Online Monitoring Health Station Using Arduino Mobile Connected to Cloud service

"Heart Monitor" System

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***Abstract*— This paper presents a monitoring health station system for vital signs called "Heart monitor". Heart Monitor is a system which can measure the heart rates and body temperatures of patients and then record them in cloud services. The cloud services can then be accessed in real-time by the medical staff to monitor the patients' health at any given location and time. This system is connected to a mobile phone which sends an alarm if the heart rate values become abnormal. After 5 abnormal readings it will automatically call the doctor or the person whose number is included in the system. The system is tested and compered to an ECG device. The results show an excellent accuracy of 97.4%.**

Keywords—Monitoring Health Station; Heart Rate Detection; Online patient Monitoring; Patient data Cloud.

I. INTRODUCTION

As the world suffers from the Covid19 which is a newly discovered corona virus that has been officially announced as a pandemic by the World Health Organization in March 2020. It is a new virus in the medical field that has no specific treatment and no vaccines until the time of writing this article, believing in the importance of using electronic and technological development to raise the level of health care, our system idea came to design Online Monitoring Health station which displays the vital data in Real-time, including the accurate measurement of Heart Rate and Body Temperature and special alarm system without a need of going to the hospital.

Monitoring the vital signs of a human body including body temperature, heart rate, respiratory rate, blood pressure and saturation of blood oxygen are very important since they help assess various body functions and indicate potential diseases. Measurements often vary by gender and age. Other biomarkers may be included according to diagnostic requirements and expected disease.

New applications for health sensors have been added to smart devices for measuring vital signs, unfortunately they are expensive.

In our system, we connected an electronic circuit to a mobile phone that stores and displays vital data of heart rate and body temperature in real-time in cloud service which made the monitoring process easier. It sends an alarm when the readings are abnormal, and makes an automatic call after 5 abnormal readings. In this paper, we will present the software and hardware implementation.

The paper is organized as follows. In section II we present related work. We present system components in section III and system architecture in Section IV. In Section V we present the results and conclude the paper in section VI.

II. RELATED WORK

Many people have heart problems which need a daily and periodic follow-up. One of the most important solutions for health monitoring is the Internet of Things (IoT) applications which are used for monitoring and regularly track the patient's health. These applications can highly reduce the number of patients visiting the hospital for health monitoring. These IoT applications are different in their software and hardware implementations, which leads to different accuracy and options especially in the remotely monitoring field.

Miah et al. [2] developed an integrated portable device for heart rate and body temperature monitoring system by using Arduino UNO microcontroller, transmission system (Bluetooth), and Android-based application. This approach uses the analog signal of pulses for each person and uses a Bluetooth device to send and receive data then sending it to Android application.

Hashem et al. [5] developed a device which measures heart rate and the body temperature using infrared technology and analog temperature sensor respectively. This approach calibrates the analog signal of pulses for each person and uses a wireless device to send and receive data then sending it to computer by using serial port then the data is sent to a webserver using internet and can be viewed from anywhere using any web browser.

Vaishnave and Jenisha [6] developed a remote sensing parameter of the human body pulse and temperature. The data are sent through wireless sensors which can be viewed on the web to observe the health status of a patient. The data is collected in a database and used to inform patients of any unseen problems to undergo possible diagnosis.

Parihar et al. [7] developed an approach that consists of heartbeat and body temperature sensors which are controlled by the microcontroller and the readings are displayed on an LCD monitor. This approach uses a wireless system (nRF24L01) to transmit the measured data from the remote location then the data are displayed at the receiving end.

Elagha et al. [8] developed a medical device which measures the heartbeat rate and the peripheral oxygen (SpO2) saturation in a patient's blood. They used (PIC 18F4520) and a transmitting optical sensor, then display the measured values on an LCD screen and via an RS232 connection which helps to send the measured values to the MATLAB program for processing. They tested the results and the accuracy of measurements was high.

In our "Heart monitor" system, we made measurements for heart rate and body temperature with the possibility of monitoring these values from anywhere using the internet connection which reduced the need of having nurses near the patient by having an alarm run automatically during emergency situations.

III. PROPOSED SYSTEM COMPONENTS

The Heart monitor" system consists of the following hardware and software components:

- Electronic circuit.
- Arduino Uno.
- Android application.
- Google sheets cloud

A. *Electronic circuit*

The electrical circuit contains the following components: heart rate sensor, body temperature sensor, wireless module and 9volt battery with voltage regulator to get the suitable voltage for the micro controller and all the elements in the electronic circuit which work on 5 DC volt.

1) Heart Rate Sensor

Heart rate sensor (SN-11574) which shown in Fig. 1 is an optical heart rate sensor that measures the heart beats per minute. The changes in bloods volume in the organ related to the changes in the intensity of the reflected light through it.

The source of light in a heartbeat sensor is an IR LED and the detector can be Photo Detector (Photo Diode), LDR (Light Dependent Resistor) or a Photo Transistor and the reading are taken by using one of the figures.

The optical sensor uses two wavelength light (usually IR led & red led) to cross the organ and make an accurate measurement of the heartbeat.

Our system adapts the reflective method for the light source and the detector as they are adjacent to each other and the person's finger placed in front of the sensor.

It should be noted that the heart rate sensor is provided with a filter to reduce the noise and increase the accuracy of the measurements [1].

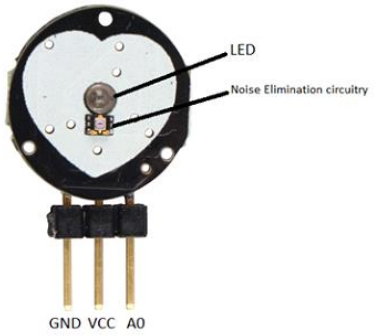


Figure 1: Heart Rate Sensor

2) Body Tempreture Sensor

LM35 "Temperature sensor" series is a precession integrated-circuit temperature sensor whose output voltage is linearly proportional to the Centigrade temperature of the body. LM35 is a Low-Cost sensor with current consumption less than 60-µA and can be operated with a voltage ranging between 4 volt to 30 volts. The sensor has the following specifications:

- Measure temperature from -55 degree Celsius to +150 degree Celsius with linear output voltage (10-mV/°C Scale Factor).
- Calibrated Directly in Celsius (Centigrade)
- Low-Impedance Output, 0.1 Ω for 1-mA Load [2].

3) HC-05 Bluetooth module

Bluetooth is a wireless technology designed to replace wire connections; HC-05 module is based on Bluetooth technology to connect electronic circuits with smart devices like smart phones. HC-05 module shown in Fig. 2 communicates with Arduino Uno using serial communication (USART).

We used the default settings of HC-05 Bluetooth module that can be changed using AT commands. The module has the following pin configuration:

- Enable: used to toggle between Data and AT mode.
- Tx: Transmits Serial Data.
- Rx: Receive Serial Data.
- Vcc: Powers the module.

Here, we will transmit data to Smartphone via Bluetooth using the Arduino Uno and display the readings on mobile screen [3].

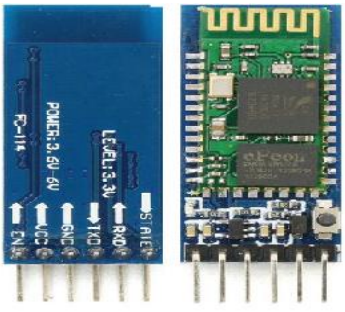


Figure 2: HC-05 Bluetooth module

4) Electronic Circuit Schematic Diagram:

In our system, we used a separated power supply to avoid the noise caused by the Bluetooth module. The heart signal is too small and sensitive so it can easily be affected by any noise. The circuit Schematic diagram is presented in Fig. 3.

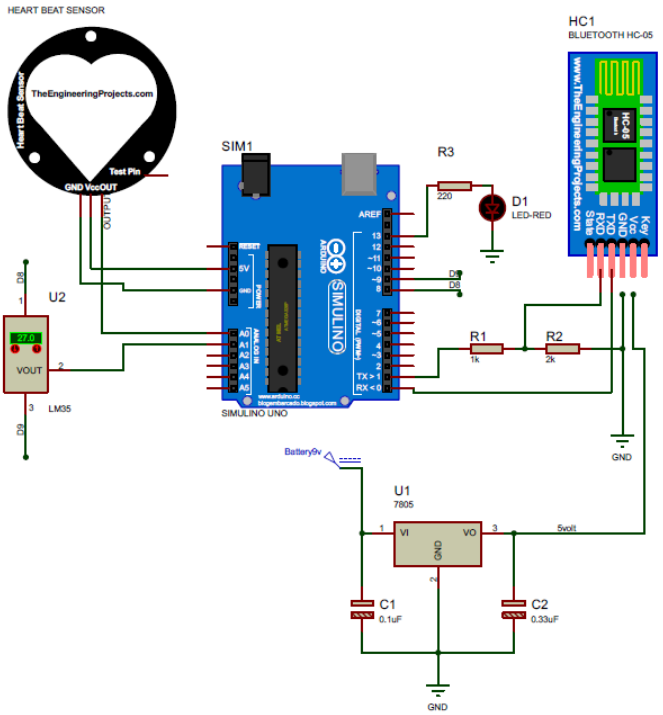


Figure 3: Electronic circuit Schematic diagram

B. *Arduino Uno*

Arduino UNO is a development board based on ATmega328. It measures the heart beats and body temperature using the previously mentioned sensors, then sends the measured vital values to "Heart Monitor" android application using Bluetooth module (HC-05). If the measured voltage was above the specific threshold, it is considered as a heartbeat. Arduino UNO uses an internal timer to measure the time for 30 beats and calculate the patient's heart rate [7].

The software code have been written using Arduino C programming language as shown in Fig. 4 which contain specific library to measure heart rate and communicate via Bluetooth module then sends values to the android application via the serial communication UART protocol.

C. *"Heart Monitor" Android Application*

We developed a simple mobile phone application that displays all the measured data. When a heart rate value is abnormal (less than 40 or more than 120), the application will make an alarm then after 5 abnormal readings it will make an automatic call to a specific phone number that can be the patient's companion number or a health care professional.

"Heart Monitor" application will also display the patient's parameters (heart rate and body temperature) as shown in Fig. 5.

```
const int PulseWire = 0;
const int LED13 = 13;
int Threshold = 520;
float Temp;
int tempPin = 1;
PulseSensorPlayground pulseSensor;
void setup() {
 Serial.begin(9600);
```

```
Temp = analogRead(tempPin);
Temp = Temp * 0.48828125;                //calculate temperature in Celsius
void loop() {
 int myBPM = pulseSensor.getBeatsPerMinute();     // get BPM value
if (pulseSensor.sawStartOfBeat()) {
Serial.print(myBPM);          // send heart rate value
 Serial.print(",");
 Serial.print(Temp);                    // send body temperature value
}  delay(20);    }
```

Figure 4: Android App code

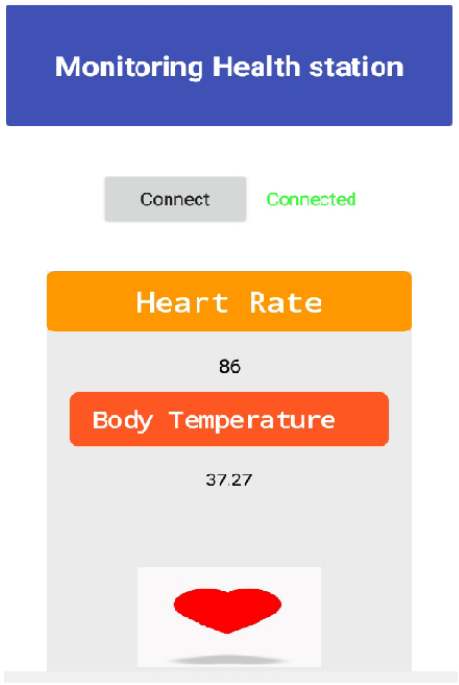


Figure 5: "Heart Monitor" Application

Heart Monitor application has been created on the online platform "MIT App Inventor". "Heart Monitor" code is created to do the following:

- Mobile phone pairing with the electronic circuit and make sure the communication is done and data flows successfully to "Heart Monitor" application as seen in Fig. 6.

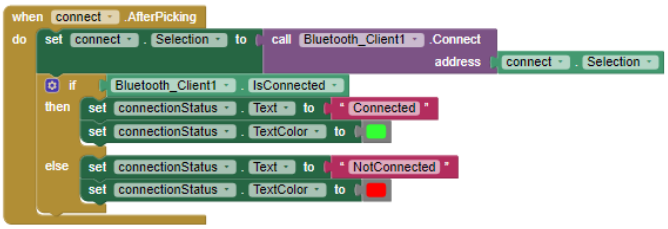


Figure 6: Pairing code

- The application will display the heart rate and the body temperature values on the mobile screen as shown in Fig. 5.
- Communicate with google sheet cloud services by using web-viewer component. As shown in Fig. 7 we added the HR and Temp values to the link, after that the "Heart Monitor" application will send the values automatically to the cloud.

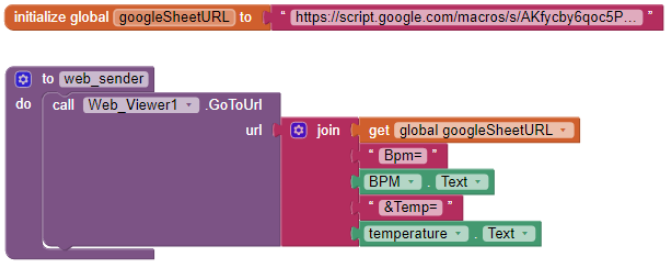


Figure 7: Display the Heart rate and body temperature values then communicate with google sheet cloud services

- Alarm system is an important feature in our system. It runs automatically when the patient's parameters are abnormal as shown in Fig. 8. The alarm system consist of:
  - Voice alarm: when the heart rate values are abnormal (HR> 120 or HR< 40), and it will turn off when the values return to normal again.
  - Automatic call**:** when the heart rate values are abnormal (HR> 120 or HR< 40) for five consecutive times, mobile phone will automatically call a specific number that is already registered.

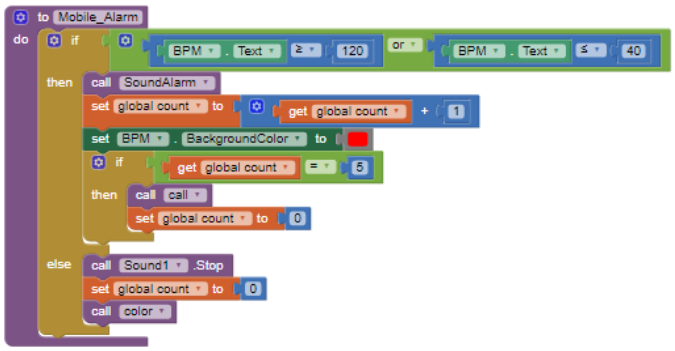
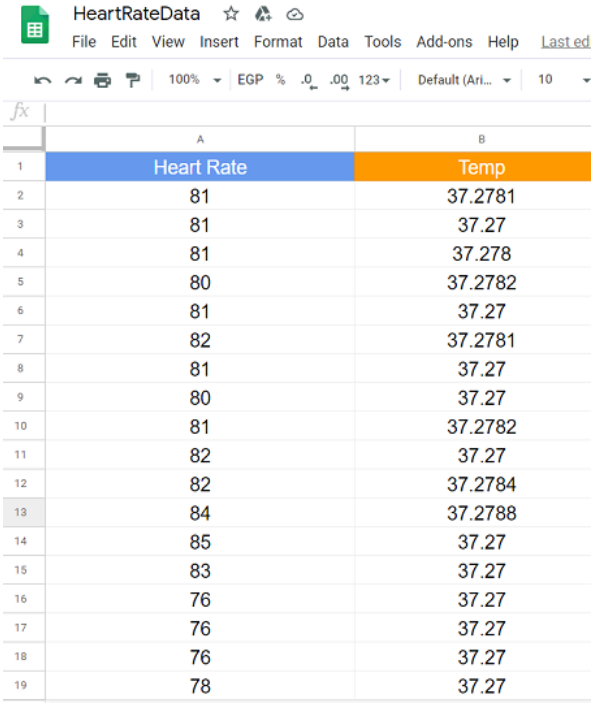


Figure 8: Alarm and Auto call code

D) Google sheets cloud

In order to make all vital values available for the medical staff, we used Google sheets cloud to send the values and store them in cloud sheet as shown in Fig. 9. Google cloud service is free and supports real time feature. The following steps are performed to access the cloud:

1. To use google sheets cloud you need to have google account (gmail.com).
2. Open new google sheets.
3. Edit Header tables name and properties
4. Connect to Android application using Google Script which receives data from mobile app and displays it in specific column and row to be available online for monitoring and storing [4].


HeartRateData

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	A	B
1	Heart Rate	Temp
2	81	37.2781
3	81	37.27
4	81	37.278
5	80	37.2782
6	81	37.27
7	82	37.2781
8	81	37.27
9	80	37.27
10	81	37.2782
11	82	37.27
12	82	37.2784
13	84	37.2788
14	85	37.27
15	83	37.27
16	76	37.27
17	76	37.27
18	76	37.27
19	78	37.27

Figure 9: Google sheets cloud

IV. SYSTEM ARCHITECTURE

A. System Block Diagram

The block diagram shown in Fig. 10, shows the components of the system and the communication between them. The following sequence describes the data flow:

1. Heart rate and temperature sensors get Non-numerical values from the patient.
2. Arduino microcontroller processes the data and convert it to numerical values.
3. The numerical values are sent to mobile phone using Bluetooth module.
4. Mobile phone uses its internet connection and the web viewer component to connect to the cloud and store the data.

5. The results are monitored from anywhere with internet connection through a special link we have previously created in Google Sheets cloud. The link has the form: https://docs.google.com/spreadsheets/...

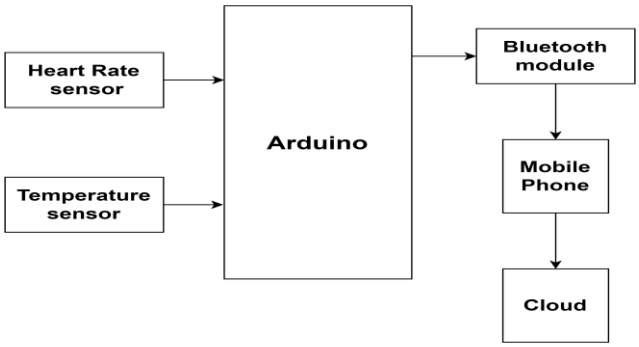

Figure 10: Block Diagram of the Project

B. *Software Flowchart diagram*

The flowchart diagram for the "Heart Monitor" application shows the sequence of our system as seen in Fig. 11:

1. Send analog voltage from sensors which is proportional to the heart rate and temperature values to Arduino.
2. Calculate heart rate and body temperature values using Arduino code.
3. Send data to mobile via HC-05 module.
4. Monitoring the vital values and switching the sound of alarm when the heart rate values are abnormal.
5. Make automatic calls for a specific number when the heart rate values are abnormal for 5 consecutive times.
6. Send data to Google Sheets cloud to be available for medical staff.

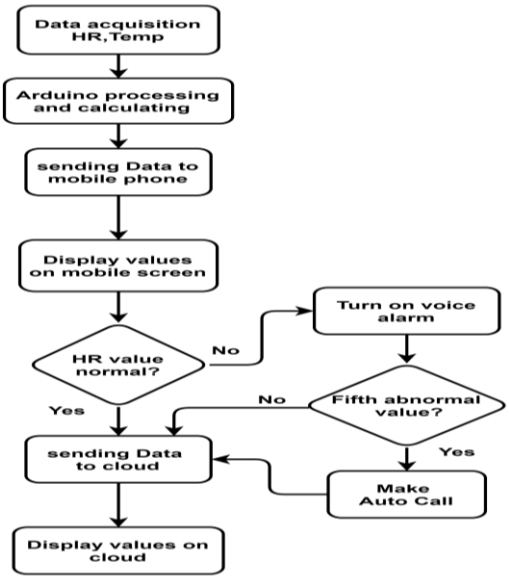

Figure 11: System Software Flowchart diagram

V. RESULTS

To make an accurate results, we fixed the heart sensor around the patient's finger using a dark piece of plastic as shown in figure 12 to avoid reading's errors caused by motion or light interference.

We compared the results that we get from "Heart Monitor" system with an ECG device in a cardiologist clinic to compare the accuracy of our system.

The Error Rate calculated by finding the difference between the measured value from the HR sensor-11574 in our system and the known value from the ECG device, divided by the known value:

$$E = |known - measured| / known \quad (1)$$

Where: *known*: result from ECG device,
measured: result of Heart rate sensor-11574.

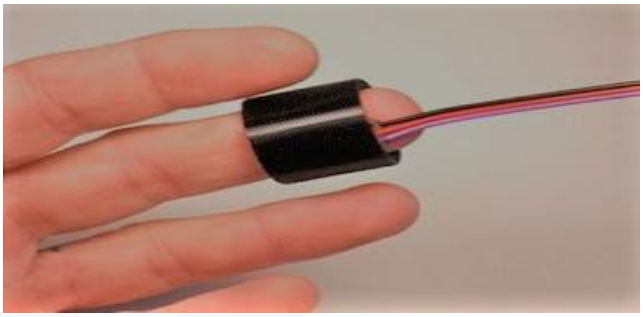

Figure 12: Fixing HR sensor around finger

Table 1 shows the comparison results between the ECG device and the heart rate sensor-11574 for five patients at a Cardiologist clinic. By calculating arithmetic average value, the error rate value is (2.56%) and the accuracy of heart rate sensor is (97.4%).

Table1: Results accuracy comparison

Reading number	ECG device (bpm)	HR-sensor 11574(bpm)	Error rate (%)
patient 1			
1	81	79	2.4
2	85	81	4.7
patient 2			
1	76	78	2.6
2	76	79	3.9
patient 3			
1	82	84	2.4
2	80	80	0
patient 4			
1	86	87	1.16
2	85	85	0
patient 5			
1	72	75	4.16
2	70	73	4.26

VI. CONCLUSION

Monitoring the human vital signs such as heart rate and body temperature is important for people who have critical health situation as they can be an indicators to other diseases. "Heart monitor" system shows a high accuracy results compared to the same reading measured by an ECG device. The measured values are displayed on a mobile phone using “Heart Monitor” application. The results are stored and displayed in cloud service simultaneously for a continuous and real time monitor to the patient's heart rate and body temperature by the medical staff anywhere and anytime without the need for going to the hospital.

Furthermore, it is programmed to make an alarm and an automatic call to a registered number when the measured values are abnormal using android capabilities programming without a need of going to the hospital or even a person to monitor the patient's health.

In the future, we aspire to add more parameters and sensors to make Full Online Monitoring Health Station.

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