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Design and Implementation of Remote Health Monitoring System Using IoT

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Abstract

The advancement of the Internet of Things Technology (IoT) plays a crucial role in developing the health sector by making it much more accessible and affordable through easy-to-use applications for virtual and distant patient interactions. There are several scopes for IoT to make a difference in patients' lives. The devices can capture and monitor related patient data, allowing providers to obtain insights without bringing the patients visiting. The procedure can assist the patient results and prevent possible communications for the process that involves risk. To alleviate the problems above, we propose IoT Based Remote Health Monitoring System. The proposed prototype consists of two health sensors: a heart rate sensor (MAX30100) which measures the heart rate and blood oxygen level, body temperature sensor, which measures temperature. The IoT-based system is a real-time health monitoring system utilizing the measured values of the patient's body temperature, pulse rate, and oxygen saturation, which are the most important measurements required for critical care. Node MCU reads all these sensors' data values of the patient. The data acquired from the sensors is transferred to cloud storage via the Node MCU. The cloud storage is continuously being updated in a real-time database, and from those values, the condition of the patients can be monitored remotely by doctors and health workers.

Keywords: Body temperature, Heart rate sensor, Internet of Things, Node MCU

1. INTRODUCTION

Wireless technology has had a tremendous impact in different sectors due to technological advancements in recent years. The Internet of Things (IoT) has successfully taken over the majority of the industrial sector, particularly automation and control, as well as the fields of health and biomedicine. IoT technology is used not only in hospitals but also in personal health-care facilities. Doctors play an essential role in health check-ups in the traditional technique.

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This procedure necessitates a significant amount of time for registration, appointment, and check-up. Reports are also generated afterwards. Working individuals prefer to disregard or postpone check-ups due to the lengthy process. Remote monitoring, as a solution, allows medical personnel to watch a patient remotely utilizing a variety of technology gadgets. These services can deliver similar health outcomes to traditional in-person medical meetings, provide greater patient satisfaction, and be cost-effective. With the growing popularity of mobile internet and the use of Wireless Sensor Networks (WSNs), wearable/portable health monitoring devices that can monitor and record long-term health metrics without the need to visit hospitals or diagnostic centers on a regular basis are now conceivable.

The two key drivers of this technology are IoT-based data collecting and cloud-based analytics. In the last decade, the Internet of Things (IoT) has made everything internally connected, and it has been dubbed the next technological revolution. The most significant application of IoT is in healthcare management, which uses it to track health and environmental conditions. IoT is the process of connecting computers to the internet via sensors and networks [1, 2]. These interconnected components can be utilized in health-monitoring devices. The data is subsequently sent to remote areas via M2M (machinery to machine), which includes computers, humans, handheld devices, and smartphones [3]. It's a straightforward, energy-efficient, considerably smarter, scalable, and interoperable method of tracking and optimizing care for any health issue. Modern technologies now offer a configurable interface [4], assistant devices [5], and mental health management [6] to enable humans to live a smarter life.

The two most important indices of human health are heart rate and body temperature. The heart rate, often known as the pulse rate, is the number of heart beats per minute. Calculating the pulses can be used to determine the pulse rate by measuring the increase in blood flow volume. For healthy persons, a normal heart rate is between 60 and 100 beats per minute. Adult males have a restful heart rate of 70 bpm, while adult females have a restful heart rate of 75 bpm [7].In comparison to boys, females over the age of 12 had higher risks of heart disease. The quantity of heat radiated by the body is scientifically determined, and the temperature of the human body is simply the heat of the body. The average person's body temperature is affected by a variety of factors, including ambient temperature, gender, and eating habits. It is most likely to be between 97.8 °F (36.5 °C) and 99 °F (37.2 °C) in healthy adults. A shift in body temperature can be caused by a variety of circumstances, including the flu, low-temperature hypothermia, or any other ailment. Fever is a common symptom of practically all diseases [8]. There are a variety of invasive and noninvasive methods for measuring heart rate and body temperature.

Patients with COVID-19 exhibit a variety of symptoms, including fever, shortness of breath, decreased oxygen saturation level, dry cough, diarrhea, vomiting, sore throat, headache, loss of taste and smell, bodily discomfort, and an irregular pulse rate [9]. High fever, low oxygen saturation, and an irregular pulse rate are all considered dangerous symptoms. Hypoxemia and hypoxia are caused by low oxygen saturation levels and shortness of breath, respectively. Patients with hypoxemia and pulse rate abnormalities have a lower likelihood of surviving. Patients may fail to notice hypoxemia and an increased pulse rate, and as a result, they die without receiving necessary treatment. As a result, it's critical for COVID-19 patients to be kept up to date on their health status, particularly their body temperature., heart rate, and oxygen saturation (SpO2) [10, 11].

The primary goal of this study is to create a prototype for real-time health monitoring via the Internet of Things (IoT). Temperature sensor (DS18B20) and pulse sensor (MAX30100) are medical sensors that are used to record patient health characteristics such as body temperature, heart rate, and oxygen level. The data is collected and processed by the Node MCU before being sent to the IoT cloud and visualized using a webpage. The physician can use the cloud platform to diagnose patients in faraway areas with this method (like home). Patients can also use this cloud service to view their medical records. These records can be reviewed remotely by a doctor or archived and accessed later.

2. MATERIALS AND METHODS

2.1 Methods

A block diagram and flowchart were used as guides to visualize the arrangement of steps to be followed throughout the system management process.

2.1.1 Flow chart

The complete system's flow chart is shown in Figure 2.1. The active program must be loaded into the Node MCU. The MAX30100 (pulse sensor) and DS18B20 (body temperature sensor) are turned on, and the Node MCU collects and processes patient health data such as body temperature, pulse rate, and oxygen level before sending it over the internet to the web server via the built-in Wi-Fi module. The data sent by the Node MCU is recorded in a SQL database, which is then presented and monitored by the doctor via a PHP-based webpage.

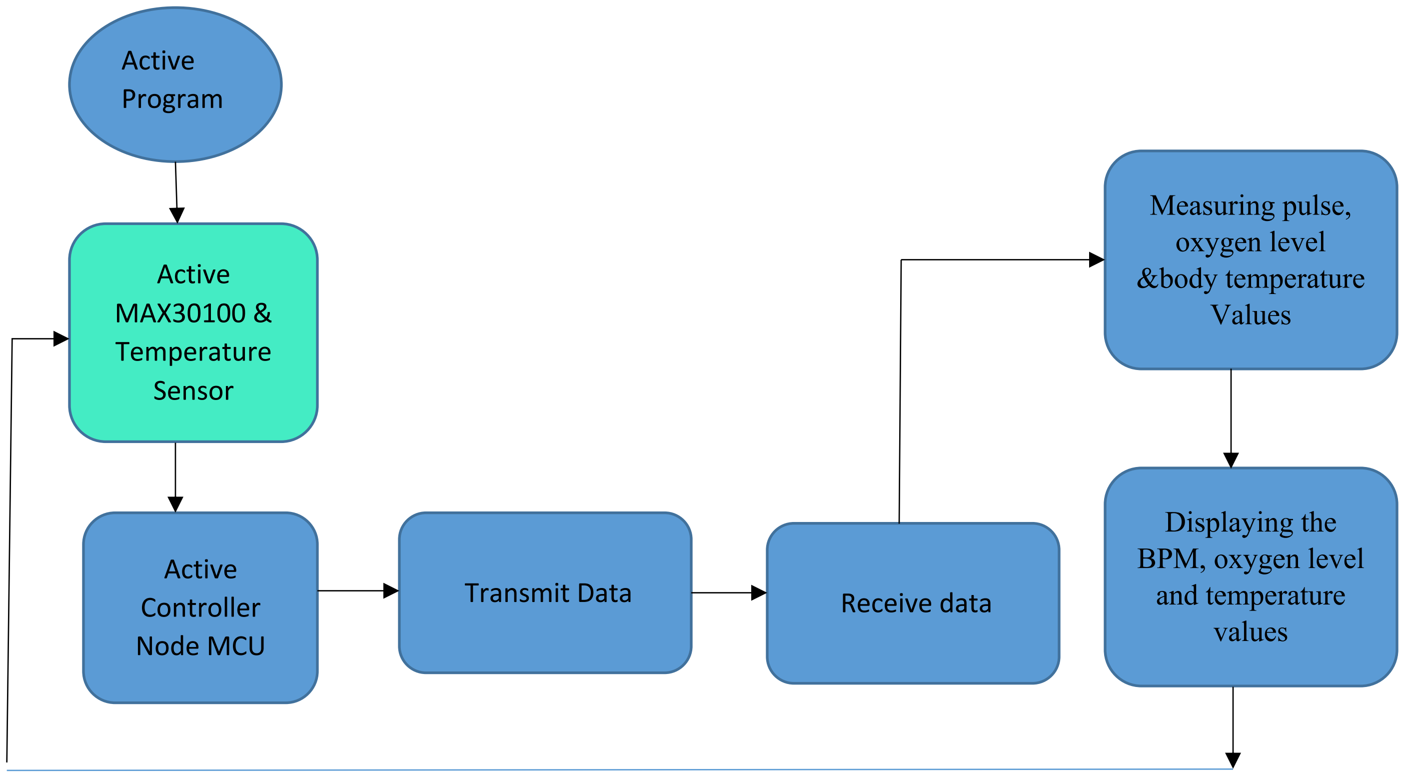

Fig. 1. Flow chart of the overall system

2.1.2 Block diagram

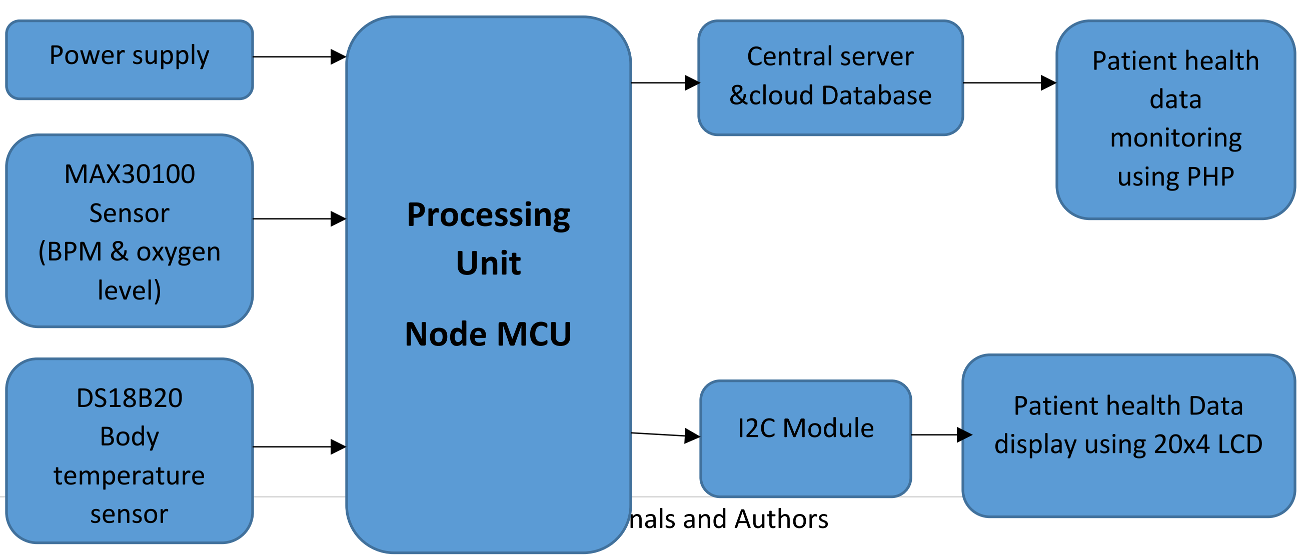

Fig. 2. Block diagram of the system

Fig. 2 depicts the overall system's block diagram. The power supply is responsible for providing power to the entire system. The Node MCU is connected to the max30100, which measures the patient's pulse rate and blood oxygen level (SpO2), as well as the DS18B20, which measures the patient's body temperature. The Node MCU is the processing unit that will collect and process sensor data. The data will be transferred to a cloud server or a web server and saved in a database after it has been processed. The I2C module is utilized in the prototype to connect the Node MCU to the LCD 20X4 for patient-side display of health data. Finally, collected data can be monitored by doctor at remotely using webpage.

2.2 Materials

2.3 Hardware materials used

Pulse Sensor (MAX30100): The MAX30100 is a sensor that can determine blood oxygen saturation and pulse rate. The prototype of the SpO2 Pulse Sensor is shown in Figure 2.5. (MAX30100). The amount of oxygenated hemoglobin in the circulation is measured by peripheral oxygen saturation (SpO2), which is a measurement of blood vessel oxygen saturation. SpO2 levels in the human body typically vary from 90 to 100 percent. A MAX 30100 pulse oximeter was suited for this setup. It’s a combination of a beat oximeter and a heart rate sensor that gives precise results. This sensor is suited for this system because it combines two LEDs, a photo detector, improved optics, and low-noise analog flag processing to recognize beat oximetry and heart rate signals.

Node MCU: For this system, we employed the node MCU ESP8266, as illustrated in Figure 2.3. Because the ESP8266 microcontroller has Wi-Fi functionality and the node MCU has a wireless system that can transfer data to a server, this is a wireless module. The node MCU ESP8266 microcontroller requires a 3.3 V operating voltage and a 7 to 12 V input voltage to operate. It has a 4 MB flash memory and a 64 KB SRAM. There are 16 digital input and output pins on the board, as well as one analog input pin. A PCB antenna is also included with the node MCU. The node MCU wireless module sends the measured pulse rate, oxygen saturation, and temperature to the server. This component was chosen because it links the server IP address to the node MCU to obtain the measured value through a web application.

DS18B20 Sensor. Figure 2.6 shows the DS18B20 sensor, which uses the 1-wire correspondence technique. It just requires a draw-up resistor on the information pin of the microcontroller, and the other two pins are used for control. When transport is not in use, the pull-up resistor is utilized to keep the line in a high state. This sensor is used to accurately monitor temperature. In a 2-byte register inside the sensor, the temperature measured by the sensor will be absent. By delivering them in a data arrangement, these data can be evaluated using the 1-wire technique. To inspect the values, two sorts of commands must be sent: one is a ROM command and the other may be a working command.

*LCD module***:** A 20x4 LCD shown in figure 2.4, can display 20 characters per line and there are 4 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. This is standard HD44780 controller LCD. It is used display the pulse rate, oxygen level and body temperature values measured from the patient using sensors.

I2C module: I2C module shown in figure 2.7 is a synchronous, multi slave, multi master packet switched, single-ended serial bus. i.e. Multiple chips can be connect to the same bus. I2C uses only two bidirectional open collector or open drain lines, Serial Data Line (SDA) and Serial Clock Line (SCL), pulled up with resistors.

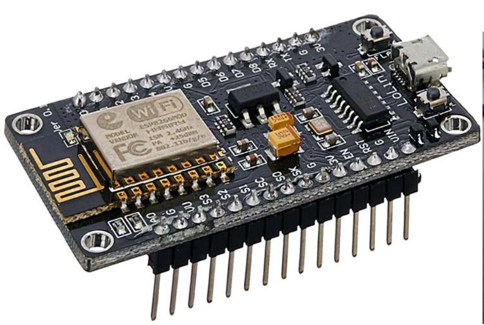

Fig. 3. Node MCU (ESP8266)

Fig. 4. LCD 20x4

Fig. 5. Pulse sensor (MAX30100)

Fig. 6. DS18B20 (Temperature sensor)

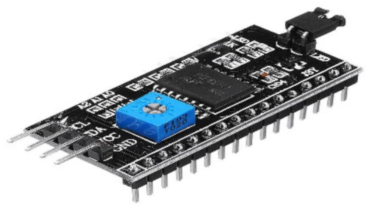

Fig. 7. I2C module

2.2.2 Software Used

MySQL Database: MySQL is a relational database management system based on SQL – Structured Query Language. The application is used for a wide range of purposes, including data warehousing, e-commerce, and logging applications. The most common use for MySQL however, is for the purpose of a web database.

PHP Myadmin: phpMyAdmin is a free software tool written in PHP that is intended to handle the administration of a MySQL or MariaDB database server. You can use phpMyAdmin to perform most administration tasks, including creating a database, running queries, and adding user accounts.

Visual Studio code: Visual Studio Code is a streamlined code editor with support for development operations like debugging, task running, and version control. It aims to provide just the tools a developer needs for a quick code-build-debug cycle and leaves more complex workflows to fuller featured IDEs, such as Visual Studio IDE.

3. RESULTS AND DISCUSSIONS

The hardware and the web application are the two components of the system. Both elements are necessary for the system to function, and users can benefit from both. The circuit diagram (block diagram) and flow chart depicted in Figures 2.1 and 2.2 were used to create this system. The system prototype is depicted in Figure 3.1. To complete the system, the LCD display, pulse sensor, temperature sensor, node MCU, and I2C module were included. The observed pulse rate, SpO2 (oxygen) level, and body temperature are displayed on the system's display. This system prototype is straightforward and straightforward to use. Because it is a lightweight prototype, it may be readily transferred from one site to another. Because all of the components are in the right place, the overall result is satisfactory.

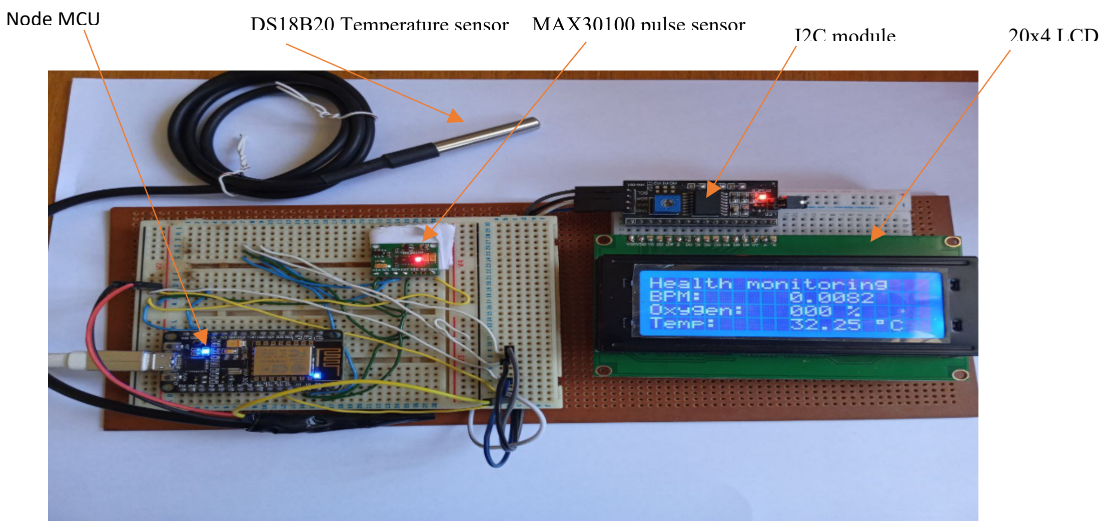

Fig.8. System Prototype

After inspecting the system separately, it was discovered that it functioned properly. This indicates that the project's system design and implementation procedures were right, and that the user's data were accurately measured. There are two key aspects to the entire system. Users can access measured values of their vital signs through this system's online application as well as the system's LCD.

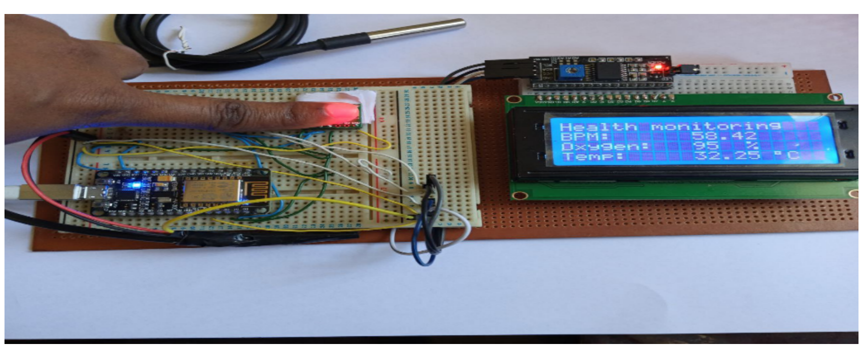

Fig. 9. The user experience and measured value

The system was put to the test on a real human. Figure 3.2 depicts the user's experience as well as the measured values of vital signs. The user may see the displayed results from the system on the LCD and web applications, which show the measured heart rate, SpO2, and temperature. This system sends data to a web application, which is one of the system's most important components. Users can acquire the required results via a web application using this device; consequently, this method is user-friendly and convenient. The system performed admirably.

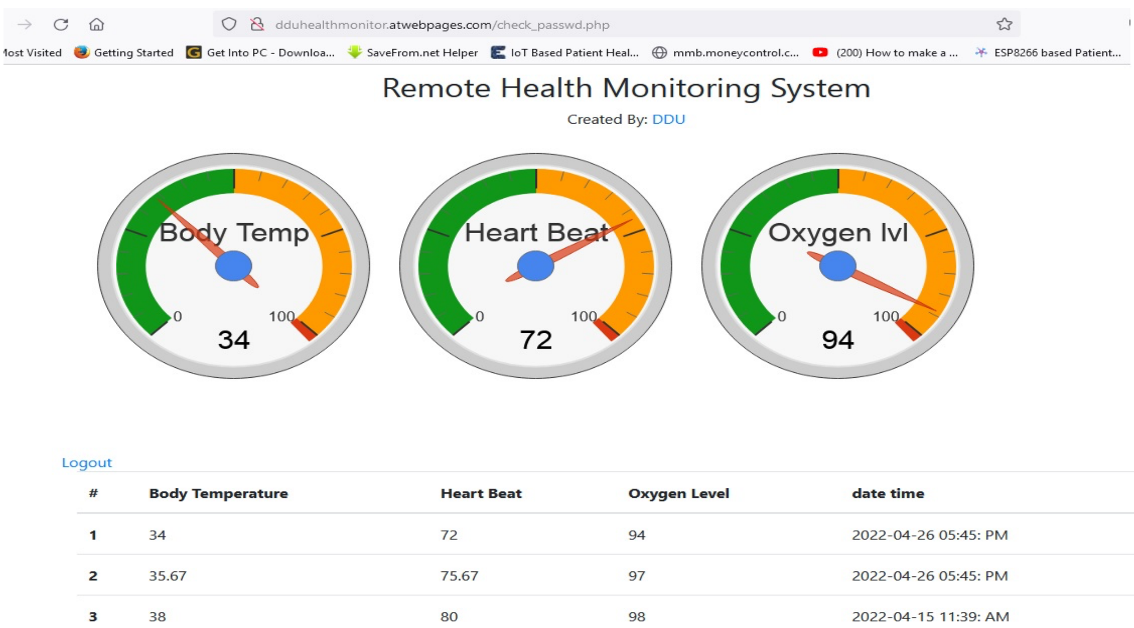

Fig. 10. Web page for displaying the health parameters

Figure 3.3 shows the measured values of SpO2 (oxygen level), pulse rate, and temperature of the patient on webpage. It is an important interface for web applications because it provides the main results of the system. All sensors worked satisfactorily.

4. CONCLUSION

The primary goal of this system is to provide a healthcare setup for elderly patients and patients who live in remote areas and cannot access hospitals on time. The system we have devised functions as a primary health check-up. The system is created and built using IoT applications to remotely monitor essential health data such as pulse rate, blood oxygen level, and body temperature. Even though the tests are performed outside the hospital, authentic medical professionals may monitor and track the data in real time using a web application. The technology can also help nurses and doctors in epidemics or crises because raw medical data can be examined quickly. The prototype that was created is incredibly easy to design and use. The method is quite helpful for infectious diseases, such as a novel coronavirus (COVID-19) treatment. The new system will improve the current healthcare system, potentially saving many lives. More sensors, such as respiration, ECG, and other health metrics, can be added to the current system, allowing more health parameters to be tracked.

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