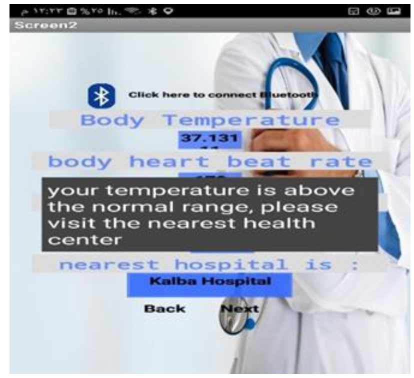

Figure 14 *Readings from Arduino*

The system locates the nearest healthcare center comparing the distances between hospitals and current location of the patient. Fig.18 shows the main hospitals in the local region. The distance calculation is also illustrated in Fig. 18. The figure shows two cars. The dotted line indicates the nearest hospital for each car. It shows the patient and two main hospitals in the area. The system provides the patient with the nearest hospital so that she/he can reach there faster. The nearest hospital is the shorter line and our system provides this information to the patient while he is moving. Table 2 shows the information of the main healthcare centers in the local region that we use their coordinates in our system. Although there are several healthcare service providers located in this region, we include only the hospitals (as shown in Table II) because these hospitals have only the emergency units.

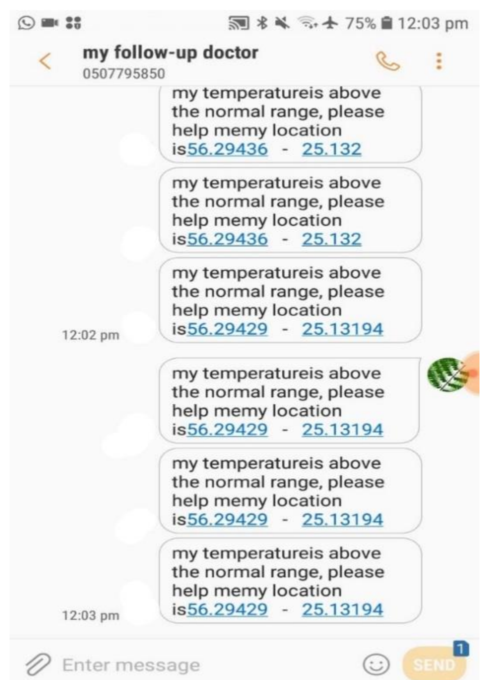

Figure 15 *Message to doctor*

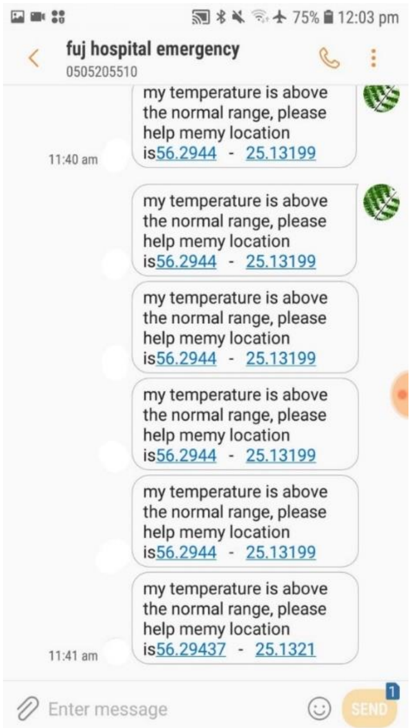

Figure 16 *Message to hospital emergency*

Figure 17 *The measurement of the distances*

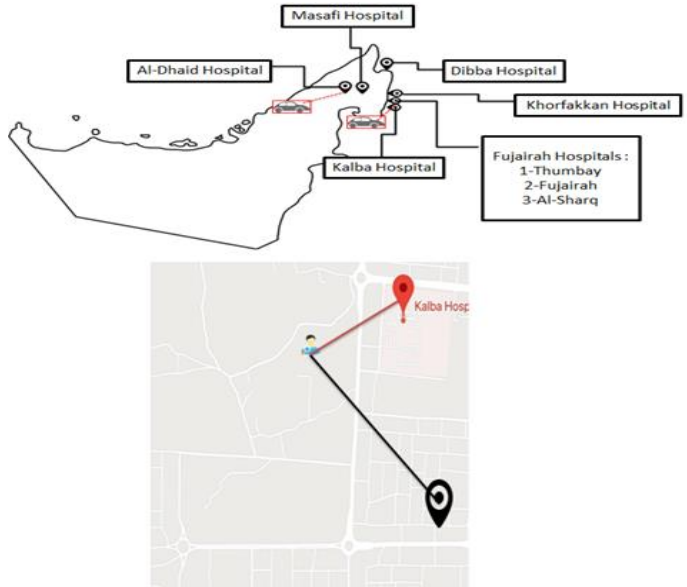

Figure 18 *Hospitals in the eastern region, and (b) the nearest hospital*

TABLE 2: *THE LOCAL HEALTHCARE PROVIDERS' DATA*

Place	*Latitude*	*Longitude*
Kalba Hospital	*25.0359*	*56.3441*
Thumbay Hospital Fujairah	*25.131967*	*56.341291*
Fujairah Hospital	*25.1255*	*56.315*
Khorfakkan Hospital	*25.3366*	*6.3433*
Alshaarq Hospital	*25.1513*	*56.351*
Dibba Hospital	*25.5884*	*56.2665*

6. CONCLUSION

In this paper, we present an emergency healthcare system for emergency cases. The current designed system eliminates the need for utilization of expensive facilities, decreases the unnecessary back-and-forth patient visit to the healthcare centers, reduces the tasks for healthcare professionals, and provides the doctors with the information about their patients at anytime and anywhere. We present test results of our system in this paper. The results show that our system is very efficient and accurate in measuring and monitoring patients' data. Unlike other existing systems, our system not only sends the patients' data, but also sends the location information of the patient and the healthcare centers. Hence, the system helps both the patient and the healthcare centers to locate each other so that they take immediate actions depending on the emergency situations. We make our system flexible so that the system can be easily adapted to the future technologies.

REFERENCES

[1] Abdullah, A., Ismael, A., Rashid, A., Abou-ElNour, A., and Tarique, M., "Real time wireless health monitoring application using mobile devices", International Journal of Computer Networks and Communications (IJCNC), Vol. 7, N. 3, May 2015, pp.13-30.

[2] Abdelgawad A., Yelamarthi K., Khattab A. (2017) IoT-Based Health Monitoring System for Active and Assisted Living. In: Gaggi O., Manzoni P., Palazzi C., Bujari A., Marquez-Barja J. (eds) Smart Objects and

Technologies for Social Good. GOODTECHS 2016. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 195. Springer, Cham, pp. 11-20

[3] Nani, P. , “A project report on patient monitoring system”, available at http://www.academia.edu/11154016/a_pject_report_on_patent_monitoring-system Accessed 19 January 2019.

[4] Aminian, M., and Naji, H. R., “A hospital healthcare monitoring system using wireless sensor networks”, Journal of Health Medical Informatics, Vol. 4, No. 2, February 2013, pp. 2-6.

[5] ElProCus - Electronic Projects for Engineering Students. “Automatic Wireless Health Monitoring System Circuit and Working” available at: https://www.elprocus.com/automatic-wireless-health-monitoring-system-circuit/ [Accessed 19 May 2018].

[6] Gay, V., and Leijdekkers, P., “A health monitoring system using smart phones and wearable sensors”, International journal of ARM, Vol. 8, No.2, June 2007, pp. 29-35.

[7] Reyes, A. K., Camargo, J. E., and Diaz, G. M. , “Pervasive mobile application to assist elderly people with cognitive impairment”, Proceedings of the 10th IEEE Computing Colombian Conference (10CCC), September 21-25, Bagota, Columbia, pp. 229-236

[8] Al Sharqi, K., Abdelbari, A., Abou-Elnour, A., and Tarique, M., “Zigbee Based Wearable Remote Healthcare Monitoring System for Elderly Patients”, International Journal of Wireless & Mobile Networks, Vol. 6, No. 3, June 2014, pp. 53-67

[9] Navdeti, P., Parte, S., Talashilkar, P., Patil, J., & Khairnar, V., “Patient parameter monitoring system using Raspberry Pi”, International Journal of Engineering And Computer Science, Vol. 5, No. 3, March 2016, pp. 16018-16021

[10] Lee, M., Gatton, T. M., & Lee, K. K., “A monitoring and advisory system for diabetes patient management using a rule-based method and KNN”, Sensors, Vol. 10, No.4, April 2010, pp. 3934-3953.

[11] Sendra, S., Parra, L., Lloret, J., & Tomás, J, “Smart system for children's chronic illness monitoring”, Information Fusion, Vol. 40, March 2018, pp. 76-86.

[12] Hossain, M. S., & Muhammad, G. (2016). Cloud-assisted Industrial Internet of Things (IIoT)–Enabled framework for health monitoring”, Computer Networks, Vol, 101, June 2016, pp. 192-202.

[13] Hossain, M. S. (2017). Cloud-supported cyber–physical localization framework for patients monitoring. IEEE Systems Journal, Vol. 11, No.1, March 2017, pp. 118-127.

[14] Dunsmuir, D. T., Payne, B. A., Cloete, G., Petersen, C. L., Görges, M., Lim, J., and Ansermino, J. M. , “Development of mHealth Applications for Pre-eclampsia Triage”, IEEE journal of Biomedical and Health Informatics, Vol. 18, No. 6, November 2014, pp. 1857-1864.

[15] Landolsi, T., Al-Ali, A. R., & Al-Assaf, Y. , “Wireless Stand-alone Portable Patient Monitoring and Logging System”. Journal of Communication, Vol. 2, No. 4, June 2007, pp. 65-70

[16] Bin Yu ; Lisheng Xu ; Yongxu Li(2012) “Bluetooth Low Energy (BLE) based mobile electrocardiogram monitoring system”, In the proceedings of International Conference on Information and Automation, June 6-8, 2012, Shenyang, pp. 763-767

[17] Zhang, C. , “Healthcare mobile app development with app inventor in a health IT course”, Proceedings of the Southern Association for Information Systems Conference, Macon, GA, USA March 21st –22nd, 2014, pp. 1-6

[18] Teja, A. D., and Rao, K. S. , “A Smart Wearable System for ECG and Health Monitoring”, International Journal of Advance Research and Development, Vol. 3, No.2, February 2018, pp. 57-63

[19] Using the BlueSMiRF available at https://learn.sparkfun.com/tutorials/using-the-bluesmirf/all accessed on January 29,2019

[20] Bluetooth Basics available at https://learn.sparkfun.com/tutorials/bluetooth-basics accessed January 29,2019

[21] E-Health Sensor Platform V2.0 for Arduino and Raspberry Pi [Biometric / Medical Applications]. Retrieved November 5, 2018, from https://www.cooking-hacks.com/documentation/tutorials/ehealth-biometric-sensor-platform-arduino-raspberry-pi-medical

[22] Pulse Sensor. Retrieved November 1, 2018, from https://components101.com/sensors/pulse-sensor