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Patient Medical Emergency Alert System

Benjamin Kommey
Kwame Nkrumah University of Science and Technology
Knust - Kumasi
Ghana

Seth Djanie Kotey
Kwame Nkrumah University of Science and Technology
Knust - Kumasi
Ghana

Daniel Opoku
Kwame Nkrumah University of Science and Technology
Knust - Kumasi
Ghana

ABSTRACT
Healthcare and health of people is an important need of the human population. Heartrate and body temperature are two very important vitals related to the health of a person. The ability to monitor these two vital signs is key to ensure proper healthcare is delivered early. In this paper, a system to monitor heartrate and body temperature of a user and alert the user when these values are abnormal is proposed. Patient Medical Emergency Alert System (PMEAS) consists mainly of two components, a wearable hardware unit and an android application. The wearable unit contains sensors to monitor the heartrate and body temperature of the user, which are displayed on an LCD screen. These sensor values are transmitted to an android device via Bluetooth and are managed by the android application. An alert is sent to confidants via email or SMS when these values are abnormal. The application is also able to display the recorded values in the form of a graph to help determine the state of health of the user over a period of time.

General Terms
Healthcare Alert

Keywords
Patient, Health, Alert, Heartrate, Temperature

1. INTRODUCTION
In recent times, it has become necessary to have a system that constantly monitors a patient's heartrate and body temperature autonomously and then send an alert when readings are out of range to ensure healthcare is always provided on time. People are dying from heart related diseases like coronary heart disease, congestive heart failure, heart attack, and congenital heart disease especially the aged who need 24 hours monitoring [1]. Body temperature is a vital sign that medical professionals measure to help them determine the condition of their patients [2]. The normal temperature of the body is dependent on a recent activity, time of the day, age and ranges from 36.1 degrees Celsius (97 degrees Fahrenheit) to 37.2 degree Celsius (99 degrees Fahrenheit) for healthy adults [3, 4]. The number of times a person's heart beats every minute is what is referred to as heartrate, sometimes referred to as pulse, varying from person to person depending on their medical conditions or the state in which they find themselves. Cardiac muscles have the ability to contract and relax on their own during the cardiac cycle which is the expected normal heart beat of a healthy person. Resting heartrate, a term used by cardiologist to refer to the recorded heartrate of a healthy person when calm and relaxed usually falls within the range of 60 to 100 beats per minute for an average adult [5, 6]. Heartrates out of this range are considered alarming. Tachycardia is a condition that results when the heartrate is above 100 beats per minute. This condition can be caused by high blood pressure, inadequate supply of blood to the heart muscles due to coronary artery disease, drinking so much alcohol or caffeine and smoking [7, 8]. Bradycardia is a condition where the heartrate is less than 60 beats per minute and therefore calls for alarm. This condition occurs because the electrical systems of the heart functions abnormally and can be caused by age, coronary artery disease, fluid imbalance (high amount of Potassium in blood stream) [7, 9]. Therefore, there is the need to have a system that can determine the heartrate especially when it is outside the range of 60-100 beats per minute and send alerts so that such people can be rescued.

Patient Medical Emergency Alert System (PMEAS) is a wearable device that monitors the user's heartrate and temperature anywhere. Temperature sensors and pulse sensors are used to measure the respective values and display them on a screen for the user to see. These values are also sent to an application on an android device via Bluetooth and an alert is sent to confidants when measured values are abnormal.

The rest of the paper is organized as follows: Related works are presented in Section 2, the Proposed Model is presented in Section 3, Testing and Results are presented in Section 4 and the Conclusion is in Section 5.

2. RELATED WORKS
Several patient monitoring systems have been proposed in literature.

Ufoaroh et al. [10] proposed a heartbeat monitoring and alert system. The system uses a pulse sensor to measure the changes in the heartbeat of the user, and then calculates the heartrate in beats per minute (BPM). The system consists of a microcontroller unit, an LCD unit, a buzzer, a pulse sensor and a GSM module. The microcontroller calculates the BPM and displays it on the LCD screen. Each time the heartrate rises above or falls below a threshold, the buzzer sounds and an SMS message is sent via the GSM module with the current BPM value.

Abdullah et al. [11] proposed a real time wireless health monitoring application. The system, a smartphone-based one, provides real time information about the medical status of a person. It is also able to send messages about the user's health status to a mentor for medical diagnosis and advise. The system consists of ECG electrodes, a temperature sensor, blood glucose sensor, blood pressure sensor and a Microsoft Surface Pro Tablet running a LabVIEW software. The LabVIEW software displays the recorded values from the sensors for monitoring and analysis.

Subhani et al. [12] proposed a GSM-based heartrate and temperature monitoring system. The system consists of a heartrate sensor, a GSM modem, a temperature sensor, an

LCD display and a microcontroller. The heartrate sensor is made up of an LED and an LDR placed parallel to each other such that when the light from the LED hits the finger, the reflected rays are received by the LDR and the heartrate can be calculated based on the received signal at the LDR. The values recorded by the temperature and heartrate sensors are displayed on the LCD screen and are transmitted to some medical personnel before arriving at a hospital for timely diagnosis.

Sengeeth et al. [13] proposed a patient monitoring system using GSM technology. The system measures the heartrate of the user from the index finger using an Infrared sensor. A temperature sensor also measures the body temperature and these values are displayed on the LCD screen. The system sounds an alarm when the recorded values exceed a threshold value set. These values are transmitted to a doctor via a GSM module.

Pereira & Nagapriya [14] proposed an IoT based system to monitor the health of patients. The system is capable of measuring the heart rate, temperature and body fat. An LPC 2129 Arm Processor development board was used. An electrocardiograph was used to measure the heartrate, a temperature sensor for measuring temperature and a body fat analyzer, made up of an optical isolator circuit, human impedance circuit and a split supply circuit, was used to measure the body fat. An LCD screen also displays the measured values. The measured values are uploaded via WIFI to an online database for a medical practitioner to access from any part of the world for further analysis.

Digarse and Patil [15] proposed a wireless health monitoring system based on the Arduino UNO. The system measures the heartrate, body temperature and saline level of the user. The system consists of a pulse sensor, temperature sensor, saline level sensor, a GSM modem and an Arduino UNO microcontroller. The sensors measure the respective vitals of the user. If any of the measured values is above the threshold value, an SMS message is sent containing the measured values to a medical practitioner or caretaker for necessary action to be taken.

The proposed systems in the literature were tested and performed well. However, the systems proposed by Ufoaroh et al., Subhani et al., Sengeeth et al. and Digarse and Patil do not provide a platform to view a history of recorded values. The systems proposed by Abdullah et al. and Pereira & Nagapriya are not portable, and cannot be used outdoors to monitor the user's vitals continuously, hence do not automatically send an alert when the user's vitals are abnormal.

3. PROPOSED MODEL

The PMEAS system uses a microcontroller module, pulse sensor module, temperature sensor, Bluetooth module, a buzzer, an LED and an LCD. The pulse sensor reads the pulse of the user and the temperature sensor reads the body temperature of the user. The LCD displays these values and the Bluetooth module sends an alert when these values are abnormal to the user's phone to be sent to the confidants. The buzzer sounds and the LED also lights up to alert the user when the temperature or pulse values are abnormal. There is also a push button which enables the alert to be sent manually by the user. A block diagram of the system is shown in Figure 1.

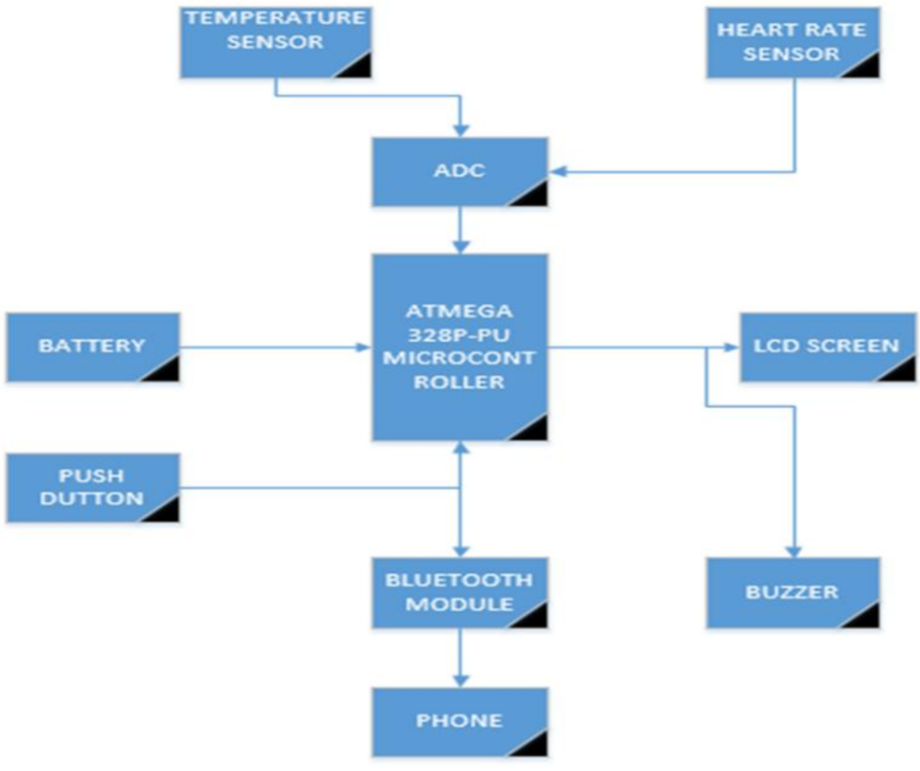

Figure 1: Block diagram of PMEAS

An android application was developed to manage the PMEAS system. The application mainly sends alerts to the confidants of the user when recorded values of the pulse and temperature are abnormal. Alerts can be sent via email, SMS or both email and SMS. The application also keeps a database of the recorded values and the user can view a graph of the values.

Alerts sent to the confidants include the location of the user. When the application is opened, there is a Login or Signup option. After logging in, a Bluetooth connection is started to pair with the PMEAS device. Once the connection is made, recorded values from the sensors are automatically received in the application and stored. Confidants can be added under the 'Relatives' submenu. The 'Check Heart Rate' submenu displays a history of recorded heartrates of the user, which can be shared to a confidant at any time. A personalized alert message can also be created to be sent when an alert is being sent to a confidant. Screenshots of the application are shown in Figure 2.

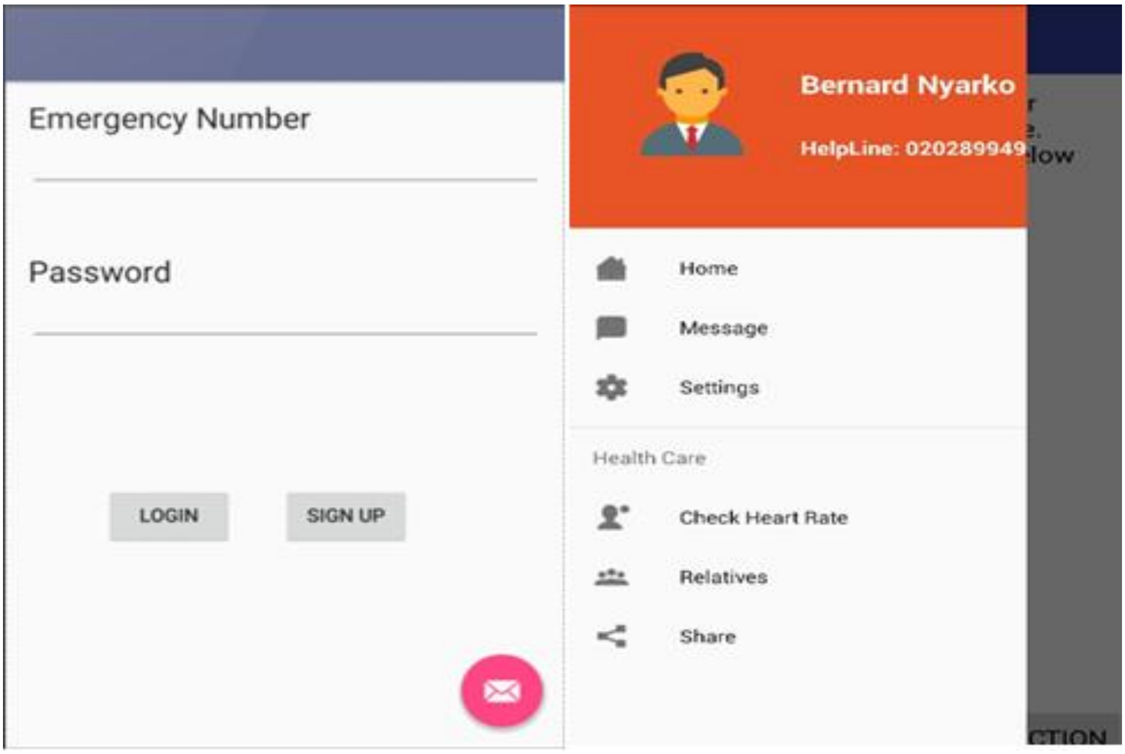

Figure 2: Screenshots of PMEAS application

3.1 System Operation

The PMEAS system automatically monitors the heartrate and body temperature of the user and sends an alert to the confidants of the user when these values are abnormal. The system begins monitoring these vital signs when the user wears the device and turns it on. The recorded values are transmitted to the phone via Bluetooth. On the phone is an android application that receives and stores the measured data from the PMEAS device. On the android application, the user of the PMEAS device can view a graph of the recorded data from the device. The most important feature and main purpose of the android application is to serve as a platform to be used to send alert messages. As such in case of an emergency, alerts are sent with the location of the user to confidants who may be of help in case of an emergency automatically by the android application or manually by the pressing a button on the device. On the android application, an SQLite database has been created to be used to store measured data from the PMEAS device and can be updated. If the temperature and heartrate are within the normal range, the system keeps monitoring. If either the temperature, heartrate, or both temperature and heartrate are not within the normal range, the LED lights up, the buzzer sounds and a message is sent to the confidant. If the user presses the button on the device, an alert is sent to the confidant. A flowchart of the system is shown in Figure 3. An overview of how the entire system works is shown in Figure 4.

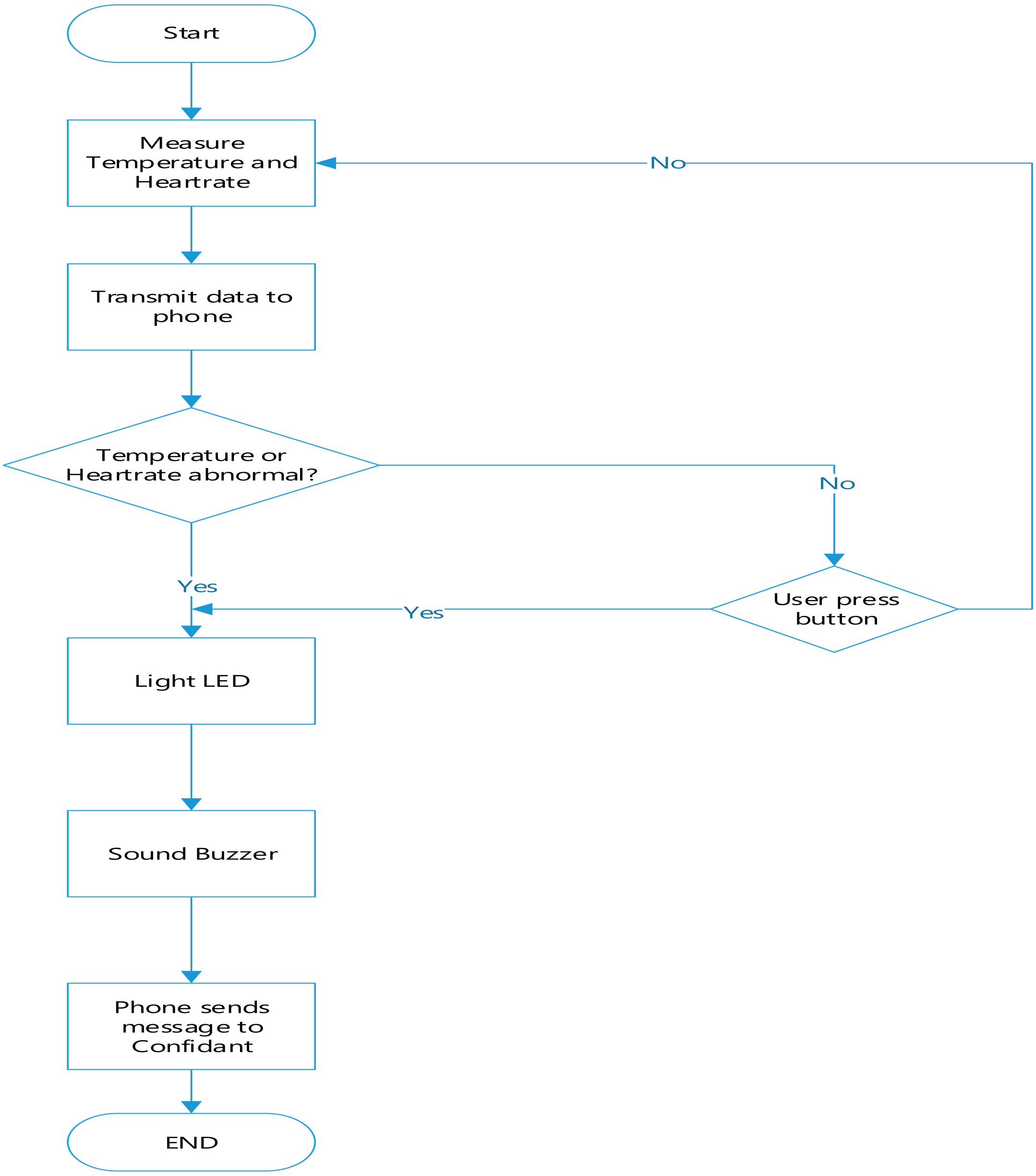

Figure 3: Flowchart of PMEAS

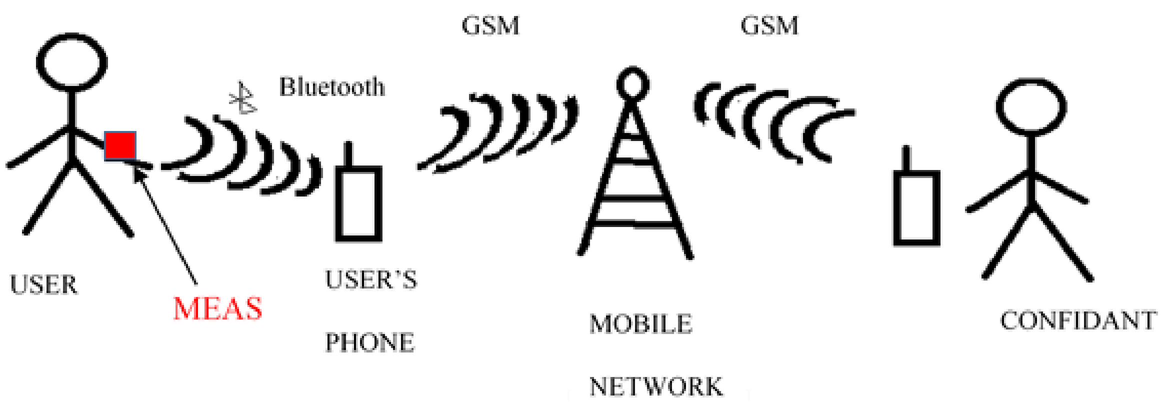

Figure 4: Overview of PMEAS operation

3.2 Algorithm of PMEAS

Print Welcome message

Initialize system

Read temperature and pulse sensor values

Display values on LCD screen

Send values to android device through Bluetooth

If values are outside normal range or button pressed

{

Light LED

Sound buzzer

Send alert message

}

3.3 Calculating Threshold Values for Heartrate

Single Exponential Smoothing (SES) statistical algorithm was applied in the analysis of heartrate reading. Also, it is used to make forecast of the values being received from the pulse sensor. More weight was given to present values as compared to past values. This statistical method was chosen because it is one of the best method to produce a Smoothed Time Series (STS) and it is not computationally intensive for the android app that does the computations and data storage.

For any time period t, the smoothed heartrate reading St is given as

$S_t = \alpha Y_t + (1-\alpha) S_{t-1} \qquad 0< \alpha \leq 1$

where

α =smoothing parameter

S_{t-1} =current predicted heartrate reading

Y_t =current observed heartrate reading.

In other to make sure the predicted heartrate reading as close in value to the current observed heartrate reading, an error value thus differences between current observed heartrate reading and predicted heartrate reading of 10 is used. With this assumption the individual's heartrate reading is monitored for a certain period of time and the threshold taken as the predicted heartrate reading. Based on the age and sex of the individual this value is compared to standard values and if abnormal, alerts are sent to confidants.

The Mean Square Error (MSE) is also calculated to help make the heartrate reading and smoothed value close, also it helps us to decide whether to give more priority to the current observed heartrate reading or predicted heartrate reading in terms of choosing the smoothing parameter.

The Mean Square Error (MSE) is calculated using the formula

$MSE = \frac{1}{N} = \sum_{t=1}^{N} e^2$

Where N = number of observation, e = error

4. TESTING AND RESULTS

The system was simulated with Proteus® software to give a fair idea of how the actual hardware will behave. A screenshot of the simulation is shown in Figure 5. The simulation performed well and was as expected.

A prototype of the system was also built, along with the android application. An Arduino® Uno microcontroller was used in building the prototype. A temperature sensor, pulse sensor, a push button, a Bluetooth module, an LCD display and an LED were connected to the microcontroller. The application was also installed on an android device and connected to the microcontroller via Bluetooth. The temperature and heartrate were measured and were displayed on the LCD screen. The values recorded were also sent to the android device to be stored. A number was stored in the application to represent the number of the confidant. When the push button was pressed, the information was passed on to the android device and an SMS message was sent to the number with the recorded values and the location of the device. The system was not tested on an individual recording abnormal heartrate or temperature; however, the use of the push button gives an indication of how the system will perform when abnormal values are recorded. The prototype of the system in shown in Figure 6.

Throughout the tests, the PMEAS system accurately recorded the temperature of the user approximately 80% of the time. The errors in recording were determined to be as a result of a bug in the programming which kept the previous recorded value and displayed it if the system is not restarted. This problem was fixed and the system was tested again to verify the change. Overall, the PMEAS hardware device functioned correctly as expected. To ensure functionality of the system, the android application was always connected with the device.

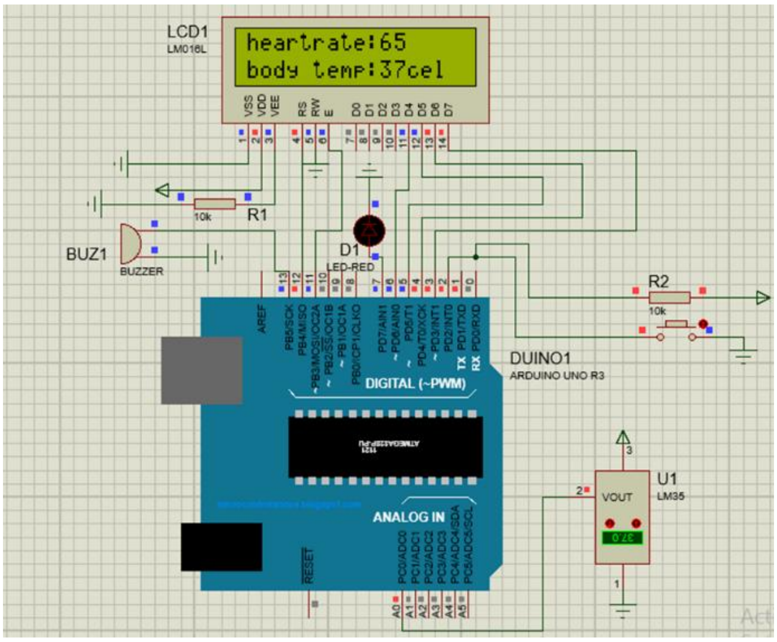

Figure 5: Screenshot of simulation

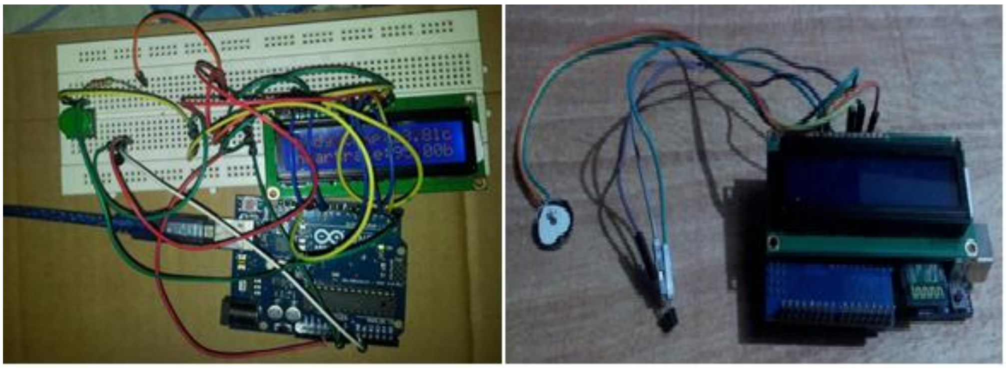

Figure 6: Prototype of PMEAS hardware

5. CONCLUSION

Heartrate and body temperature are two important vital signs which determine the health of a person. Many different systems and devices have been proposed to enable monitoring of these vital signs to ensure timely healthcare is provided to a patient. In this paper, a Patient Medical Emergency Alert System (PMEAS) has been presented. A wearable device, accompanied with an android application, monitors the temperature and heartrate of the user. The system has sensors to measure body temperature and heartrate of the user and displays them on a LCD screen. These values are then sent to the user's phone via Bluetooth to be stored. When the values recorded are abnormal, a LED light lights up, a buzzer sounds and an alert is sent to a confidant of the user with his/her location. The alert is sent from the phone after the recorded values are received and stored on the phone. A user can view these recorded values on the application on the phone in the form of a graph. A prototype of the device was built and an android application was written to test the system. The system performed as expected from the tests.

6. REFERENCES

[1] World Health Organization [Internet]. Cardiovascular diseases (CVDs), 2017. [cited 2018 October 28]. Available from: http://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds).

[2] John Hopkins Medicine [Internet]. Vital Signs (Body Temperature, Pulse Rate, Respiration Rate, Blood Pressure). [cited 2018 October 28]. Available from: https://www.hopkinsmedicine.org/healthlibrary/conditions/cardiovascular_diseases/vital_signs_body_temperature_pulse_rate_respiration_rate_blood_pressure_85,p00866

[3] Simmers, L. Diversified Health Occupations. 1988. 2nd ed. Canada: Delmar. Pp. 150-151

[4] Healthline [Internet]. What Is the Normal Body Temperature Range, 2018. [cited 2018 October 28]. Available from: https://www.healthline.com/health/what-is-normal-body-temperature.

[5] Das, C. K., Alam, M. W., Hoque, M. I. A Wireless Heartbeat and Temperature Monitoring System for Remote Patients. 2014. Proceedings of the International

Conference Mechanical Engineering and Renewable Energy; 2014 May 1-3; Chittagong, Bangladesh.

[6] Harvard Medical School [Internet]. Your resting heart rate can reflect your current — and future — health, 2016. [updated 2018 March 12; cited 2018 October 28]. Available from: https://www.health.harvard.edu/blog/resting-heart-rate-can-reflect-current-future-health-201606179806.

[7] Mukherjee, D., Gupta, K., Pandey, M., Agrawal, A. Microcontroller Based Cardiac Counter System. 2013. In International Journal of Engineering, Applied and Management Sciences (IJEAM) Vol. 02, Issue 1, April 2013.

[8] Heart.Org [Internet]. Tachycardia: Fast Heart Rate. [cited 2018 October 28]. Available from: http://www.heart.org/en/health-topics/arrhythmia/about-arrhythmia/tachycardia--fast-heart-rate

[9] Mayo Clinic. Bradycardia. [cited 2018 October 28]. Available from: https://www.mayoclinic.org/diseases-conditions/bradycardia/symptoms-causes/syc-20355474

[10] Ufoaroh, S. U., Oranugo, C. O., Uchechukwu, M. E. Heartbeat monitoring and alert system using GSM technology. 2015. In International Journal of Engineering Research and General Science Volume 3, Issue 4, July-August, 2015. Pp. 26-34

[11] Abdullah, A., Ismael, A., Rashid, A., Abou-ElNour, A., Tarique, M. Real time wireless health monitoring application using mobile devices. 2015. In International Journal of Computer Networks & Communications (IJCNC) Vol.7, No.3, May 2015. DOI: 10.5121/ijcnc.2015.7302. pp. 13-30.

[12] Subhani, S. M., Sateesh G. N. V., Chaitanya, C., Prakash, B. G. Implementation of GSM Based Heart Rate and Temperature Monitoring System. 2013. In Research Journal of Engineering Sciences Vol. 2(4), 43-45, April (2013). Pp. 43-45.

[13] Sengeeth, K., Santhosh, K. R., Siva, K. R., Kumersan, T., Venkatesh, C. Patient Monitoring System Using GSM Technology. 2016. In International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering Vol. 4, Issue 3, March 2016. DOI: 10.17148/IJIREEICE.2016.4364. pp. 244-246.

[14] Pereira, M., Nagapriya, K. K. A novel IoT based health monitoring system using LPC2129. 2017. In International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), Bangalore, 2017. Pp. 564-568. DOI: 10.1109/RTEICT.2017.8256660

[15] Digarse, P. W., Patil, S. L. Arduino UNO and GSM based wireless health monitoring system for patients. 2017. In International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, 2017, pp. 583-588. DOI: 10.1109/ICCONS.2017.8250529