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IOT Based Mobile Health Monitoring Coupling with ECG Sensor

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Abstract: *Internet of Things (IOT) has many applications in the medical field. With remote-information gathering, healthcare professionals can evaluate, diagnose and treat patients in remote locations using telecommunications technology. This study aimed to develop a small-scale electrocardiogram (ECG) monitoring device that will measure heart rates and waveforms and send the data in a database and a web server. An ECG acquisition device was developed using a single-lead heart rate monitor sensor and an Arduino microcontroller. The goal of this study is to use sensor technologies to develop a smart platform for health monitoring. Our platform consists of a sensor node, a firebase server and a health cloud. Through this system we can get the electrocardiography (ECG) signals. The sensor node can detect the QRS pick value. Through this system most normal ECG can be filtered out, and the abnormal ECG is further analyzed in the health cloud. The average of the QRS sensitivity and positive prediction is above 99%. The device was deemed functional and reliable. The main purpose of our project is to measure the heart rate using Wi-Fi Module and the ECG sensor with using an app.*

Keywords: *IOT, ECG, Health, Sensor, Mobile.*

1. Introduction

As the population is becoming progressively older, higher quality of health and medical care is now expected in countries with significant again problems. This care is particularly important for countries with 75% of the elders suffering from chronic diseases. Health conditions of aged people usually need to be checked more frequently, which poses a greater challenge to existing medical systems. Therefore, how to identify human diseases in a timely and accurate manner with low costs has been paid an increasing attention. Due to the dominance in the diagnosis of heart-related diseases, electrocardiogram (ECG) monitoring has been widely applied in both hospitals and medical research. The study focuses on developing a small-scale heart monitoring system using Electrocardiogram (ECG) technology. The device is composed of a single-lead heart rate monitor sensor which converts the ECG signal into analog data. The data is sent to an external computer where it will be processed into ECG rates and waveforms by a MATLAB program. The proposed design is capable of measuring heart-rate and ECG of the patient and sending results using internet. In our system, we use peer to peer connection for getting the right signal for ECG. For ECG, the sampling rate will be 40 HZ. So, for 40 HZ frequency we use the peer to peer connection which is directly connected with mobile phone and NODMCU through Wi-Fi hotspot. Through this process we can get data and waveforms for the ECG and monitoring the heart rate.

2. Literature Review

A) Heart rate monitoring using fingertip: This paper presents the design and development of a microcontroller based heart rate monitor using fingertip sensor. The device uses the optical technology to detect the flow of blood through the finger and offers the advantage of portability over tape-based recording systems (Dogan *et.al.* 2003;Mohamad *et.al.* 2009;Naazneen *et.al.* 2013;). The system provides an LCD screen to output the measured heartbeat rate. Also, this display is used when entering user and configuration data. The system consists of an infra red (IR) LED as transmitter and an IR photo-transistor as a receiver that acts as a fingertip sensor. The results show agreement with the analogue measurements, with errors of around 1.4%. The data presented in indicates that the zero-crossing count technique resulted in an average error of 4.1%.This is in line with the inherent counting errors in such systems (Hashem *et.al.* 2009;Mohamed *et.al.* 2007;Sukkar *et.al.* 2000;John,2008;Van,2005). With an error of ±1 during a 10 sec period, the total error can be as high as ±6 when the 1-minute rate is computed resulting in an overall 8.3% total error.

B)E-Health Monitoring system: These monitoring devices which were only available in the hospitals were constantly on the patient's body. Many of them are not user friendly and it is important that the patient have a portable device that can always be used to measure these parameters when no one is around. The system monitors the heart beat and temperature of a patient simultaneously with the pulse sensor and the temperature sensor by populating a centralized database with its readings at defined intervals. When the readings are abnormal, or have risen beyond preset threshold, the device makes use of the GSM/GPRS/GPS shield to send the readings and location coordinates to the patient's doctor/guardian to quickly track and examine/diagnose the patient's condition and take early precaution to save the patient's life. The system is setup to constantly measure these parameters and reduce mortality rate for the elderly (Hashem *et.al.* 2009;Mohamed *et.al.* 2007;Sukkar *et.al.* 2000;John,2008;Van,2005).

C) **Photo-Plethysmography system:** In this project, a real-time heart rate measurement technique called Photo-Plethysmography (PPG) is implemented using simple infrared transmitter and receiver circuit . Arduino Uno board has been used for calculating the heart rate from the fingertip. The obtained heart rate values are initially displayed on a Liquid Crystal Display (LCD) and sent serially to Raspberry Pi which is used as an Internet of Things (IoT) gateway. The values are then sent to the cloud through Message Queuing Telemetry Transport (MQTT) protocol. The designed system updates the user with their heart rate through electronic mail (email), Short Message Service (SMS). and real-time plots and provides name and address of a nearby prominent hospital in case of an emergency(Hashem *et.al.* 2009;Mohamed *et.al.* 2007;Sukkar *et.al.* 2000;John,2008;Van,2005) .

3. Objectives of Research

In our system we use the ECGAD8232 sensor module that is worked as a differential amplifier. Also for the Wi-Fi module we use the ESP8266 module. We choose the peer to peer connection for graph plotting. the sampling which is directly connected with mobile phone and NODMCU through Wi-Fi hotspot. In this system we get data as analog pin output and time. The heart rate can be measured with the process of filter that is worked as a QRS detector. We measured the Instant heart rate and also the average heart rate. We use a mobile App for signal processing and graph plotting. Then we can get the heart rate. The heart rate can be different with various purposes. But, we used only the perfect pick value for getting the perfect heart rate.

3. Methodology

In our system we use the ECGAD8232 sensor module that is worked as a differential amplifier. Also for the Wi-Fi module we use the ESP8266 module. We choose the peer to peer connection for graph plotting. the sampling which is directly connected with mobile phone and NODMCU through Wi-Fi hotspot. In this system we get data as analog pin output and time. The heart rate can be measured with the process of filter that is worked as a QRS detector. We measured the Instant heart rate and also the average heart rate. We use a mobile App for signal processing and graph plotting. Then we can get the heart rate. The heart rate can be different with various purposes. But, we used only the perfect pick value for getting the perfect heart rate.

4. Proposed System

In our system, AD8232 module is connected with the ESP8266 module that works as a Wi-Fi module. Through this system when we get data then that data was sent into server. We used Google’s Firebase server. When server response then we can get signal and graph through mobile application. Then ultimately we get the heart rate and we measure the condition.The block diagram of fig 3.1 shows the process of working. Each block has its individual functionality. The first block represents the AD8232 module. It works as a differential amplifier. The next block represents the ESP8266 module.it works as a Wi-Fi module. The microcontroller is the heart of system. This microcontroller sends data in the server. Here we used the Firebase server for to get current data. Then the server sends data in mobile application. This app receive data and shows signal. This part is called the signal processing and Graph plotting. From the App and through the IP address of Wi-Fi hotspot we get the heart rate and condition report.

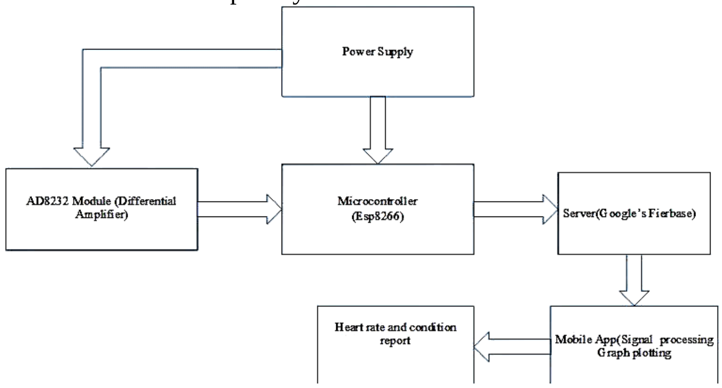

Figure 1: Block Diagram of Proposed System

5. Implementation Technique

The main part of the project is graph plotting. This can be solved with two ways. One is Firebase and the other is peer to peer connection. Here firstly we use the peer to peer connection then we convert it into Firebase. With this connection when we get the sampling it will be directly connected with the mobile phone and NODMCU through Wi-Fi hotspot.
Through this process we can get two types of data.
a) Voltage or Analog pin output
b) Time
For to differentiate between analog pin output and time, we used comma (,) When we access data through server connection then it gives a screen. When we got the screen then we used a split function to divide the screen. This gives us an output. We convert that output into integer. Then we did plotting. We took first output as-
VOLTAGE=Y AXIS
TIME=X AXIS

Note that: For time measuring we used a variable that is called "Data point variable". Through this variable we pushed data continuously for plotting.
Heart rate measuring:
INSTANT HEART RATE(IHR):

To measure the heart rate, we used a filter that is QRS DETECTOR. This filter can detect the pick value. Filter can detect the pick value by using-

- Low pass Filter-CUT OFF Line=16 HZ
- High pass Filter-CUT OFF Line=8HZ

Then we did the moving average and differentiate. That creates the "Time Domain Filter". Here's the getting output will have converted into average. We waited minimum for 100 data as if we can get a CUT OFF Window. This CUT OFF Line is adoptive. That is Average Cut Off Line.
Average Cut Off Line*2/3=QRS pick value

For the QRS pick value we waited minimum 500 Ms. When we will note time, the difference should be-
Next Time-Previous Time=Result/60
Then we can get the INSTANT HEART RATE(IHR).

AVERAGE HEART RATE(AHR):
Starting time(Time0)-N number of time=result/Heart beat number=Result/60

If two QRS pick value is above the 1200 ms then we should be ignoring that value. When we ignore that The (Time 0) will be moved the left side. Then we added the new time value with the(Time0) and made it adoptive.

Note that: We sent request through SOCKET Connection from App to IP address. Then IP address accepted that request and reposed. Then we read that data as server response. When it is off the solution gets into the tank by drain outlet. After all the solution is gone into the tank the process is repeated.

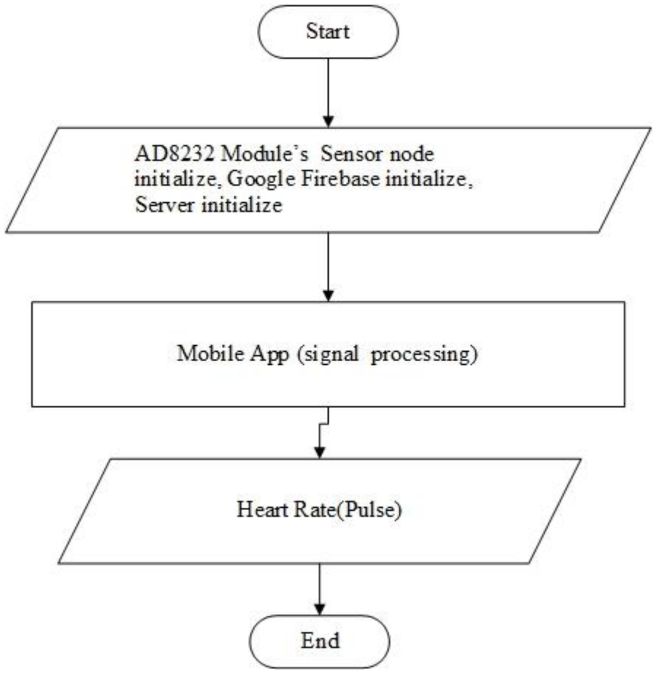

Figure 2: Flow Chart for Implement Circuit

The whole system is designed with the help of the above fig 2. The software implementation of this system has followed fig 1. First of all, the system starts with the microcontroller device AD8232 module and ESP8266 Wi-Fi module. This microcontroller sends data to the server and server response that data and send request to the mobile app for the signal and plotting of graph. Through this app we can measure the heart rate.

5.1 Design of mobile application

For this system we prepared the mobile application with the program of JAVA SOCKET CONNECTION. Here we used the Google's Firebase server. Firstly, we used peer to peer connection and then we convert it to firebase for the frequency of ECG that is 40HZ.Through this mobile application we mainly get the signal for heart rate measuring. We used this application through the Wi-Fi hotspot and then we insert the IP address. Then we can able be to get the signal. Exactly we measured the real time data, QRS detector parameters and QRS filer.

```
    MS160          = ((int) (160/MS_PER_SAMPLE + 0.5)) ;
    MS175          = ((int) (175/MS_PER_SAMPLE + 0.5)) ;
    MS195          = ((int) (195/MS_PER_SAMPLE + 0.5)) ;
    MS200          = ((int) (200/MS_PER_SAMPLE + 0.5)) ;
    MS220          = ((int) (220/MS_PER_SAMPLE + 0.5)) ;
    MS250          = ((int) (250/MS_PER_SAMPLE + 0.5)) ;
    MS300          = ((int) (300/MS_PER_SAMPLE + 0.5)) ;
    MS360          = ((int) (360/MS_PER_SAMPLE + 0.5)) ;
    MS450          = ((int) (450/MS_PER_SAMPLE + 0.5)) ;
    MS1000         = SAMPLE_RATE ;
    MS1500         = ((int) (1500/MS_PER_SAMPLE)) ;
    DERIV_LENGTH   = MS10 ;
    LPBUFFER_LGTH  = ((int) (2*MS25)) ;
    HPBUFFER_LGTH  = MS125 ;
    WINDOW_WIDTH   = MS80 ;
    }

public static class PreBlankParameters
    {
    public int PRE_BLANK ;
    /** filter delays plus pre blanking delay */
    public int FILTER_DELAY ;
    public int DER_DELAY ;

    public PreBlankParameters(QRSDetectorParameters qrsDetParas, int preBlank)
        {
        PRE_BLANK = preBlank ;
        FILTER_DELAY = (int) (((double) qrsDetParas.DERIV_LENGTH/2) + ((double) qrsDetParas.LPBUFFER_LGTH/2 - 1) + (((doul
        DER_DELAY = qrsDetParas.WINDOW_WIDTH + FILTER_DELAY + qrsDetParas.MS100 ;
        }
    }
```

Figure 3: Java Coding For Application design (1)

```java
    long y0 ;
    int output ;
    int halfPtr ;

    halfPtr = lpfilt_ptr-(qrsDetParas.LPBUFFER_LGTH/2) ; // Use halfPtr to index
    if(halfPtr < 0) // to x[n-6].
        halfPtr += qrsDetParas.LPBUFFER_LGTH ;
    y0 = (lpfilt_y1 << 1) - lpfilt_y2 + datum - (lpfilt_data[halfPtr] << 1) + lpfilt_data[lpfilt_ptr]
    lpfilt_y2 = lpfilt_y1;
    lpfilt_y1 = y0;
    output = (int) y0 / ((qrsDetParas.LPBUFFER_LGTH*qrsDetParas.LPBUFFER_LGTH)/4);
    lpfilt_data[lpfilt_ptr] = datum ; // Stick most recent sample into
    if(++lpfilt_ptr == qrsDetParas.LPBUFFER_LGTH) // the circular buffer and update
        lpfilt_ptr = 0 ; // the buffer pointer.
    return(output) ;
    }

/**
```

Figure 4: Java Coding for Application design (2)

```java
public class RealTimeData extends AppCompatActivity {
    //global variable
    private LineGraphSeries<DataPoint> series;
    private Vibrator myvib;
    private RadioGroup Rgroup1;
    private TextView IHRv,AHRv;


    private short sampleRate=50;
    QRSDetectorParameters qrsDetectorParameters=new QRSDetectorParameters(sampleRate);
    QRSFilterer qrsFilterer=new QRSFilterer(qrsDetectorParameters);
    matrix myMatrix=new matrix();

    //filter data & HR calculate
    int datapoint=0,prev=0;
    int nHR=0,IHR=0,AHR=0,n=0;
    boolean Start=false;
    double sum=0,avg=0;
    DataPoint[] refresh=new DataPoint[]{new DataPoint(0,0)};
    //boolean newData=false;

    //peer to peer
    String ipAddress="";
    private String serverResponse="";


    private String child=null;
    FirebaseDatabase firebaseDatabase;
    DatabaseReference databaseReference;
    String hrData=new String();
```

Figure 5: Java Coding for Application design (3)

Figure 6: Final view of implemented Mobile application

6. Results and Discussion

For a human adult of age 18 or more years, a normal resting heart rate is around 72 beats per minute (bpm). A lower heart rate at rest implies more efficient heart function and better cardiovascular fitness. Babies have much higher rate than adults around 120 bpm and older children have heart rate around 90 bpm.

When we measured heart rate through our system we found that a healthy persons Instantons heart rate (IHR) is (80-99) bpm. But sick people or those who are facing heart problems then as per situation their heart rate is measured that is (50-52) bpm or High that is 100 bpm.

When we measured data we saw that from one QRS pick value to another QRS pick values difference will be 500ms.if the time difference is low than 500ms then that value will not be counted. Again if the time difference is higher than 1200ms then that QRS pick value will not be counted also. We also find that the heart patients give the QRS pick value consecutively.

Figure 7:Measured waveform

Figure 5:Implemented Circuit

Table 1: Normal database test result

Age	QRS sensitivity	Instantons Heart Rate
25	99%	99
23	96%	95
19	99.93%	99
21	99.87%	96
20	99.89%	97
24	99.97%	98
26	98%	99
65	70%	72
50	86%	90
85	53%	52

Average Heart Rate of age between (19-26): 99%

When we tested an adult heart patient, his heart beat proves that the QRS pick value is consecutively.So we see that the difference is, heart problems patients shows the different instantons heart rate. We tested that if the time difference is below than 500 ms then we cannot find the QRS pick value. Again is we tested that if the time differences higher than 1200 ms then we need to ignore that value because of in that point we could not find the cut off window.

Table 1: Normal database test result

Age	Time(ms)	QRS sensitivity	Instantons Heart Rate(bpm)	Decision After measuring bpm
85	24000	53%	52	Problem of Heart
25	2000	97%	99	No problem of Heart
23	4000	98%	98	No problem of Heart
65	36000	63%	51	Problem of Heart
Age	Time(ms)	QRS sensitivity	Instantons Heart Rate(bpm)	Decision After measuring bpm
85	24000	53%	52	Problem of Heart
25	2000	97%	99	No problem of Heart
23	4000	98%	98	No problem of Heart
65	36000	63%	51	Problem of Heart

Here we see that, first row shows the instantons heart is 52bpm.it’s proved that the rate is not normal. Because of the healthy people’s heart range is (80-99) bpm .so, we say that it’s not normal. Again, we see the second row shows the heart rate is 99 bpm. So, its normal. So, we will be able to know the one’s heart rate conditions before going to the hospital or health care centers.

7. Conclusion

In today's fast moving world, human body is getting more prone to heart related diseases and there is an increase in number of deaths due to heart diseases. So this paper describes the design and development of a heart rate monitoring system which tells the heart beat rate of the person. If the exact heartbeat of the person is known, then the problems related to heart can be detected and cured. This system has been developed by other researchers also but they followed different algorithms. In our system we can easily measure the heart rate. This processing will not be very costly so others can easily maintain to their heart rating. If anyone want, then they can check their heart rate with this technology and using this app system without going to doctor’s chamber. This is a prototype of our main target. It has some future scope if we can overcome the limitations and can implement the ideas what we gained during the project.

Copyright

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