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Smart Healthcare Monitoring Based On IoT

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ABSTRACT

Recently, the implementation of Raspberry Pi controlled monitor system performs well defined medical applications for diagnosis of DCM Healthcare. The development of IoT (Internet of Things) is an important application domain in medical field that draws huge interest from industry, research field and public sector. In medical applications, the temperature and humidity data are often major considerations. The main objective of this framework is to give immediate necessary services where cardiac patient can measure body temperature, heart rate in bpm and body position by themselves and promote hygienic environment. The framework is tested for a volunteer to check the body temperature, heart rate and observe the movement of body position and view the ECG graph using Serial Plotter Software on a local server.

Keywords: Arduino Uno, Bluetooth 4 BLE module, Raspberry Pi model B+, Electronic sensors, 16X2 LCD module, WI-FI/4G.

1. INTRODUCTION

Now, IoT is one of the buildings blocks that is considered to be use for developing smart system for Healthcare services. “Objects” connected to the internet are highlighted to cross 20 billion in the upcoming smart Technology. Over a billion “smart products” connected to the internet, recently IoT is about networking of physical objects and these physical objects are embedded to exchange data in between the IoT components and also sense surrounding environments in which they are operating. In environments like hospital and clean room, precise environment control is paramount in meeting your objectives of patient and product safety. The data such as temperature and humidity are collected and transmitted for data analysis. With the help of ECG and heart rate sensor, cardiac disease could be diagnosed with subject to body position. The uploaded data will be sent to the physicians / Care takers. It provides necessary services near the patient if any problems in breathing due to the harsh environments. The message notification will also be sent if any serious abnormalities.

2. LITERATURE REVIEW

The evaluation of monitoring vital parameters for healthcare services can be achieved by different researches with the advancements in IoT networking. These are functioning in medicinal domain and shown improvements in maintaining the health reward of a patient.

Tanveer Reza et.al. [1] focuses on android based pulse monitoring system which compromises heart monitor App for the mobile devices using android studio and web portal as doctor’s interface by the user using Bluetooth module HC-05. The developed system performs analysis of beats per minute of individual data on the website and predicted as a graph. The framework of the system consists of Arduino as a gateway which is interfaced with the pulse sensors.

Ravi Kishore Kodali et.al. [2] illustrates the experimental setup for the healthcare based IoT device, which monitors the temperature of a patient using network protocol of XBee S2 modules. The system has used its gateway as Intel Galileo generation 2 bound and interfaced with LM 35 temperature sensor.

Surya Deekshith Gupta et.al. [3] describes about the system design for Healthcare on IoT using Raspberry Pi. In this System, the combination of Raspberry Pi and GSM module are used to observe different ECG mechanisms which are monitored to know the type of cardiac illness by using python coding algorithms. The result of heart beat data is automatically updated in website database using MySQLdv module. Wi-Fi updates can also be accessed using USB 2.0 port which consists of an Ethernet port for network connection.

Punit Gupta et.al. [4] offers a service survey of the concept of medical care in order to provide medical data information by interfacing heart beat and temperature sensor through internet via Wi-Fi / Ethernet. The developed system has a 2nd generation Intel Galileo board and patient's data is monitored on live graph using a Xampp based database server to analyse the health reports for tracking further.

Jusak Jusak et.al. [5] has examined a smart system for recording of all the sounds made by the heart during a cardiac cycle using phonocardiography (PCG). A framework was made similar to mobile module, working on the basis of Internet of Medical Things. The cardiac activity can be detected in the form of ECG or PCG signal using heart sound sensor. Doctors can access the patient's data, anywhere through the web server media using cloud data centre. The performance of the system is examined in terms of sampling frequency band ratio and bandwidth utilization parameters.

Omar S.Alwan et.al. [6] has installed the system to monitor body temperature parameter cone through two transceivers. The system is based on wireless transmission consists of first devices as raspberry Pi-2 and Zigbee module while the second device consists of Arduino through Zigbee shield.

R.Kumar et.al. [7] describes a smart monitoring system using Raspberry Pi without environmental sensors and alert modification.

Emre Oner Tartan et.al. [9] demonstrates an android application for geo-location based health monitoring consultancy using alarm system. It includes real time remote monitoring of heart rate, geo-location tracking of a patient, decision making for different alarm situations in the smart phones and providing consultancy modules with the health experts to get advice. The prototype framework is equipped with Arduino Uno board and a wireless transmission of sensor data (GPS sensor and pulse sensor) to the smart phone via Bluetooth HC-05module through USB cable. The internet connection over cellular networks is based on 3G / 4G wireless technologies.

Kavita Jaiswal IIIT et.al. [16] Presents a system to measure only three biomedical parameters such as temp, ECG, BP using Raspberry Pi gateway and Docker container method.

3. COMPONENTS USED IN SYSTEM

3.1. Arduino Uno

It is an open source electronic platform, which is microcontroller-based as well as programmed with Arduino IDE. It comprises of following components: USB connector, Power port, Microcontroller, Analog input pins, Digital I/O pins, Reset switch, Crystal oscillator, USB interface chip, and TX - RX LEDs. The power source for this board can be provided by AC – DC adapter or batteries, even USB ports can be used. Through the USB port, program can be uploaded from Arduino IDE to the board. The board can be operated with a supply voltage of about 5 v through a power jack. The board can withstand a maximum of 20 volts. Voltage regulator comes into play at the time of high supply voltage in order to prevent it from burning.

The Uno board has ATmega328P microcontroller which consists of 28 pins. ATmega328P has a flash memory of 32 KB, 2 KB RAM. It also has a non-volatile type of EEPROM memory of 1 KB. Arduino boards are pre-programmed, thereby making it user-friendly. In addition to this, it allows us to import new programs directly into the device without the support of external programmer.

4.0 WI-FI/4G LTE Connectivity

4G is more secure when compare with public Wi-Fi spots. Whenever log into an unknown public Wi-Fi spot, there is a chance that device and information are forcible to attack. 4G networks offer better privacy, security and safety. 4G is fast and easy to use in comparison with 3G. With videoconferencing, a patient in a rural area with 4G coverage can receive a consultation from a world-renowned specialist in an urban
location without ever leaving their neighbourhood or home. Furthermore, by receiving regular updates on a patient's vitals from telehealth devices, physicians can be immediately alerted to a potential medical problem that requires treatment.

5. Algorithm of Proposed Model:

Input: Environmental data and patient data.

Output: Visualize the current status of patient data and environmental conditions.

Step 1: Begin.

Step 2: When slave circuit is switched on. The wireless sensors capture the environmental data of patient room and patient’s vital data.

Step 3: Transform the sensed data to the open source microcontroller via wireless network.

Step 4: Monitor both the data continuously on the display screen of LCD in regular intervals.

Step 5: Analysis of observed data at the slave circuit.

Step 6: Enable self-care service according to the output data observed.

Step 7: Analysis of observed data at the Master Circuit.

Step 7.1: If data value reaches the abnormal Then Patient_Status = Unstable. Go To Step 8

Step 7.2: Else Patient_Status = Stable.

Step 7.3: Return Step 4.

Step 8: Transform data to the processor of master circuit for processing and transmit to the cloud database for analysis.

Step 9: Create alert notification to client 1 (patient).

Step 9.1: Deliver the required emergency services.

Step 10: End

6. METHODOLOGY

The proposed system will be carried out in two circuit parts which consists of slave and master circuit. The implementation of experimental setup is shown below.

6.1. Slave Circuit:-

The different wearable electronic wireless sensors are interfaced with Arduino, shown in Fig.1.

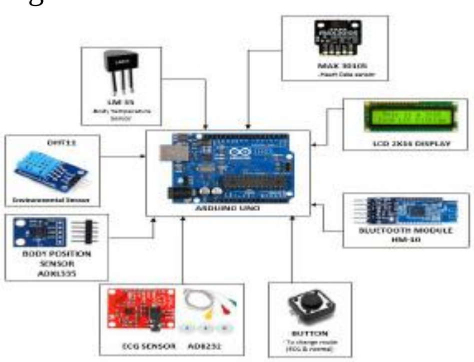

Figure.1.Architecture of Slave Circuit

The various physiological data such as body temperature, humidity, room temperature, body position and ECG are monitored using sensors and processed data for analysis and store the data on regular intervals. The LCD display is used to view the above specified data to ensure the status of self-healthcare and comfort of Room Parameters at the patient. Slave circuit is operated in two different modes namely, Normal mode and ECG mode. In ECG mode, the cardiac movement of the heart is plotted as a graph using **Serial Plotter** software if electrodes are properly fitted into our body without the intervention of parameters. A single lead ECG sensor is used to visualize the changes in amplitude of QRS wave and QT interval variability. It provides the information of cardiac thickness and cardiac volumes as well as heart rhythm. The ECG data is transmitted wirelessly for further analysis and store the output result as an Analog reading, whereas in normal mode of operation, the other physiological data such as body Temperature, Room Parameters, heart rate are viewed on the LCD display without the intervention of ECG. The data of Room Parameters and body Posture are also transmitted wirelessly to the master circuit via HM-10 BLE module for further analysis and store the output result on the webpage of local server.

6.1.1. Programming code for Arduino

```
#include <Wire.h>
#include "MAX30105.h"
#include <LiquidCrystal.h>

#include "heartRate.h"
#include "dht.h"
#define dht_apin 6
dht DHT;
MAX30105 particleSensor;
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

const byte RATE_SIZE = 4; //Increase this for more averaging. 4 is good.
byte rates[RATE_SIZE]; //Array of heart rates
byte rateSpot = 0;
long lastBeat = 0; //Time at which the last beat occurred

float beatsPerMinute;
int beatAvg;

void setup()
{
  Serial.begin(9600);

  lcd.begin(16, 2);
  Serial.println("Initializing...");

  // Initialize sensor
  if (!particleSensor.begin(Wire, I2C_SPEED_FAST)) //Use default I2C port, 400kHz speed
  {
    Serial.println("MAX30105 was not found. Please check wiring/power. ");
    while (1);
  }
  Serial.println("Place your index finger on the sensor with steady pressure.");

  particleSensor.setup(); //Configure sensor with default settings
  particleSensor.setPulseAmplitudeRed(0x0A); //Turn Red LED to low to indicate sensor is running
  particleSensor.setPulseAmplitudeGreen(0); //Turn off Green LED
}
```

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```
void loop()
{
  DHT.read11(dht_apin);
  long irValue = particleSensor.getIR();

  if (checkForBeat(irValue) == true)
  {
    //We sensed a beat!
    long delta = millis() - lastBeat;
    lastBeat = millis();

    beatsPerMinute = 60 / (delta / 1000.0);

    if (beatsPerMinute < 255 && beatsPerMinute > 20)
    {
      rates[rateSpot++] = (byte)beatsPerMinute; //Store this reading in the array
      rateSpot %= RATE_SIZE; //Wrap variable

      //Take average of readings
      beatAvg = 0;
      for (byte x = 0 ; x < RATE_SIZE ; x++)
        beatAvg += rates[x];
      beatAvg /= RATE_SIZE;
    }
  }

  Serial.print("BPM=");Serial.print(beatsPerMinute);
  Serial.print("Current humidity = ");Serial.print(DHT.humidity);Serial.print("%  ");
  Serial.print("temperature = ");Serial.print(DHT.temperature); Serial.println("C  ");

  if (irValue < 50000)
    Serial.print(" No finger?");

  Serial.println();

  lcd.setCursor(0,0);
  lcd.print("BPM: ");
  lcd.print(beatAvg);
  delay(1000);
  lcd.clear();
  lcd.setCursor(0,1);
  lcd.print("HUMI:");
  lcd.print(DHT.humidity);
  delay(1000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("TEMP:");
  lcd.print(DHT.temperature);
  delay(1000);
  lcd.clear();
}
```

6.2. Master Circuit:-

The Raspberry Pi model B+ processor acts as a gateway platform in Master Circuit that received these physiological parameters from the Slave circuit via HM-10 BLE module. The parameters such as humidity, Temperature and body posture are then fed to the processor for further analysis and store the data in local server using **LAMP** which is configured with static IP address of the authority to ensure security. The master circuit module will send the information on regular intervals to the VNC server/ Personal server via Wi-Fi / 4G module. These data are viewed on the monitor / screen of the desktop using VNC viewer software through online application. The retrieved data will be displayed using DHCP network server on the webpage of physician so that the patient's life can be saved immediately and advised if requires any treatment plan remotely.

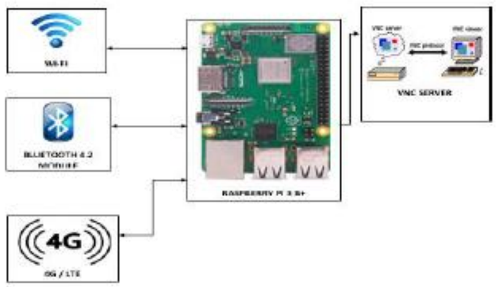

Figure.2. Architecture of Master circuit

7. RESULTS AND DISCUSSION:-

High temperatures or extreme humidity can negatively impact one's physical health, particularly those afflicted with cardiovascular disease. For those suffering with cardiovascular disease, these conditions can have catastrophic effects and in some cases can lead to the formation of deadly blood clots (called thrombosis).

The electrical activity of the heart rhythm is continuously monitored for a volunteer plotted in the front panel of **Serial Plotter** software using the ECG sensor AD-8232. This framework will be beneficial for a cardiac patient to ensure their heart functions whether found normal or not in single lead ECG graph. The changes in body posture such as on-bed to on-foot, right to left and left to right, causes changes on the amplitude of QRS waves in ECG graph. For instance, when posture changes from on-bed to on-foot, QT interval is reduced from its normal value that leads to tachycardia. It causes greater heart rate over 100 bpm. The fast heart beats reduced the effusion fraction ratio (EF rate) which leads to sudden cardiac arrest and death. The above study is used to observe various clinical causes and help for the diagnosis to categorize patients as cardiac and non-cardiac.

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The effect of body posture on cardiac disease causes arterial pressure to fall. If arterial pressure falls appreciably upon standing, this is termed orthostatic hypotension. Patient may suffer dizziness because of the narrow blood flow to brain due to the drop in blood pressure. The effect of fever by means of viral infection is the most cause of acute myocarditis which can lead to DCM. It can be monitored by LM-35 body temperature sensor. The LM-35 temperature Sensor is used to observe the body temperature of the patient which has interfaced with the Arduino and output result is viewed on the LCD display. A single chip temperature and humidity sensor is used for respiratory therapy while controlling, monitoring and maintaining humidity. This is important for patient comfort and even more imperative for safety in medical facilities and other critical environments. There are also many other applications for smart monitoring where maintaining a specific temperature is vital for certain medical products in clinics and laboratories. The overall experimental setup is implemented for the proposed system shown in fig.3.and fig.4. Likewise, the data of room parameters such as temperature and humidity are also continuously monitored using DHT11 sensor. The results are viewed on the webpage of local server. The authorized ID web portal is shown in fig.4.

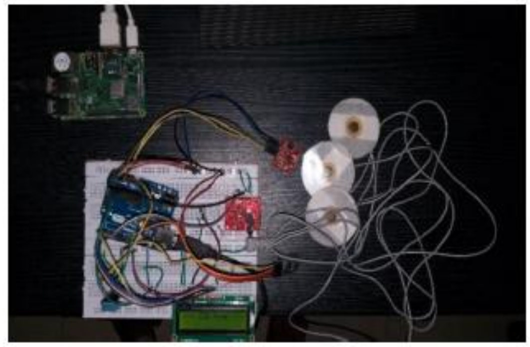
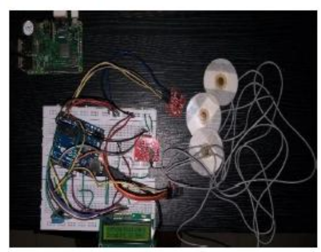
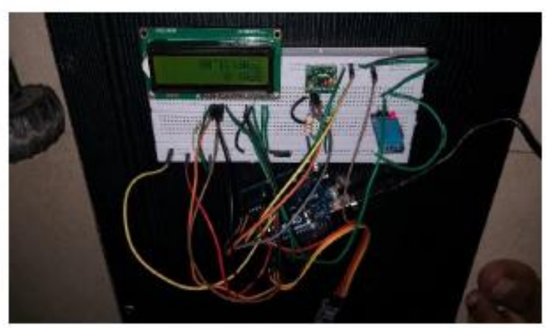


Figure.3. Experimental setup in ECG mode and result tested for a volunteer.

Figure.4.Experimental setup in normal mode and Authorized ID web portal.





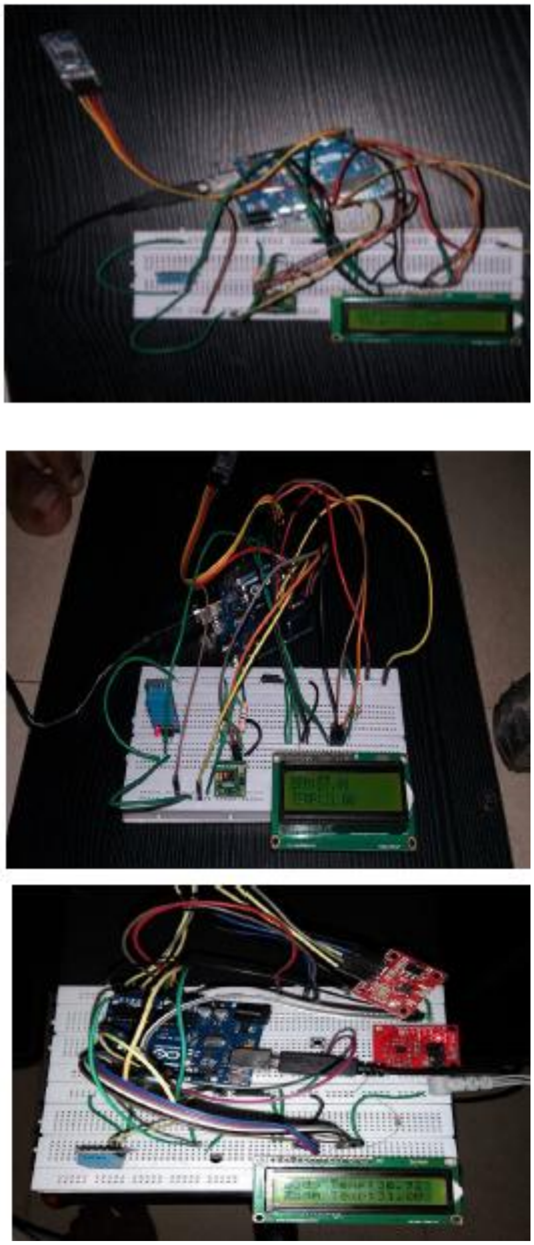


Figure.5. Snapshots of results using LM 35, BPM using MAX30105 and DHT11 Sensor in slave circuit.

The accelerometer sensor ADXL-335 is used to monitor movement of the patient. If movement of the patient body is changed, the sensor observe the positions and results are viewed such as on foot, on bed(right/left) on both LCD display and webpage of the server. The snapshots of above results are shown in fig.6.

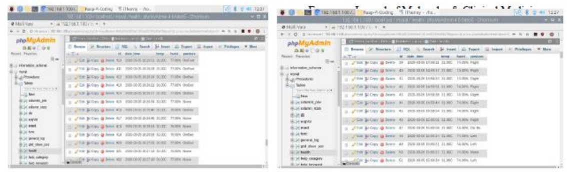


Figure.6. Snapshots of result on webpage using ADXL-335 and DHT11 sensor in master circuit.

8. COMPARATIVE STUDY ON OBSERVED DATA

S.No.	Input Data	Normal Range	Observed Data
1.	Humidity	40 % – 70 %	67 % - Normal
2.	Room Temperature	20°C – 27 °C	31 °C - Moderate
3.	Body Temperature	36 °C – 37 °C	36.92 °C - Normal
4.	Heart Rate in beats per minute (bpm)	60 – 100 bpm	87.00 bpm - Normal

o **Self-Care Services**

o **Emergency Ambulance Services**

o **Portable Wireless System for Home Healthcare Services**

o **Clinics**

9. APPLICATIONS

10. CONCLUSION:-

The proposed system offers remote capabilities that support the patients who feel discomfort for the regular health check-up and long stay in the clinics which minimises the cost. It also facilitates to track the environmental progress to enable patient in the comfort at their home. The patient's data can be collected and accessed from any location remotely as well as efficiently using web app. The entire prototype framework can be converted as self-health care service for clinical monitoring such as body temperature, body posture, ECG, heart rate and environmental parameters at the patient. The above parameters can also be visualized on the display screen of LCD in the Slave circuit near the patient. Physicians can view the result on the webpage of personal server / mobile device. A GSM SIM800 module can also be incorporated to get alert messages as SMS in mobile device if data reaches abnormality value

In future work, the role of Nano Sensor modules under machine learning based decision model will be focussed via Advanced ZigBee connectivity to predict the accuracy in Datasets and efficiency of monitoring the physiological parameters. The security measure can also be promoted in thing speak loud. The system can be implemented with cloud server in future to clinics / hospitals for immediate treatment with necessary intensive care.

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