Quarantined Patient Health Monitoring System Using IoT with ESP32 module

Abstract

Internet of Things (IoT) based smart health monitoring system is a patient monitoring system in which a patient can be monitored 24 hours. In the present world, IoT is changing the infrastructure of technologies. By facilitating effortless interaction among various modules, IoT has enabled us to implement various complex systems such as smart home appliances, smart traffic control systems, smart office systems, smart environment, smart vehicles and smart temperature control systems and so on in very little space. Health monitoring systems are one of the most notable applications of IoT. Many types of designs and patterns have already been implemented to monitor a patient's health condition through IoT.
In November 2019 a major outbreak took place of a virus named coronavirus (COVID-19) from Wuhan, China. Outbreak was so massive that it exponentially spreaded in parts of the U.S.A., European Union and parts of Asia. WHO declared COVID-19 outbreak as a global pandemic in March 2020. People as well as medical infrastructure was not ready for this. Due to lack of PPE kits and face shields many doctors also got contracted with the virus and lost their battle in it.
In this paper, a review of IoT based smart health monitoring systems for quarantined patients is presented. This review aims to highlight the common design and implementation patterns of intelligent IoT based smart health monitoring devices for patients.

Introduction

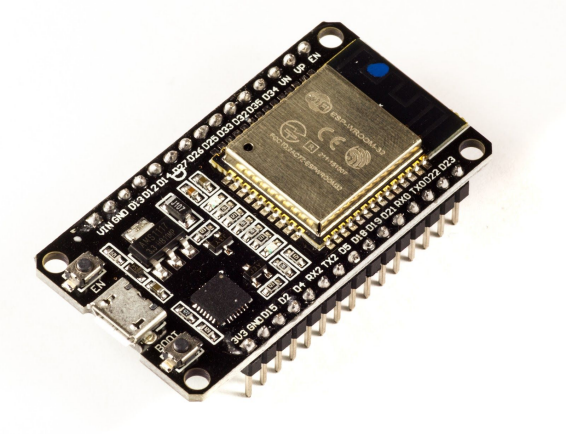
Amid the coronavirus crisis, many patients who are infected with the virus are left without the care they need, particularly those who are experiencing mild to moderate symptoms. It is essential to monitor them because of the nature of the disease, which may lead to drastic and abrupt changes in their health status.The new system is based on combined data from various sensors to detect disease progression and severity. The patient's heart rate, blood pressure, and respiratory rate can be monitored.The proposed system enables monitoring patients from their homes that save governmental cost and time through measuring the changes in patient's medical readings. It will serve humanity in the reduction of coronavirus infection and save healthcare members around the world. It also saves hospital places for emergency cases.

Heart rate and body temperature are the two most significant indicators for human health. Heart rate is the per minute amount of heartbeats, commonly known as the pulse rate. To measure the pulse rate, an increase in the blood flow volume can be used by calculating the pulses. Normal heart rate ranges between 60 and 100 beats per minute for healthy people. The typical restful heart for adult males is roughly 70bpm and for adult females 75bpm. Female with 12years of age and above, typically have higher rates of heart in contrast with males. The temperature of human body is simply the heat of body and the sum of heat radiated by the body is scientifically determined. The average person's body temperature relies on different factors such as ambient temperature, the person's gender, and his eating habits. In healthy adults, it is likely to range between 97.8°F (36.5°C) and 99°F (37.2°C). Different factors such as flu, low-temperature hypothermia, or any other illness may lead to a change in body temperature. In almost all illnesses, fever is a typical indicator. Various methods exist to invasively and noninvasively assess the heart

rate and body temperature. For the consumer, noninvasive approaches over a while have proven accurate and convenient. It is suggested that healthcare should provide good room conditions to facilitate the patients. Some measures like room humidity, level of all gases like CO, and CO_2 can determine the quality of a room environment. The toxic gases and certain levels of humidity are very harmful to patients. For optimum comfort, the room humidity should be between 30 and 65%. Some studies are done only for a smart home, not for dedicated healthcare.

Hardware Components required

ESP32 module



The ESP32 is a low-cost system-on-chip (SoC) series created by Espressif Systems. It is an improvement on the popular ESP8266 that is widely used in IoT projects. The ESP32 has both Wifi and Bluetooth capabilities, which make it an all-rounded chip for the development of IoT projects and embedded systems in general.

Pulse Oximeter Sensor

The MAX30100 is an integrated pulse oximetry and heart- rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals.The MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times.

DS18B20 Temperature Sensor

The DS18B20 is a 1-wire programmable Temperature sensor from Maxim integrated. It is widely used to measure temperature in hard environments like in chemical solutions, mines or soil etc. ... It can measure a wide range of temperature from -55°C to +125° with a decent accuracy of ±5°C. I have used this sensor to take body temperature data.

DHT11 Temperature-Humidity Sensor

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. I have used this sensor to take room temperature and humidity data.

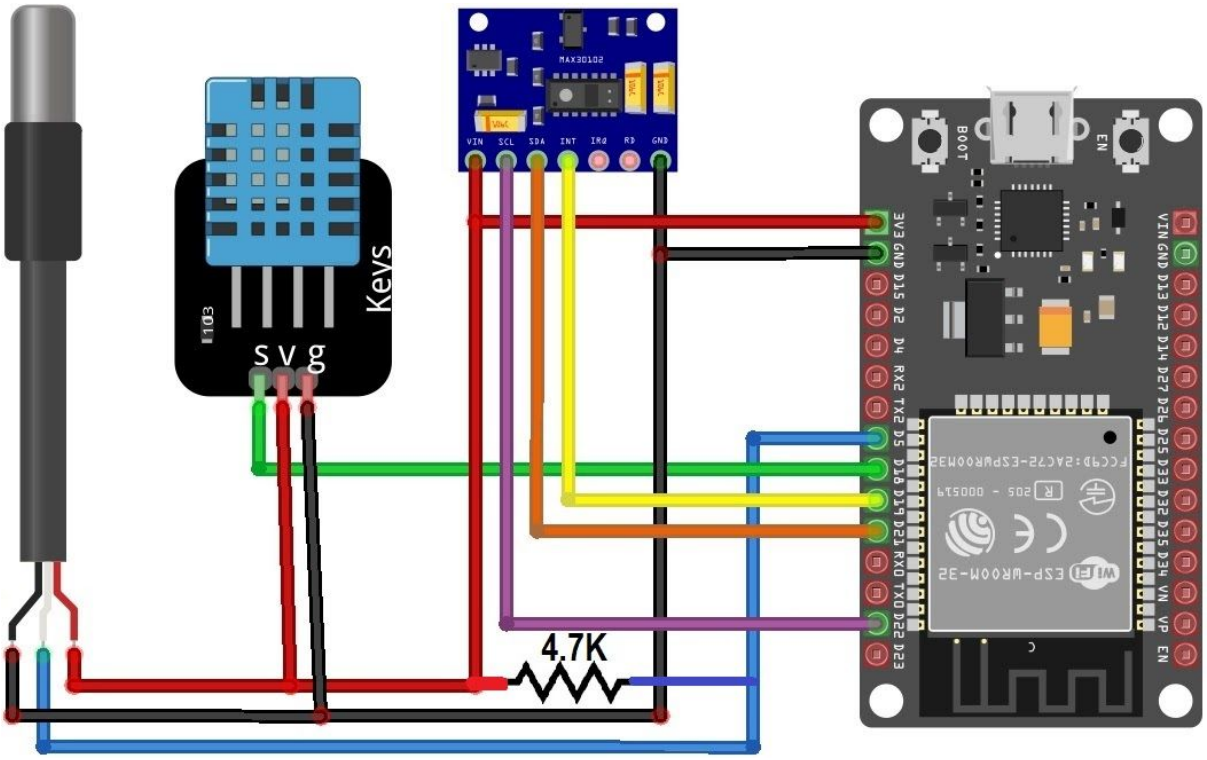
Software requirements

Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and other microcontroller hardware to upload programs and communicate with them.ex in my case ESP32 module.

Implementation details

The following is the diagram for connection of circuit All the sensor can work at 3.3V VCC. So connect their VCC to 3.3V Power Supply. Connect the GND to GND. MAX30100 is an I2C Sensor, so connect its SDA & SCL pin to GPIO21 & GPIO22. Connect its INT pin to GPIO19 of ESP32. The output pin of DHT11 is connected to GPIO18 of ESP32. Similarly, the output pin of DS18B20 is connected to GPIO5 of ESP32. A 4.7K pull-up resistor is connected between output pin & VCC pin of DS18B20.



Coding Details(Full Code)

START of CODE

```
/*
 * SHRIRANG ALIAS SAMARTH PATIl
 * 19BAI10079
 * CSE3001 Database Management Systems B11 slot
 * Project Presentation
*/

#include <WiFi.h>
#include <WebServer.h>
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#include <OneWire.h>
#include <DallasTemperature.h>
#include <dht.h>

#define DHT11_PIN 18
#define DS18B20 5
#define REPORTING_PERIOD_MS     1000

float temperature, humidity, BPM, SpO2, bodytemperature;
```

```
/*Put your SSID & Password*/
const char* ssid = "Kalpataru";  // Enter SSID here
const char* password = "samarth@1234";  //Enter Password here

dht DHT;
PulseOximeter pox;
uint32_t tsLastReport = 0;
OneWire oneWire(DS18B20);
DallasTemperature sensors(&oneWire);


WebServer server(80);

void onBeatDetected()
{
  Serial.println("Beat!");
}

void setup() {
  Serial.begin(115200);
  pinMode(19, OUTPUT);
  delay(100);

  Serial.println("Connecting to ");
  Serial.println(ssid);

  //connect to your local wi-fi network
  WiFi.begin(ssid, password);

  //check wi-fi is connected to wi-fi network
  while (WiFi.status() != WL_CONNECTED) {
  delay(1000);
  Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected..!");
  Serial.print("Got IP: ");  Serial.println(WiFi.localIP());

  server.on("/", handle_OnConnect);
  server.onNotFound(handle_NotFound);

  server.begin();
  Serial.println("HTTP server started");
```

```
  Serial.print("Initializing pulse oximeter..");

  if (!pox.begin()) {
    Serial.println("FAILED");
    for (;;);
  } else {
    Serial.println("SUCCESS");
    pox.setOnBeatDetectedCallback(onBeatDetected);
  }

   pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

  // Register a callback for the beat detection

}
void loop() {
  server.handleClient();
  pox.update();
  sensors.requestTemperatures();
  int chk = DHT.read11(DHT11_PIN);

  temperature = DHT.temperature;
  humidity = DHT.humidity;
  BPM = pox.getHeartRate();
  SpO2 = pox.getSpO2();
  bodytemperature = sensors.getTempCByIndex(0);


  if (millis() - tsLastReport > REPORTING_PERIOD_MS)
  {
    Serial.print("Room Temperature: ");
    Serial.print(DHT.temperature);
    Serial.println("°C");

    Serial.print("Room Humidity: ");
    Serial.print(DHT.humidity);
    Serial.println("%");

    Serial.print("BPM: ");
    Serial.println(BPM);

    Serial.print("SpO2: ");
    Serial.print(SpO2);
```

```
    Serial.println("%");

    Serial.print("Body Temperature: ");
    Serial.print(bodytemperature);
    Serial.println("°C");

    Serial.println("**********");
    Serial.println();

    tsLastReport = millis();
  }

}

void handle_OnConnect() {

  server.send(200, "text/html", SendHTML(temperature, humidity, BPM, SpO2,
bodytemperature));
}

void handle_NotFound(){
  server.send(404, "text/plain", "Not found");
}

  String SendHTML(float temperature,float humidity,float BPM,float SpO2, float
bodytemperature){
  String ptr = "<!DOCTYPE html>";
  ptr +="<html>";
  ptr +="<head>";
  ptr +="<title>Quarantined Patient Health Monitoring</title>";
  ptr +="<meta name='viewport' content='width=device-width, initial-scale=1.0'>";
  ptr +="<link
href='https://fonts.googleapis.com/css?family=Open+Sans:300,400,600'
rel='stylesheet'>";
  ptr +="<style>";
  ptr +="html { font-family: 'Open Sans', sans-serif; display: block; margin: 0px auto;
text-align: center;color: #444444;}";
  ptr +="body{margin: 0px;} ";
  ptr +="h1 {margin: 50px auto 30px;} ";
  ptr +=".side-by-side{display: table-cell;vertical-align: middle;position: relative;}";
  ptr +=".text{font-weight: 600;font-size: 19px;width: 200px;}";
  ptr +=".reading{font-weight: 300;font-size: 50px;padding-right: 25px;}";
  ptr +=".temperature .reading{color: #F29C1F;}";
  ptr +=".humidity .reading{color: #3B97D3;}";
```

```
  ptr +=".BPM .reading{color: #FF0000;}";
  ptr +=".SpO2 .reading{color: #955BA5;}";
  ptr +=".bodytemperature .reading{color: #F29C1F;}";
  ptr +=".superscript{font-size: 17px;font-weight: 600;position: absolute;top: 10px;}";
  ptr +=".data{padding: 10px;}";
  ptr +=".container{display: table;margin: 0 auto;}";
  ptr +=".icon{width:65px}";
  ptr +="</style>";
  ptr +="</head>";
  ptr +="<body>";
  ptr +="<h1>Quarantined Patient Health Monitoring System</h1>";
  ptr +="<h3>Patient X</h3>";
  ptr +="<div class='container'>";

  ptr +="<div class='data temperature'>";
  ptr +="<div class='side-by-side icon'>";
  ptr +="<svg enable-background='new 0 0 19.438 54.003'height=54.003px
id=Layer_1 version=1.1 viewBox='0 0 19.438 54.003'width=19.438px x=0px
xml:space=preserve xmlns=http://www.w3.org/2000/svg
xmlns:xlink=http://www.w3.org/1999/xlink y=0px><g><path
d='M11.976,8.82v-2h4.084V6.063C16.06,2.715,13.345,0,9.996,0H9.313C5.965,0,3.
252,2.715,3.252,6.063v30.982";
  ptr
+="C1.261,38.825,0,41.403,0,44.286c0,5.367,4.351,9.718,9.719,9.718c5.368,0,9.71
9-4.351,9.719-9.718";
  ptr
+="c0-2.943-1.312-5.574-3.378-7.355V18.436h-3.914v-2h3.914v-2.808h-4.084v-2h4
.084V8.82H11.976z M15.302,44.833";
  ptr
+="c0,3.083-2.5,5.583-5.583,5.583s-5.583-2.5-5.583-5.583c0-2.279,1.368-4.236,3.3
26-5.104V24.257C7.462,23.01,8.472,22,9.719,22";
  ptr
+="s2.257,1.01,2.257,2.257V39.73C13.934,40.597,15.302,42.554,15.302,44.833z'fill
=#F29C21 /></g></svg>";
  ptr +="</div>";
  ptr +="<div class='side-by-side text'>Room Temperature</div>";
  ptr +="<div class='side-by-side reading'>";
  ptr +=(int)temperature;
  ptr +="<span class='superscript'>°C</span></div>";
  ptr +="</div>";

  ptr +="<div class='data humidity'>";
  ptr +="<div class='side-by-side icon'>";
```

```
  ptr +="<svg enable-background='new 0 0 29.235 40.64'height=40.64px id=Layer_1
version=1.1 viewBox='0 0 29.235 40.64'width=29.235px x=0px xml:space=preserve
xmlns=http://www.w3.org/2000/svg xmlns:xlink=http://www.w3.org/1999/xlink
y=0px><path
d='M14.618,0C14.618,0,0,17.95,0,26.022C0,34.096,6.544,40.64,14.618,40.64s14.6
17-6.544,14.617-14.617";
  ptr +="C29.235,17.95,14.618,0,14.618,0z
M13.667,37.135c-5.604,0-10.162-4.56-10.162-10.162c0-0.787,0.638-1.426,1.426-1.
426";
  ptr
+="c0.787,0,1.425,0.639,1.425,1.426c0,4.031,3.28,7.312,7.311,7.312c0.787,0,1.425
,0.638,1.425,1.425";
  ptr +="C15.093,36.497,14.455,37.135,13.667,37.135z'fill=#3C97D3 /></svg>";
  ptr +="</div>";
  ptr +="<div class='side-by-side text'>Room Humidity</div>";
  ptr +="<div class='side-by-side reading'>";
  ptr +=(int)humidity;
  ptr +="<span class='superscript'>%</span></div>";
  ptr +="</div>";

  ptr +="<div class='data Heart Rate'>";
  ptr +="<div class='side-by-side icon'>";
  ptr +="<svg enable-background='new 0 0 40.542 40.541'height=40.541px
id=Layer_1 version=1.1 viewBox='0 0 40.542 40.541'width=40.542px x=0px
xml:space=preserve xmlns=http://www.w3.org/2000/svg
xmlns:xlink=http://www.w3.org/1999/xlink y=0px><g><path
d='M34.313,20.271c0-0.552,0.447-1,1-1h5.178c-0.236-4.841-2.163-9.228-5.214-12.
593l-3.425,3.424";
  ptr
+="c-0.195,0.195-0.451,0.293-0.707,0.293s-0.512-0.098-0.707-0.293c-0.391-0.391-
0.391-1.023,0-1.414l3.425-3.424";
  ptr
+="c-3.375-3.059-7.776-4.987-12.634-5.215c0.015,0.067,0.041,0.13,0.041,0.202v4.
687c0,0.552-0.447,1-1,1s-1-0.448-1-1V0.25";
  ptr
+="c0-0.071,0.026-0.134,0.041-0.202C14.39,0.279,9.936,2.256,6.544,5.385l3.576,3
.577c0.391,0.391,0.391,1.024,0,1.414";
  ptr
+="c-0.195,0.195-0.451,0.293-0.707,0.293s-0.512-0.098-0.707-0.293L5.142,6.812c-
2.98,3.348-4.858,7.682-5.092,12.459h4.804";
  ptr
+="c0.552,0,1,0.448,1,1s-0.448,1-1,1H0.05c0.525,10.728,9.362,19.271,20.22,19.27
1c10.857,0,19.696-8.543,20.22-19.271h-5.178";
```

```
  ptr +="C34.76,21.271,34.313,20.823,34.313,20.271z
M23.084,22.037c-0.559,1.561-2.274,2.372-3.833,1.814";
  ptr
+="c-1.561-0.557-2.373-2.272-1.815-3.833c0.372-1.041,1.263-1.737,2.277-1.928L2
5.2,7.202L22.497,19.05";
  ptr +="C23.196,19.843,23.464,20.973,23.084,22.037z'fill=#26B999 /></g></svg>";
  ptr +="</div>";
  ptr +="<div class='side-by-side text'>Heart Rate</div>";
  ptr +="<div class='side-by-side reading'>";
  ptr +=(int)BPM;
  ptr +="<span class='superscript'>BPM</span></div>";
  ptr +="</div>";

  ptr +="<div class='data Blood Oxygen'>";
  ptr +="<div class='side-by-side icon'>";
  ptr +="<svg enable-background='new 0 0 58.422 40.639'height=40.639px
id=Layer_1 version=1.1 viewBox='0 0 58.422 40.639'width=58.422px x=0px
xml:space=preserve xmlns=http://www.w3.org/2000/svg
xmlns:xlink=http://www.w3.org/1999/xlink y=0px><g><path
d='M58.203,37.754l0.007-0.004L42.09,9.935l-0.001,0.001c-0.356-0.543-0.969-0.90
2-1.667-0.902";
  ptr
+="c-0.655,0-1.231,0.32-1.595,0.808l-0.011-0.007l-0.039,0.067c-0.021,0.03-0.035,0.
063-0.054,0.094L22.78,37.692l0.008,0.004";
  ptr
+="c-0.149,0.28-0.242,0.594-0.242,0.934c0,1.102,0.894,1.995,1.994,1.995v0.015h3
1.888c1.101,0,1.994-0.893,1.994-1.994";
  ptr +="C58.422,38.323,58.339,38.024,58.203,37.754z'fill=#955BA5 /><path
d='M19.704,38.674l-0.013-0.004l13.544-23.522L25.13,1.156l-0.002,0.001C24.671,0
.459,23.885,0,22.985,0";
  ptr
+="c-0.84,0-1.582,0.41-2.051,1.038l-0.016-0.01L20.87,1.114c-0.025,0.039-0.046,0.
082-0.068,0.124L0.299,36.851l0.013,0.004";
  ptr
+="C0.117,37.215,0,37.62,0,38.059c0,1.412,1.147,2.565,2.565,2.565v0.015h16.989
c-0.091-0.256-0.149-0.526-0.149-0.813";
  ptr +="C19.405,39.407,19.518,39.019,19.704,38.674z'fill=#955BA5 /></g></svg>";
  ptr +="</div>";
  ptr +="<div class='side-by-side text'>Blood Oxygen</div>";
  ptr +="<div class='side-by-side reading'>";
  ptr +=(int)SpO2;
  ptr +="<span class='superscript'>%</span></div>";
  ptr +="</div>";
```

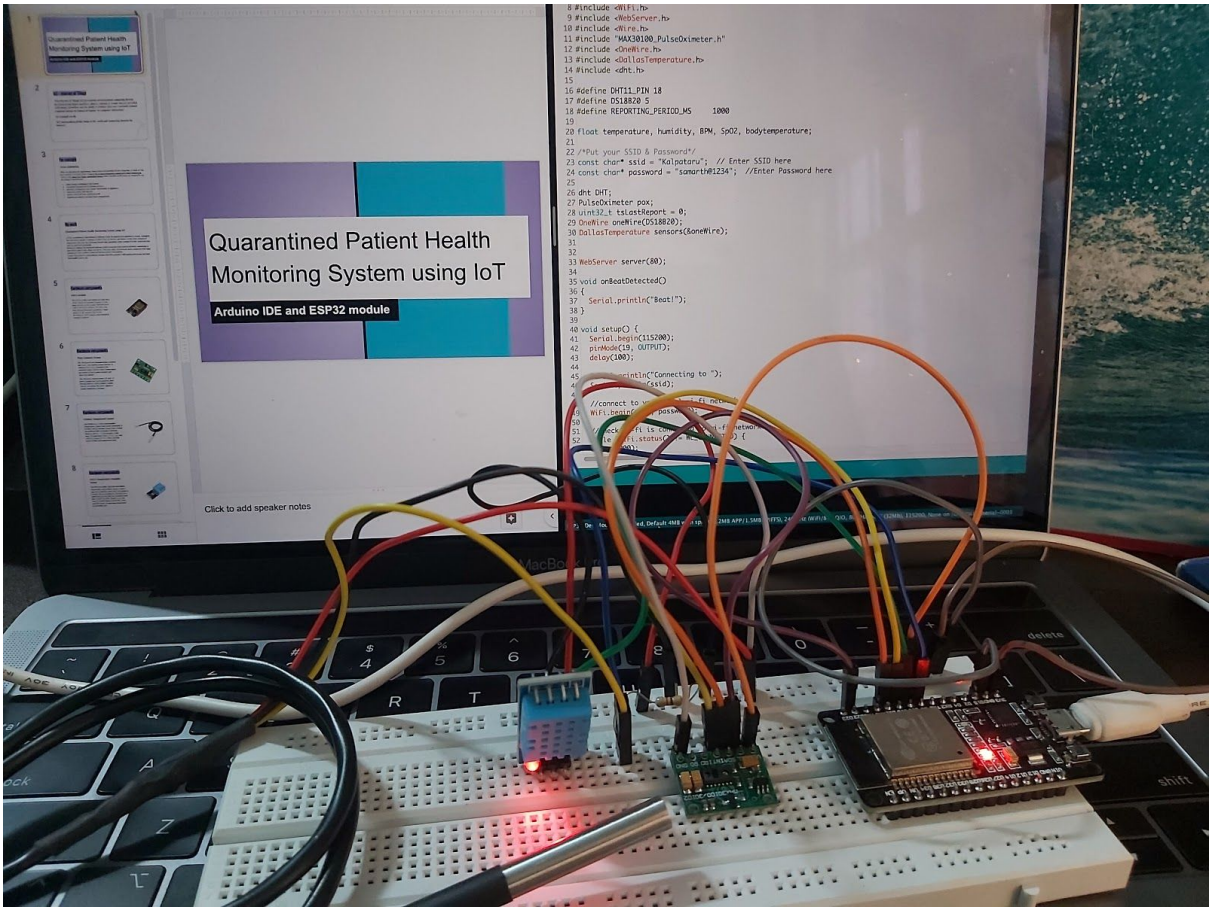
```
  ptr +="<div class='data Body Temperature'>";
  ptr +="<div class='side-by-side icon'>";
  ptr +="<svg enable-background='new 0 0 19.438 54.003'height=54.003px
id=Layer_1 version=1.1 viewBox='0 0 19.438 54.003'width=19.438px x=0px
xml:space=preserve xmlns=http://www.w3.org/2000/svg
xmlns:xlink=http://www.w3.org/1999/xlink y=0px><g><path
d='M11.976,8.82v-2h4.084V6.063C16.06,2.715,13.345,0,9.996,0H9.313C5.965,0,3.
252,2.715,3.252,6.063v30.982";
  ptr
+="C1.261,38.825,0,41.403,0,44.286c0,5.367,4.351,9.718,9.719,9.718c5.368,0,9.71
9-4.351,9.719-9.718";
  ptr
+="c0-2.943-1.312-5.574-3.378-7.355V18.436h-3.914v-2h3.914v-2.808h-4.084v-2h4
.084V8.82H11.976z M15.302,44.833";
  ptr
+="c0,3.083-2.5,5.583-5.583,5.583s-5.583-2.5-5.583-5.583c0-2.279,1.368-4.236,3.3
26-5.104V24.257C7.462,23.01,8.472,22,9.719,22";
  ptr
+="s2.257,1.01,2.257,2.257V39.73C13.934,40.597,15.302,42.554,15.302,44.833z'fill
=#F29C21 /></g></svg>";
  ptr +="</div>";
  ptr +="<div class='side-by-side text'>Body Temperature</div>";
  ptr +="<div class='side-by-side reading'>";
  ptr +=(int)bodytemperature;
  ptr +="<span class='superscript'>°C</span></div>";
  ptr +="</div>";

  ptr +="</div>";
  ptr +="</body>";
  ptr +="</html>";
  return ptr;
}
```

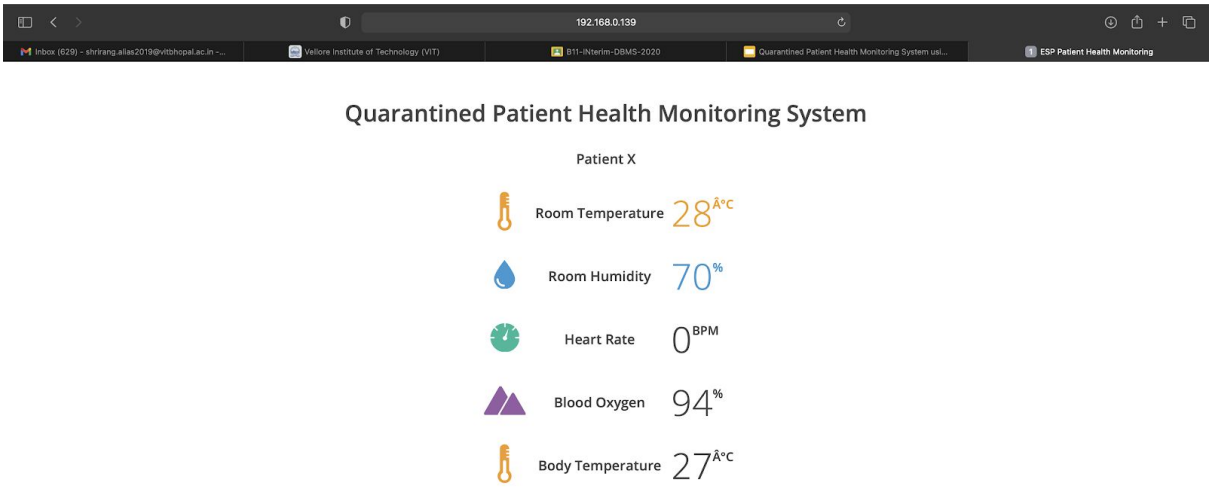
END of CODE

Result and Working of Project

Connections I made on breadboard:



Output on server webpage:



Conclusion

The system introduced smart healthcare to monitor the basic important signs of patients like heart rate, body temperature, and some measures of hospital room's condition such as room humidity,Authentic medical staff can view and track the data in real-time even though the patients perform the tests outside of the hospital. The system can also benefit nurses and doctors insituations of epidemics or crises as raw medical data can be analyzed in a short time. The developed prototype is very simple to design and use. The system is very useful in the case of infectious disease like a novel coronavirus (COVID-19) treatment. The developed system will improve the current healthcare system that may protect lots of lives from death. Although the system looks somewhat bulky, it will be a tiny device by proper manufacturing in the near future.The video as well as audio feature can be added for face to face as well as voice consultation between the doctors and patients. Some more measures which are very significant to determine a patient's condition like the level of diabetes, respiration monitoring,etc. can be addressed as future work.

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