Research Paper

Secure Remote Health Monitoring System

During the current COVID-19 epidemic, IoT-based health monitoring devices could be incredibly useful for COVID 19 sufferers. This learning develops a real time health monitoring system based on the Internet of Things that incorporates patient's measured pulse rate, body temperature, and oxygen saturation, which are the most significant critical care indicators. The LCD shows the current heart rate , body temperature and oxygen saturation level .This can easily be synced with a mobile app for quick retrieval, Using an Arduino Uno-based system, the suggested IoT based technique was verified and tested on five homosapians test participants. The result of the system were promising: the information it gathered was saved.

1 Introduction

COVID-19 was one of the most pressing worldwide health concerns. Acc to survey on 19 November persons worldwide who have been verified to have been purulent with SARS COV 2 is greater than 56.3 million, with more than 1.35 million deaths from the coronavirus, demonstrating that COVID-19 cases are on the rise .

As of November 21, 2020, there were total 445,281 active COVID 19 cases in Bangladesh, with 6350 deaths from the corona virus [2].breath shortness ,fever low oxygen saturation ,vomiting, diarrhea, throat probelom, head ache, dry cough, loss of smell and taste, body pain, and irregular rate of pulse are all signs of COVID-19 [3]. High fever, and low oxygen saturation, an irregular rate of are all considered dangerous symptoms.

Hypoxemia and hypoxia are caused by shortness of breath . Patients with hypoxemia and pulse rate issues have a lower likelihood of survival and patients may fail to notice hypoxemia and an increased pulse rate, and as a result, they die without receiving necessary treatment. The patients of COVID-19 should be known about their health problems on a frequent basis, particularly their body temperature, heart rate, and SpO2 .

As the person becomes older, it becomes increasingly important for them have regular medical checkup exams. Because getting frequent health checkup visits can be time consuming and can be difficult for most of the people, IoT arrangements can be advantageous for individuals have routine health exams . IoT has evolved into a critical innovation having countless use. Any system of physical equipment that obtains and exchanges data via wireless networks is referred to as a wireless network.

without the need for human intervention . With a significant rise in the active COVID 19 cases during the second wave, every country was having difficulty treating their patients properly. The most fundamental indicators of human health are body temperature and pulse rate. The number of pulses per minute, often called as rate of beat, is the pulse rate. For most people, The average pulse rate is 60 to 100 beats in a minute. Adult males and girls have similar resting pulse rates of 70 and 75 beats per minute, respectively [8, 9]. Pulse rates in women above the age of 12 are typically higher than in men. COVID-19 patients, on other hand, have an irregular pulse rate that necessitates the assistance of an emergency medical technician. Internal heat levels in healthy people fluctuate b/w 97.8 degrees fahrenheit (36.5 degrees celsius) and 99 degrees fahrenheit (37.2 degrees celsius) depending on a variety of parameters such as surrounding gender, temperature, arnd dietary pattern [9–11]. A fluctuation in body temperature can be caused by a variety of circumstances, including low-temperature influenza, hypothermia, and other disorders. Fever is a common sign of various disorders, including COVID-19; consequently, it is critical to monitor body temperature on a regular basis. In COVID-19 patients, oxygen saturation is also important. The human body's typical oxygen saturation (SpO2) varies from 95 to 100 percent. If a COVID-19 patient's SpO2 (oxygen saturation) level falls below 95%, they require immediate medical attention. Silent hypoxia is caused due to the SARS-COV-2 coronavirus, which causes SpO2 levels to drop below 90% without causing shortness of breath. Monitoring SpO2 with a pulse oximeter can detect silent hypoxia [10, 11]. A COVID-19 patient's oxygen saturation level may be dangerously low, and the patient may die. It's critical to keep an eye on early signs including cough, fever, SpO2 and heart rate when dealing with COVID-19.

Various types of instruments have recently been employed to measure these variables. In most countries, A fingertip pulse oximeter, for example,is commercially available and monitors SpO2 and pulse rate . This is a high-end portable pulse oximeter that can measure heart rate and SpO2 . is also commercially available, however it costs around 299 $. A pulse oximeter worn on wrist can be used to assess heart rate and SPO2 and is available over the counter. This gadget, like the others described, does not include the temperature of body monitoring capabilities. The pulse oximeter worn on wrist is pricey, costing 179 USD. Thermometers in both analogue and the digital formats are available on the market , although the majority of them are prohibitively expensive . Devices described previously are not based in Iot. Some display values, but obtaining measurements from various equipment is time-consuming. As a result, it is impossible for a doctor in Bangladesh to collect updates from all of his or her patients at the same time. Rapidmonitoring of covid patients with significant symptoms is in high demand. Patients can now receive COVID-19 treatment from the comfort of their own homes, thanks to technological advancements . Patients with low saturation of oxygen, fever, and an increasing/falling pulse rate benefit from this system. The pulse rate of an individual is determined by their body size, age, emotional stability and heart health. Because a patient's rate of pulse and saturation of oxygen are linked, As level of oxygen drops, their heart rate rises. The Internet of Things based healthcare systems are real- time patient monitoring technology that has assisted healthcare business tremendously . From a research standpoint, IoT based smart health care devices have recently gotten a lot of interest. The studied literature [18] discusses the rise of smart healthcare monitoring systems in IoT setting. In this study, we employed an Android-based pulse-monitoring system with a SpO2 based sensor, a temperature based sensor, and heart rate based sensor. did not utilise the SpO2 measuring sensor, but the collected data was communicated via the internet. For asthma patients, proposed an IoT based lungs functioning monitoring device. that did not include temperature, SpO2, or pulse rate. Heart rate monitoring systems based on Arduino, Android, and microcontrollers have been proposed in . Only a hardware prototype was made for the system in , which is based on the clous computing and Arduino uno. However, there is no data from real- world testing. A monitoring system of heart rate based on a mobile application was exhibited in. In this system, pulse rate sensor were used to measure the pulse rate of patients, and the data was analysed using Arduino. The data from the measurements was sent to the Android app. The sensors used in the study was limited . Various wireless health monitoring system based on IOT have been presented by various authors. However, IoT based solutions for tracking the rate of heart, temperature, and the SpO2 in one device for patients of covid have apparently not yet been shown.

The primary purpose of this research is to develop and test a novel health monitoring system based on IOT covid patients that is based on pulse, body temperature, and oxygen saturation.

Through a mobile application, the device may display measured oxygen saturation level, human body temperature, and the pulse rate, allowing patient to seek the medical assistance even if doctor is physically available or not. A clinician will need the patient's rate of pulse and human temperature of body, to treat covid patient. Patients may inform clinicians about conditions of health by using our system proposed. Patients with COVID-19, as well as those with asthma and chronic obstructive pulmonary disease (COPD) , may benefit from the device. COPD was responsible for 5% of all fatalities globally in 2005, and it is expected to continue to be a global health concern in the future . As a result, this system may be beneficial to certain patients. The technology emits a buzz to inform the patient If the patient's rate of pulse and patient's saturation of oxygen are abnormal, seek medical attention immediately. The oxygen saturation level, heart rate, and body temperature may all be evaluated by patients. are abnormal, seek medical attention immediately. The oxygen saturation level, heart rate, and body temperature may all be evaluated by patients using a mobile application to avert critical health problems. This system was put to the test on five people. The data can be read by the patient and doctor at any time during the day making use of mobile app . The technology also has capability of measuring temperature of body , which has done never before.

2 Materials and Procedures

2.1 *Methodologies* To visualise the order of steps to be followed, a flow chart and block were utilised asguides.

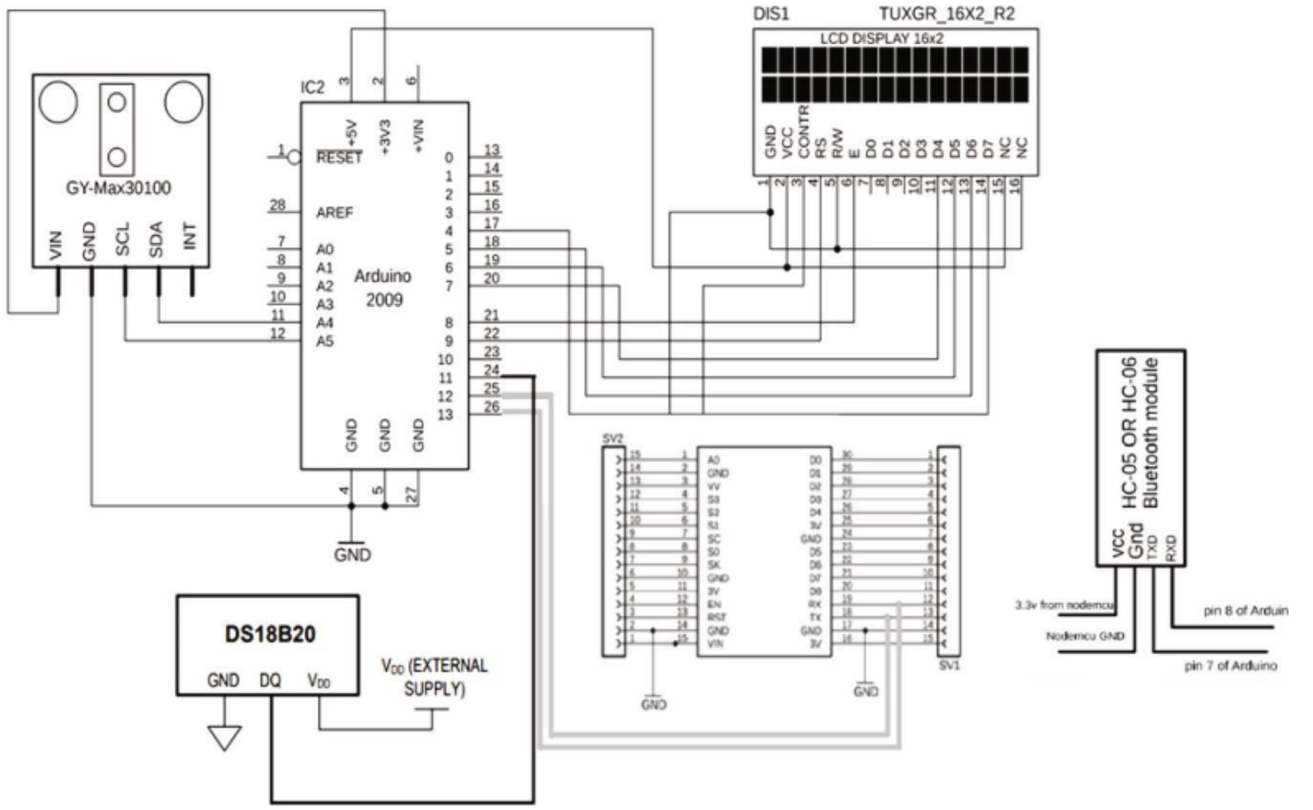


Figure 1: The system's block diagram.

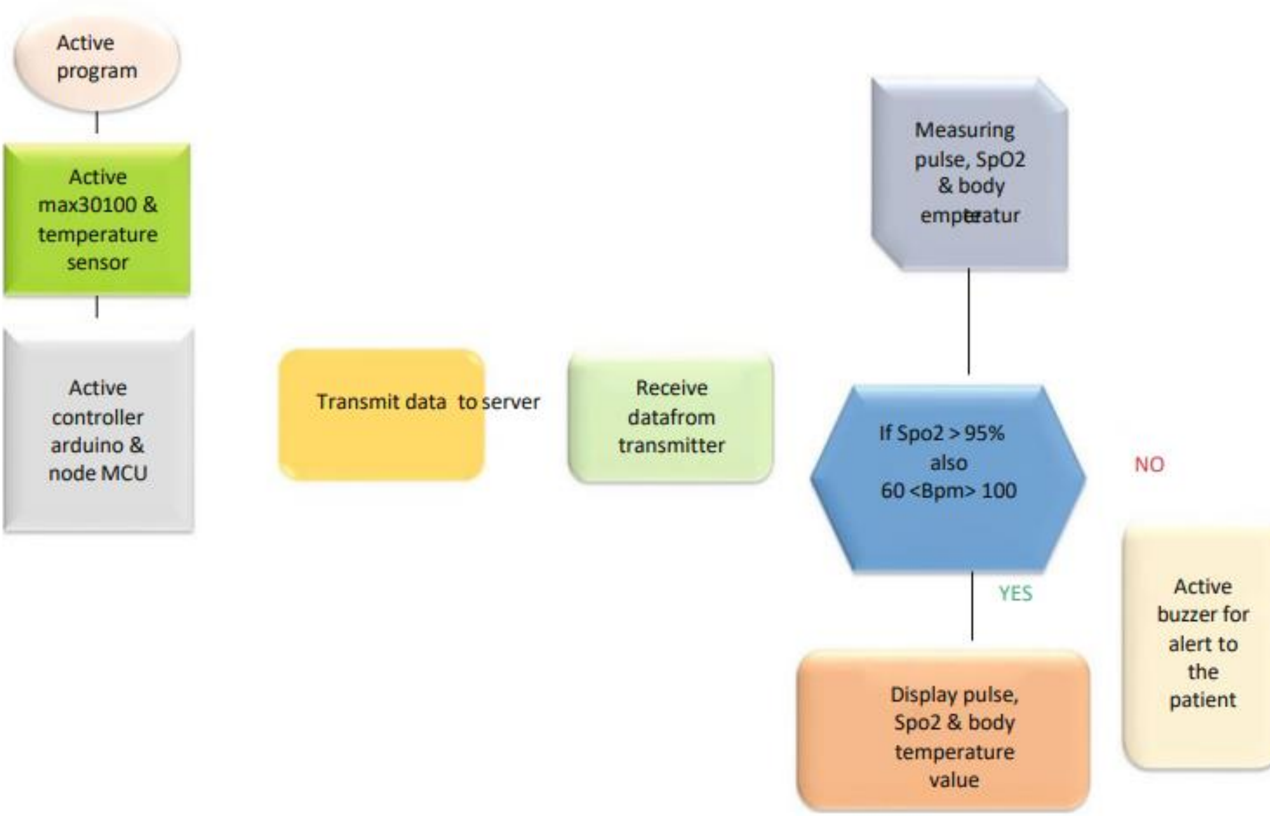


Figure 2: Flow chart of the system.

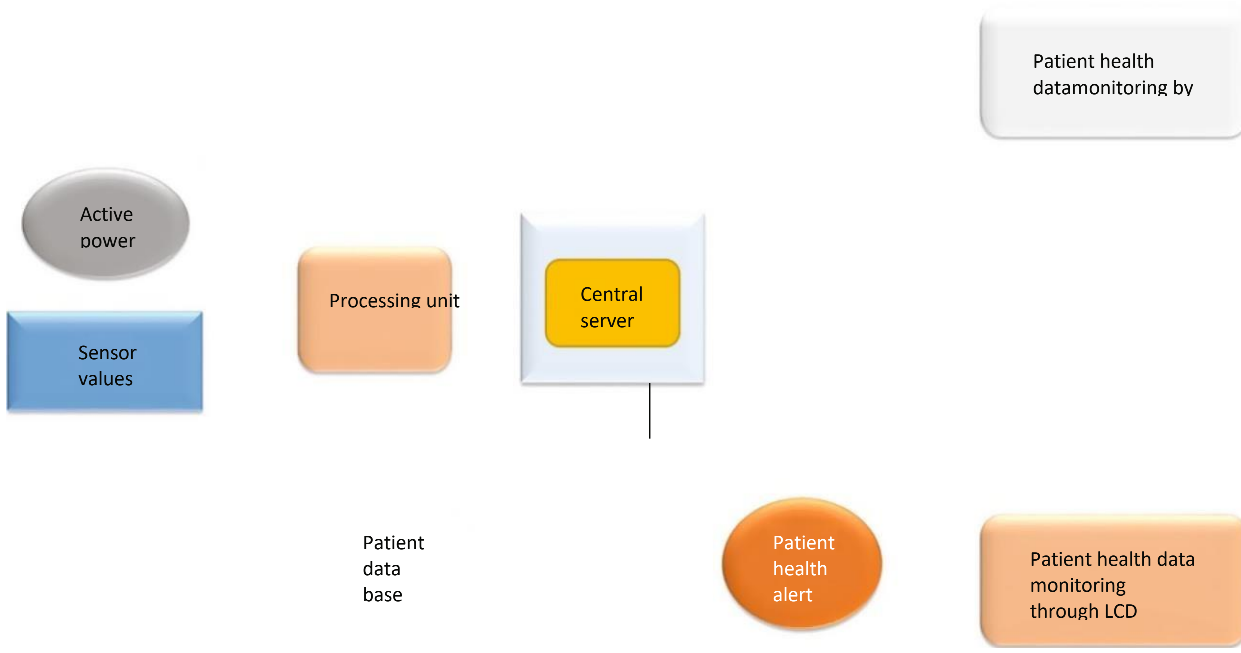


figure 3 : the circuit system's block diagram.

Table 1: A list of the hardware components that are necessary, as well as their amount and price..

Item description	Unit price	Quantity	Total price (BDTK)
Arduino Uno	420	1	420
Temperature	450	1	450
SpO2 Pulse	1400	1	1400
Node MCU WirelessModule	525	1	525
Bluetooth	280	1	280
16 × 2 LCD display	285	1	285
Buck converter	82	1	82
3.7 lithium battery	60	2	120
3.7 lithium batteryprotector	45	2	90
2 s lithium battery	1850	1	1850
2 s lithium battery protector	250	1	250
9 V 2A battery adapter	100	1	100
Wire set	120	2	240
Switch	10	1	10
Buzzer	18	1	18
Total			

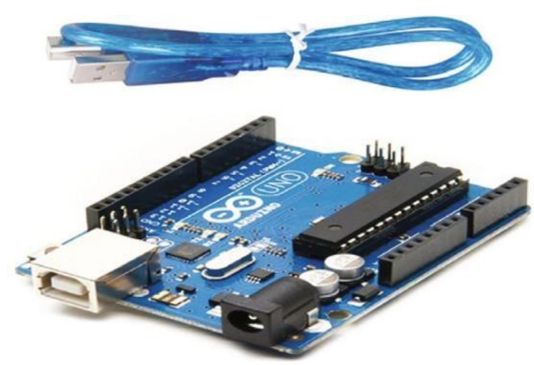


Figure 4: Arduino Uno [25]

Figure 5: Pulse Sensor (MAX30100) [27].

throughout the process of system management The cycle stream was established to direct critical times of any future actions from the start to the finish of a system. Electrical and electronic gears were planned, developed, and supported using circuit diagrams. These diagrams were extremely important for a well-developed system. The suggested system is depicted in Figure 1 as a block diagram.

The sensor begins taking values when the system's power is turned on, as shown in the system block diagram. There are two sensors for detecting pulse rate,temperature and SpO2 in this system. Sensors capture physiological data from the body and transmit analogue values to Arduino, which translates them to the digital values.

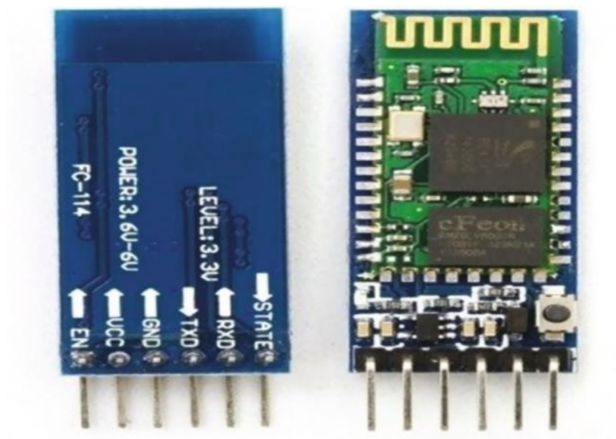


Figure 6: Bluetooth module .

digital data. The measured data is simultaneously delivered to the mobile application and shown on an LCD display by the server. Users can check their saturation of oxygen, temperature, and rate of pulse using the mobile app and gadget.

The system's flow chart is shown in Figure 2. When the device's power is turned on, It starts by taking measurements and sending them to the Arduino Uno, the primary controller, and the MCU Node. The value measured is sent to the server fixed via Node MCU. The system then display the recorded rate of pulse, temperature,and saturation of oxygen and if the detected saturation of oxygen is less than 95% and rate of pulse is less than 60 or greater than 90, system notifies the patient and doctor. Users may see measured values on the device LCD display and on a mobile app at the same time.

The block diagram of entire circuit system is shown in Figure 3. This figure shows pin connections b/w the Arduino Uno, the MCU node, the module of bluetooth, the sensor of SpO2, the sensor of temperature, and the system's supply of power. Proteus Design Suite software was used to create this circuit diagram. The fully automated system is turned on by pressing the active power button. The sensors collect data and transfer it to the processing unit, where it is analysed before being made available on the mobile application.

1.1 The Hardware Materials That Were Used The system is made up of two components: the equipments and a mobile application. Both components are essential to the system's operation. The system of health monitoring can detect saturation of oxygen , heart rate, and temperature of body in humans. The implementation of this multifunction system necessitates the use of various components. Implementation is accomplished by carrying out the tasks outlined in a work plan. The implementation of the design is critical to the system's success. The components needed to run this system are listed below in brief. Table 1 shows the hardware components that are necessary, as well as their quantities and prices. The hardware components for this system cost a total of 6120 Bangladeshi Taka, or 71.50 $.

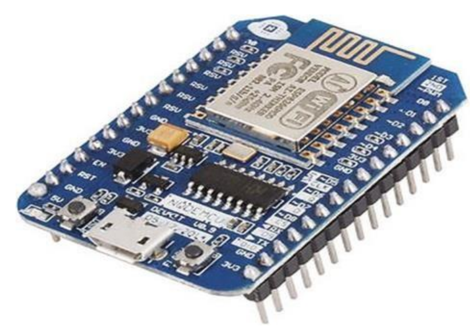


Figure 7: Node MCU ESP8266

Figure 8: Buck converter

1.1.1 Arduino Uno. The Arduino Uno, Arduino Mega, Arduino Due, and Arduino Leonardo are examples of commerciallyaccessible Arduino boards. 14 digital I/O pins 20 I/O pins, and six analogue I/O pins make up Arduino Uno. There are 54digital I/O pins, 12 analogue pins of input , and two analogue pins of output on Arduino Due. There are 54 pins of digital I/O ,16 analogue inputs, and 0 output pins on Arduino Mega.There are 20 pins of digital I/O , 12 analogue inputs, and 0 output pins on the Arduino Leonardo [26]. We used Arduino Uno to build system since the configuration of pin ofthis module meets our requirement and it is system's principal controller. It's one of the most well-known ATmega328p-based open-source microcontroller boards. The Arduino IDE can be used to programme this microcontroller. It is quite important in this system.

Figure 9: 16×2 Liquid crystal display.

Figure 10 : DS18B20 Sensor .

It serves as a link between IOT and other sensor devices. Figure 4 depicts Arduino Uno model.

1.1.2 Pulse Detection (MAX30100). The MAX30100 is sensor used to determine saturation of blood oxygen and rate of pulse. Prototype of SpO2 sensor of pulse is shown in Figure 5. (MAX30100). The amount of oxygenated haemoglobin in the circulation is measured by peripheral oxygen saturation , which is the measurement of blood vessel saturation of oxygen. SpO2 levels in human body typically vary from 90 to 100 percent. A MAX 30100 pulse oximeter is suitable for this setup. It's combination of a oximeter used for measuring beat and a sensor for heart rate that gives precise results. This sensor is suited for this system because it combines a photo detector, two LEDs, low-noise analogue and improved optics flag processing to recognise heart rate signals and beat oximetry .

Bluetooth Module 1.1.3 Commercially accessible Bluetooth modules come in a variety of shapes and sizes. Because it is user friendly, we chose HC05 module of bluetooth for our system. The Bluetooth HC05 module is a Bluetooth serial port protocol module that enables for both wireless and serial communication with Bluetooth-enabled devices with micro-controllers. The 2.45-GHz frequency band is used by the HCO5 Bluetooth module, which has range of 10 m. It has a rate of data transfer about 1 megabit per second. It can work with a 4–6 V power supply. There are two working modes for the HC05 Bluetooth module: data mode and command mode . The HC05 Blue-tooth module prototype is shown in Figure 6.

MCU Node 1.1.4 Because the ESP8266 is a wireless module, we use MCU ESP8266 node for this system.

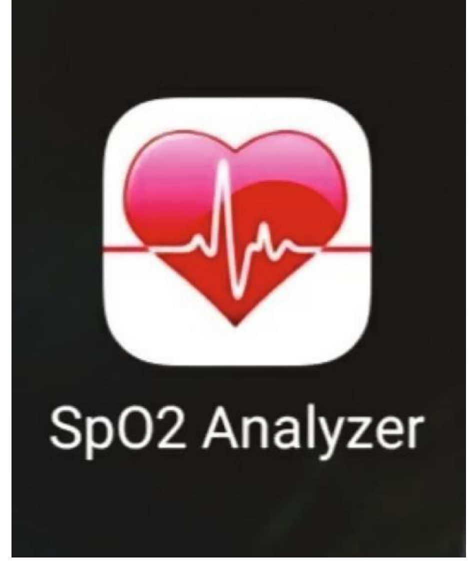


Figure 11: Mobile application logo.

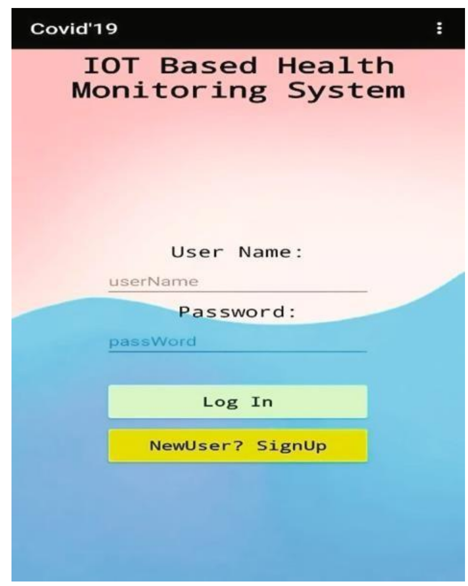
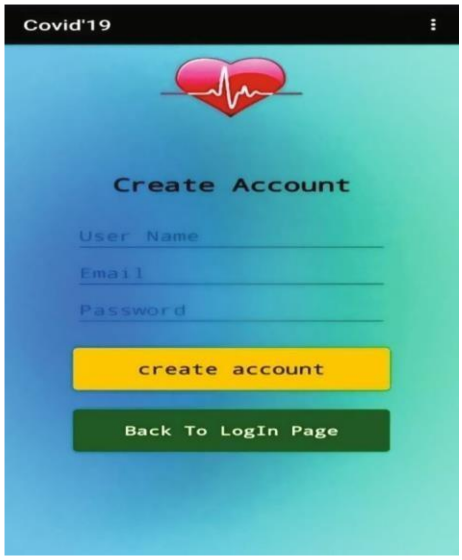


Figure 12: The mobile application's login interface.

Node MCU features wireless system that can communicate data to server, and microcontroller has Wi-Fi functionality. The Bluetooth module communicates with the MCU node via a module of asynchronous receiver- transmitter serial communication . The node MCU ESP8266 microcontroller requires a 3.3 V operating voltage and 7 V to 12 V input voltage to operate. It has 4 MB flash memory and a 64 KB SRAM. There are 16 digital input and output pins on the board, as well as one analogue input pin. A PCB antenna is also included with the node MCU .The detected pulse rate, oxygen saturation, and temperature are sent to the server via the node MCU wireless module. Because it connects the server's IP address to the MCU of the node, this component was chosen. allowing a mobile application to retrieve the measured value.



1.a

(b)

Figure 13: (a) Mobile application sign-up UI and (b) successful sign-up

The MCU node is advancement board and open source firmware based on Lua. It is designd particularly for Internet of Things (IoT) applications. and it's an important part of our system. Figure 7 depicts the node MCU ESP8266 microcontroller prototype.

Buck Converter (version 1.1.2). A buck converter is a common and straightforward DC to DC converter. Buck converters were utilised in the system since their voltage of otput is smaller than their voltage of input. This converter is used for efficient transformation control, which extends life of battery while reducing heat. Figure no 8 depicts a buck converter prototype.

1.1.3 LCD Display with 16 x 2 pixels. A 16×2 LCD is typical display module of alphanumeric LCD that can display letters as well as numbers. It has two rows and 16 columns and may be utilised in a wide range of applications. This monitor indicated the patient's oxygen saturation, heart rate, and temperature. Each character is represented by a 588 pixel matrix. The 16 2 LCD display's working voltage ranges from 4.7 to 5.3 V. When not lighted by a background, its current usage is 1 mA [33]. Figure 9 depicts a 16 2 LCD display prototype.

Sensor DS18B20, version 1.1.4 Figure 10 illustrates DS18B20 sensor, which uses the Technique of communicating using just one wire. Only the information pin requires a pull-up resistor to connect to the microcontroller, while the other two pins are used for control.. The pull-up resistor is used to retain the line in a high condition while transport is not in use. Temperature measurements are taken with this sensor. The temperature detected by the sensor will be missing from a 2-byte register inside the sensor.. By delivering them in a data arrangement, these data can be evaluated using the 1-wire technique. There are two different forms of

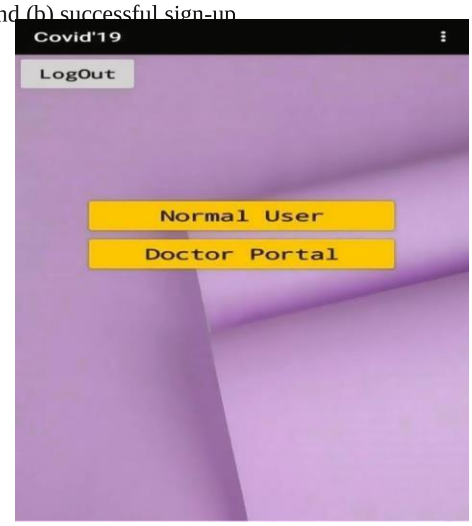


Figure 14: The mobile application's user portal interface.

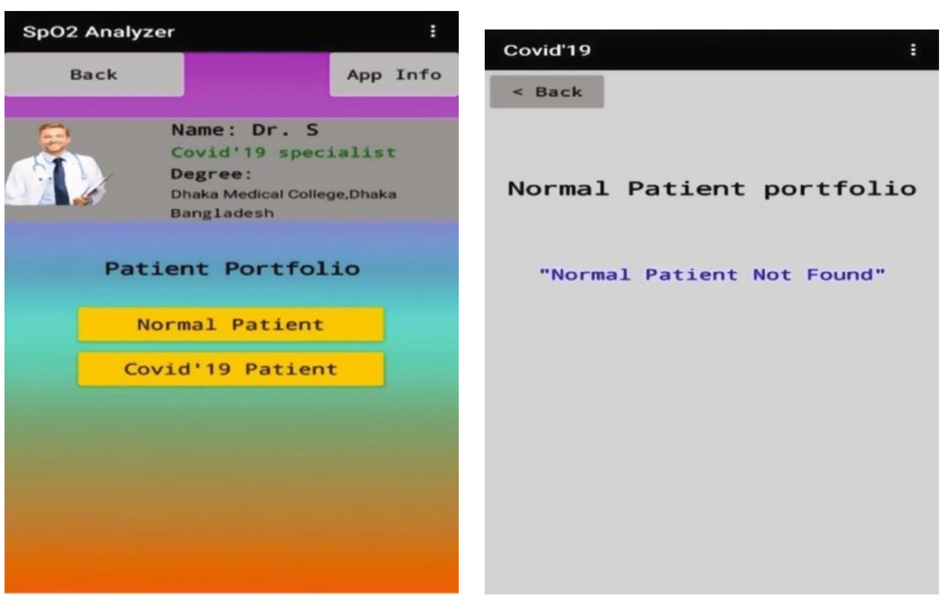
To evaluate the values, send two commands: one might be ROM command and other could be a functioning command .

Implementation of software (1.2). App Inventor from the MIT was used to construct the mobile application. MIT App Inventor is an online platform for student to create mobile apps. The MIT App Inventor allows system designers to create mobile apps for both iOS and Android. The data is stored on a Firebase backend server, which is used to create the mobile application. The languages utilised to create this application are Java and JavaScript [35].

1.2.1 User Interface for Mobile Applications There were nine different interfaces in the smartphone app. The interfaces are depicted in the diagrams below.

1.b (b)

Figure 15: (a) A typical mobile application user interface. (b) SpO2, pulse rate, and temperature were all measured.



(a) (b)

Figure 16: (a) The mobile application's doctor portal interface. (a) A typical patient portfolio for a mobile app.

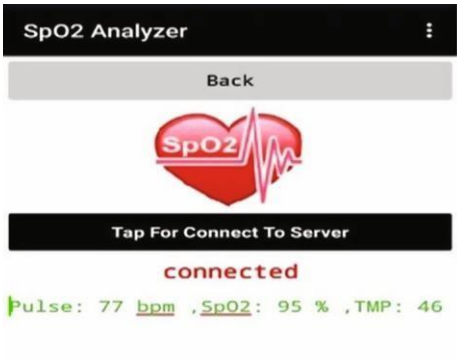
The SpO2 analyzer is a group of mobile applications. The mobile application's logo is seen in Figure 11.

Figure 12 depicts the mobile application's login interface. New users must do account creation, while existing users can log in with their password and username.

The mobile application's sign-up screen is depicted in Figure 13. Users can create an account by entering their email addresses, usernames, and passwords. After successfully signing up, the user data will be saved on cloud platform firebase, and the user will be presented with a new UI containing a login button. The user can log into mobile application by tapping login button.

The user portal interface is shown in Figure 14. This interface will show after you have successfully logged in. By pressing the normal button of user, the patient may view their measured data. By accessing the doctor portal, doctors may keep track of their patients' measured data. A "Logout"button is also available. By clicking logout button, users can exit the mobile application.

The standard user interface is depicted in Figure 15(a). This interface will appear when patient presses the regular user button. By pressing the check health condition button, the user may examine the measured pulse rate and oxygen saturation data in this interface. When the user presses the connect button on the tap,



SpO2, pulse rate, and temperature were all measured in Figure 17.

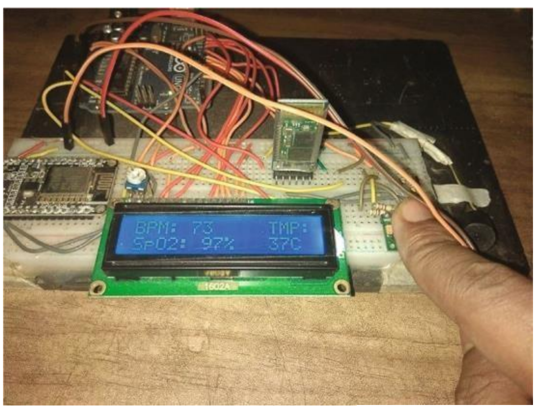


Figure 19 : Sytem’s Prototype

The button that controls the server. Using the server button, the mobile application will be connected to the device and display patient's measured saturation of oxygen, rate of pulse and temperature. Figure 15 depicts saturation of oxygen, rate of pulse, and temperature interaction (b).
The doctor portal interface is shown in figure 16(a). This screen will show if the doctor hits the doctor's portal button. By clicking on COVID patient and normal patient buttons, clinicians may compare the temperatures, SpO2, and pulse rates of normal and COVID-19 patients. A typical patient portfolio is shown in Figure 16(b). This interface will appear when user hits standard patient button. This interface will display a list of normal patients who are unaffected by COVID-19.
This interface will appear when the user clicks on portfolio of COVID paient (see Figure 17). Doctor can see the measured patient SpO2, temperature, and rate of pulse by pressing check patient button, as seen in Figure 17.

2 Results

The mobile application and the hardware are both components of the system. Both elements are necessary for the system to function, and both provide users with outcomes. The flow chart and circuit diagram in Figures 2 and 3 were used to construct this system. The system prototype can be seen in Figure 18. LCD display, The Arduino Uno, buzzer, pulse sensor, and temperature sensor are allpresent in this project.

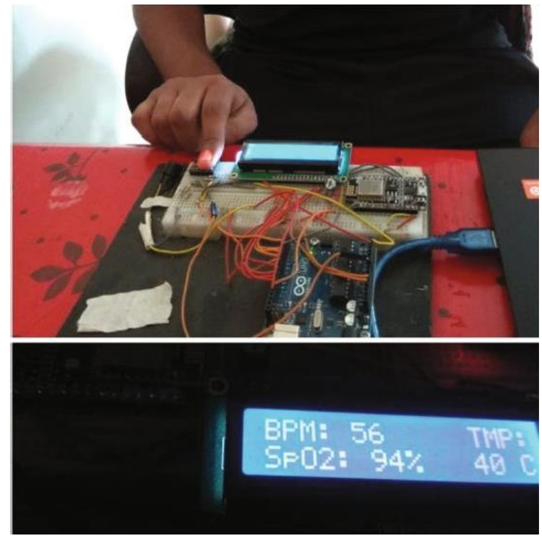


Figure 19: The user's perspective (device is testing for real human test subject).

Figure 20: In a mobile application, the user's value is measured.

The system was completed with the addition of a sensor of temperature , a MCU node, and a module of Bluetooth. The measured SpO2 level, rate of pulse, and temperature of body are displayed on system's display; if measured SpO2 and level of pulse rate fall out of range then the buzzer sounds. This prototype is straightforward and straightforward to use. Because it is a lightweight prototype, it may be readily transferred from one site to another. The overall outcome is good because all of the components are correctly positioned.

After inspecting the system separately, it was discovered that it functioned properly. This indicates that the project's system design and implementation procedures were correct, and that the user's data were accurately measured. There are two key aspects to the entire system. By selecting the COVID-19 patient and normal patient buttons, you may learn more about COVID-19.

On a real human, the system was put to the test. The user's experience, as well as the measured values of vital signs, are depicted in Figure 19. LCD and mobile device applications

TABLE 2: This system's pulse rate, SpO2, and temperature measurements for five distinct users.

Person	Age	SpO2 (%)	Pulse (bpm)	Temperature (C)
Person 01	25	97	75	37
Person 02	32	97	73	36
Person 03	34	93	70	40
Person 04	56	97	74	37
Person 05	23	97	75	40

show the user the observed heart rate, SpO2, and temperature, as well as the system's displayed results This system sends data to a mobile app, which is one of its most important components. Users can receive the desired results using this equipment and a mobile app; consequently, this method is convenient and user friendly and the system has performed admirably.

The user's SpO2, pulse rate, and temperature were all measured in Figure 20. It is a crucial interface for mobile apps because it displays the system's major findings. All of the sensors performed admirably.

This device was utilised by five people ranging in age from 23 to 56. It supplied exact values for all of the features featured in this system. Table 2 shows the measured values of saturation of oxygen level, temperatures and rate of pulse for each of five users. Most persons have a SpO2 level of 97, which is close to the typical norms, according to Table 2. The measured results for the different subjects' pulse rates were comparable. Different test individuals had different physiological data measured. All of the measured values were correct when compared to comparable commercially available equipment. This system is both dependable and user friendly, as seen in Table 1.

3 Conclusions

Thousands people died every single day as a result of the COVID19 pandemic, which has become a global health crisis. If effective therapy is given at the right time, the mortality rate can be reduced. To guarantee adequate therapy, a variety of measures have been taken, including regular pulse rate, SpO2 level, and temperature monitoring. However, a COVID-19 patient's oxygen level drops over time, and if no emergency measures are done, the patient will die quickly. In light of the foregoing, a COVID-19 patient-specific health monitoring system was based on internet of things was created. During an emergency, both the patient and the doctor can receive warnings from the system, which is powered by an IoT-based smartphone application. As a result, anyone can efficiently use this system wherever. Because the system is completely IOT based, furtherfunctionality can be added in the future.

Furthermore, this research entails a wide examination of the system's components as well as their utility. It provides list of methods that may be used to plan out this system. From the outset of this system's development, we set out to design a well organized application based gadget that canb be utilised in today's environment. pandemic. COVID 19 patients, as well as people with asthma and COPD , can utilise this device. The device is non invasive, cost effective, and adaptable, making it easier to monitor patients' health no matter where they are. It also sends real time alerts to concerned consumers and medical professionals about any situation that demands immediate attention. This system can help throughout Bangladesh. including in remote areas, resulting in a reduction in the number of

patients. Early detection of medical illness can assist the patient in taking important emergency steps that may save the patient's life. As a result, smart health monitoring systems are required to make all lives risk-free. To summarise, this system is critical in the medical field since it has the potential to help people live longer lives around the world. More sensors might be added to this system in the future to measure more physiological indicators in the human body.

Data Availability

These research findings were not based on any data.

Interest Conflicts

In this paper, the authors state that they have no competing interests to report.

Acknowledgments

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