Pulse & Blood Oxygen Monitoring System

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Abstract-With the covid-19 pandemic raging through the word especially in India, creative development in the healthcare industry has become increasingly necessary with rising number of deaths everyday. Here, we research about a Pulse and blood oxygen monitoring system which can contain a large database. The device is constructed with the help of esp8266 node MCU with an inbuilt Wifi module and a MAX3010 sensor to sense the pulse and oxygen level. The device senses the pulse and oxygen rate of the patients using MAX3010 sensor. If the pulse or oxygen level drops below a certain level, it immediately informs the concerned doctor with a pop-up notification, so that action can be taken immediately. Since, finding hospital beds is the biggest concern in the pandemic, this device can function from anywhere in the world which means the patient does not need to be in an hospital bed and still have close oxygen monitoring from a qualified doctor with the help of the attached WiFi module in the ESP8266 node MCU.

Keywords-ESP8266 node MCU, MAX3010 sensor, pulse rate, Blood oxygen level, Haemoglobin, infrared light.

1. Introduction

The IOT based systems in Healthcare has boomed over the years with multiple ground-breaking technologies. Such devices is of need now more than ever because of the raging coronavirus pandemic. In this research paper, we write about an IOT based Pulse and blood oxygen monitoring system using node MCU with an inbuilt WiFi module and MAX 30102 sensor which is used ti sense the blood oxygen level of a person. The main aim of such a device will be to quicly notify the doctor with a pop-up notification in a common app if the patients Pulse and blood oxygen level is not in the normal range which will result in immediate action and no delays that can save a patients life.

The rest of the paper is organized as follows: Section 2 presents literature survey the related work in the area . In Section 3, the proposed work and the framework for dynamic architecture is proposed with algorithm.
Section 4 discusses the experimental results and performance analysis and Section 5 concludes the paper with future directions.

2. Literature Survey

In **[1]**, they discussed about wearable device that can detect pulse rate and oxygen level of the human body as well. This device will be based on a wireless network of IOT. Infrared Rays will be coming into the picture for detecting the pulse from the tissue of the human body. To find the blood oxygen saturation, Photoplethysmography (PPG) technique is used. The device would be designed using microprocessor and IOT's concept of sensors and wireless networking of the device. **[2]** talks about the basic principles of function and mechanism behind the pulse oximeter. O_2Hb, i.e. the concentration of oxygenated hemoglobin in the blood deals with IR light and red light works more effectively under HHb, i.e. the concentration of deoxygenated hemoglobin. This research paper also tells about the pros and cons of various kind of pulse oximeter. It emphasizes that even the most effective device can't resist the fact of occurrence of gas exchange problems in the lungs. And the partial pressure of CO_2 are also not measured by these pulse oximeters. **[3]** is basically the research on the accuracy of the pulse oximeter device. It mentions that with latest research and studies it is found that finger probe-equipped device is much more effective and accurate than ear lobe-equipped devices.**[4]**

informs about various technologies used behind a pulse oximeter i.e. Spectophotometry whose main function is to measure the level of oxygen saturation in blood and the other main technology is Optical Plethysmography, which measures the impulse change in arterial blood. It also tells about the software as well as hardware parts that will further be used in implementing these technologies in real life. Hardware components have a main role of sensing detecting and responding according to the pulse, and all these can be done using the sensors, LED and the concept of IOT.**[5]** is basically a research and analysis of reports of clinical tests that were conducted so that one can compare and statistically analyze the differences occurred between various different kinds of cases. It's survey and analysis determines that there can be improvement in the current existing models by continuously monitoring SpO_2 level and oxygen supply.In **[6]** they discuss how Heart Rate Monitoring comes up with modern techniques to detect pulse rate and oxygen level of a human body. With the help of various research, calculations and intelligence we came up with several concepts that would be used in this system, such as Transmittance and Reflectance Methodology. These Methodologies are used to to detect pulse rate of human being with the help of LED and photo detectors.In **[7],** Pulse oximetry is used to measure percentage rate of haemoglobin saturation by using different wavelengths of red and infrared lights and sensors.

Multiple Tests were conducted The results of the tests conducted show that the obtained error value on measuring SPO2 is 0.89% and for the measuring BPM is 3.095%. The Difference in measurement of tempaerature of a human body has error value of 0.78%. Difference between correct measure and incorrect measure can be caused by several errors, including improper placement of finger on sensor error. The sensor responds at an average speed when the system is active for 20 seconds.In **[8]**,Wifi RoLa-32 was used for implementation of measuring the blood oxygen level . The SPo2 value can be determined by using the equation $SpO2 = K1 \times (\text{Avg radius})\ 2 + K2 \times (\text{Avg radius}) + K3$ where k1,k2 and k3 are constants Where SpO2 can be determined through the average radii.

The average radii can be determined by calculating average ratio of IR and red LED.An actuators having 2 states are used-Normally closed NC and normally open NO,which gets activated once the heart rate goes below 70 or above 90.

The work done in this paper allowed us to check the possibility of implementing IOT in the health sector with visualisation error of 1% and latency time of 600 ms.This data indicates the efficiency of the system which shows the ability of analysis ,storage and processing on data possible in future in IOT in the health sector.In **[9]** they discusses about pulse oximeter system for monitoring and all the neccesary components required for this process . The main components in this device is a pulse oximeter and a monitoring server. The proposed pulse oximeter determines the pulse of the patient and blood oxygen levels and other relevant data and sends the data to the personal monitoring server.There is a PHD agent and manager in the system .The PHD agent converts the collected data and errors to an IEEE format and transmits them to the personal monitoring server.In [**10]** ,they discuss about a wireless, continuous SpO2 monitoring system .The paper has researched and developed a PPG-based blood and pulse oxygen estimation system for close monitoring of the concerned patient.Changes in the blood oxygen level is measured by the sensor which senses through the optical light on one side of your finger which is caused by the beam of light emitted by the red LED. Then, using two different wavelengths data, the SpO2 can be measured.

Here,the formula used for SpO2 calculation is $SpO2 = (\rho HbO2)/(\rho HbO2 + \rho Hb)$ where, ρ HbO2=Concentration of oxyhemoglobin and ρ Hb = concentration of hemoglobin.In [**11]**,we demostrate a SpO2 monitoring device that can be placed on the human body on the finger .The proposed device has been tested on people and the tests show that it is stable ,robust and ready to operate.it also shows that the device is very accurate with only 1% error.It is a real time device that can be worn on a daily basis .A transceiver could replace the RF chips .Costs will be low.In [**12]**,we look into a system that will immediately notify doctors and nurses if the blood oxygen level,heart rate of a patient in the hospital in the ICU drops significantly.It talks about the previous wireless technology used in such a procedure and the main device in the focus is a smartCardia device.The new wireless SmartCardia device is dual device as it is used to monitor both the heart rate and SpO2 levels . The monitoring system is in a small box that is attached to the patients skin without wires, so that no additional complications are faced in the future related to wire removal or disconnection.

2.1 Problem Statement

With the inevitable increase in the number of COVID-19 affected patients, the hospitals are finding it hard to allot beds for new patients and doctors are finding it impossible to monitor them.

Since COVID-19 has the symptoms similar to that of Pneumonia, a sudden decrease in the Blood oxygen level and an irregular Heart Beat is noted for patients, who are in the recovery stage.

As the doctors cannot monitor the recovering patients frequently and they are generally discharged to their homes, providing quick help becomes impractical.

3. Proposed work

In this Project, we will be trying to make an IoT-based Pulse and Blood-Oxygen Monitoring System which will allow doctors to monitor the pulse and Blood-Oxygen level of isolated people remotely through the Blynk IoT App. Our device will periodically collect the parameters from the sensors and send it to the Blynk IoT App. The app will send this data to a Cloud database. Whenever the blood oxygen level drops down below the general level, the App will notify the consulted doctor by sending notifications. Also, it signals the patient that they may need oxygen cylinders as early as possible to maintain the blood-oxygen level.

Features:

- The Device setup consists of sensors, a controller and an Android application.
- The setup can support data access from multiple accounts.
- It also supports Bluetooth connectivity in addition to Wi-Fi connectivity.
- The sensor used, consumes very less power
    - Voltage- 1.8 to 3.3 V
    - Current- 0.7µA

3.1 Architectural design of Pulse Oximeter

In this project, we are having a sensor node to sense the pulse and blood oxygen level. The data is converted into standard units by the Microcontroller and is sent to be stored on web servers and is also displayed in the mobile app as it is. Also, the app has to send the notification to the doctor as a message or prompt informing that the patient's oxygen level has dropped below or is reaching the risk. In addition to this, the data can be accessed from multiple devices.
Considering all these factors, it is implemented as a Level-2 IoT system.

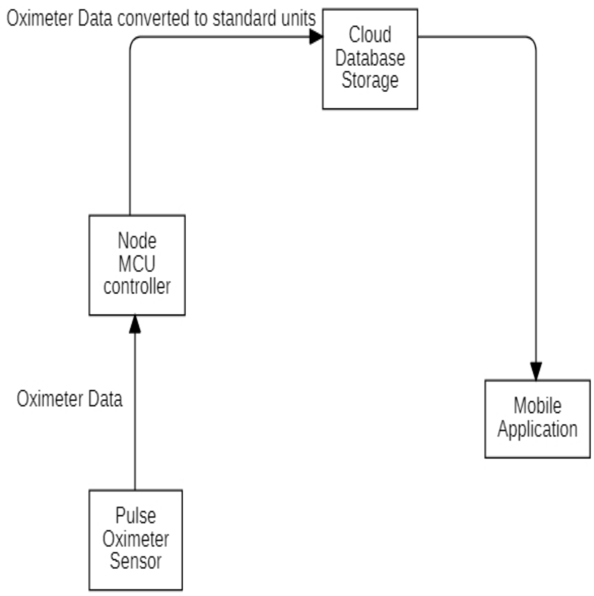

Figure 1: Architectural Design of Pulse Oximeter

3.1.1 Module-1:Pulse Oximeter Sensor

The MAX30102 Pulse Oximeter and Heart-Rate Sensor is being used in the device to detect heart beats and Oxygen Level through the blood stream of a person.

Working:

- The detection of oxygen level is carried out by the red and infrared LEDs.
- When heart pumps blood, it is oxygenated (i.e. more concentration of O_2) whereas when

the blood returns back it has less oxygen concentration.

- The oxygenated bloodcan absorb high amount of infrared light while the deoxygenated blood can absorb large quantities of red light.
- Photoreceptors detect the amount of light absorbed to determine the blood-oxygen level.
- The time difference between the detection of Oxygenated and Deoxygenated blood helps in determining the pulse rate.

3.1.2 Module-2: Node MCU Controller

The Node MCU is an IOT module which is based on the ESP8266 Wi-Fi Module, has a high processing power with a clock rate of 80-160 MHz and 128 kb RAM (flash memory of 4 Mb for programs). It also has in-built Bluetooth and Wi-Fi Modules to support Web based IOT Applications.We will also connect an implantable cardiac infribilator that will give a mild shock to the patient if the sensors detect the pulse and heart rate fall below a thresh hold value.

3.2 Algorithm

```
  LED <- D3
setup()
        pinMode(LED, OUTPUT)// Pinmode for LED
        Serial.begin(115200)// Initialize Serial
        blinkLED(5)// Blink LED for 5 seconds to signal
        start of initialization
        Print "Initializing..." in serial monitor
        if pox.begin(Wire, I2C_SPEED_FAST) is false
           Print "MAX30102 Sensor was not found.
        else
           ledBrightness <- 60
           sampleAverage <- 4
           ledMode <- 2
           sampleRate <- 100
           pulseWidth <- 411
           adcRange <- 4096
        pox.setup(ledBrightness,sampleAverage, ledMode,
        sampleRate, pulseWidth, adcRange)
         Print "Setup initialized! Enter any key to
        continue..." in serial monitor
         blinkLED(3)
         while (Serial.available() is equal to 0)
        Serial.read()
        Blynk.begin(blynkAuth, ssid, pass)
        sendTimer.setInterval(250L,
        sendToBlynkServer)
        Print "Collecting Data..." in serial monitor
        for i <- 0 to bufferlength
             while pox.available() is false //do we
                 have new data?
         pox.check()//Check the sensor for new
        data
           redBuffer[i] <- pox.getRed()
           irBuffer[i] <- pox.getIR()
            pox.nextSample()//We're finished with
        this sample so move to next sample
        Print "Data Collected!" in serial monitor
loop()
        Blynk.run()
        sendTimer.run()
        getHeartRate()
        getSpO2()
```

4. Experimental results with tables and graphs

Experimental setup

Components:

Hardware:

- Node MCU ESP8266 Wi-Fi Module Ver 1.0
- MAX30102 Pulse Oximeter and Heart-Rate Sensor
- Bread Board
- Connection Wires
- Soldering Kit
- USB Data Cable
- LED

Software:

- Blynk IoT Application (Android/ioS)
- Arduino IDE
- Blynk Libraries

- The NodeMCU is connected to the bread board.

- It is then connected with the Data transfer-USB Cable to the Computer system to upload the code into the module.
- The SCL pin present in the sensor is connected to the D1 pin slot of Node MCU.
- The SDA pin present in the sensor is connected to the D2 pin slot of Node MCU.
- The INT pin present in the sensor is connected to the D0 pin slot of Node MCU.
- The GND pin present in the sensor is connected to the GND pin slot of Node MCU.
- The VIN pin present in the sensor is connected to the 3.3V input slot of Node MCU.
- After setting up the hardware, we can proceed to set up the App.

The experiments are carried out to validate the detection capabilities of the MAX30102 sensor. Experiment are carried out and tables are created and graph is formed on the basis of infrared led v/s Pulse rate and infrared red led v/s SPO2 level.

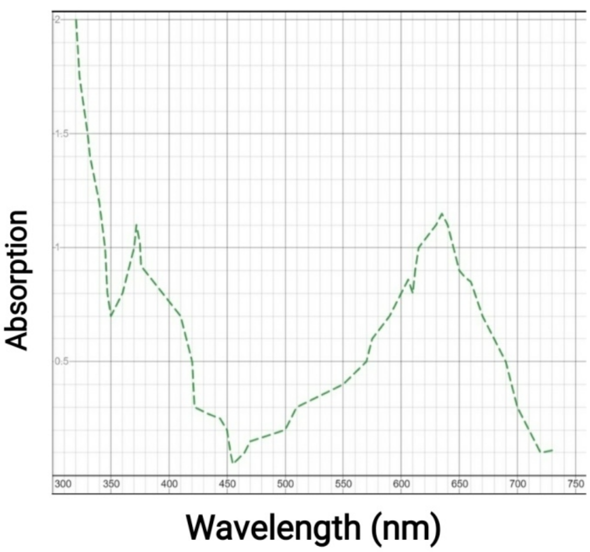

Figure 2: Absorption V/S Wavelength Graph

The above graph is absorption v/s wavelength (nm) graph where the X-axis denotes the wavelength and the Y-axis denotes the absorption of infrared light.

Due to this graph we can observe and conclude various parameters.

Oxygenated blood absorbs high amount of infrared light and allows more red light to pass.

Deoxygenated blood allows high amount of infrared light to pass and hence absorbs more red light.

5. Conclusion And Future Work

In conclusion, this paper intends to bring improvement the medical industry, especially when the world is hit by the deadly COVID-19 pandemic. This paper researches on a pulse and blood oximeter system using NODE MCU and MAX3010 sensor, which can detect the pulse and blood oxygen level of a patient and send a immediate pop-up notification to the concerned doctor from anywhere in the world with the help of an embedded wifi module in the node MCU

In future work, we will be researching on a system that gives a mild shock to the patient if the patients pulse drops below a certain level .Many modules are available for including such a system in our system. We will also be looking at new and innovative ways to improve the system and help doctors and patients in need as much as possible

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