Design of health monitoring system controlled by voice using internet of things (IOT)

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Abstract

The Internet of Things (IOT) is a system of networked objects that can communicate and gather data thanks to software, sensors, network connectivity, and electronic devices that allows the system to easily exchange the data. This work aims to collect the reading of essential health parameters like body temperature, blood oxygen, and pulse rate by using different biosensors. The complete system is on the Arduino UNO and NodeMCU. The system collects the various inputs provided by the sensors which work with the voice command and it sends the data to the concerned authorities by using the
Thingspeak platform and displays the data to the user on the LCD, the proposed system can be very useful for the nursing staff and doctors to monitor the health status of the individual. So, that better treatment can be provided to the patient. This can also help in improving health monitoring in rural parts of India.

Keywords: Internet of things, Thingspeak, Arduino UNO, NodeMCU**,** Biosensors,

Introduction

It has been observed that IOT has played a major role in improving the efficiencyof the healthcare sector.

Doctors are able to quickly analyze the person and start the treatment. During the coronavirus pandemic despite health, institutions were operating at their full potential many lost their lives because of the unavailability of sufficient trained staff who can operate the medical equipment. The spread of diseases like dengue in a particular area which increases the number of patients in a short duration of time. As a result, it limits the capabilities of health services. Health monitoring systems using IoT (Internet of Things) technology have emerged as a promising solution for monitoring the health of the individual and provide timely interventions when necessary. These systems use a combination of sensors, connectivity devices, and cloud-based platform to collect the data, store the data, and analyze the data collected.

The health monitoring system which is based on internet of things typically consists of sensors that measure different physiological parameters, such as heart rate, blood pressure, glucose level, oxygen saturation, and body temperature. These sensors are connected to a gateway device that collects data from the sensors and transmits it to a cloud-based platform. The platform stores the data and processes it using analytics algorithms to generate insights and alerts.

Healthcare providers can easily access the data from the thingspeak platform through a web-based portal or a mobile app. They can monitor patients' health status in real-time, track trends, and intervene when necessary. Patients can also access their data through the mobile app and take an active role in managing their health.

IoT-based health monitoring systems offer several benefits over traditional monitoring methods. They allow healthcare providers to monitor patients remotely, reducing the need for frequent in-person visits. This can save time and money for both patients and healthcare providers. IoT-based systems also enable early detection of health problems, leading to timely interventions and better outcomes.

In conclusion, health monitoring systems using IoT technology have the potential to revolutionize healthcare by enabling remote patient monitoring, early detection of health problems, and timely interventions. The technology is evolving continuously, more innovation can be expected from the field of IOT which further increases the efficiency of the health care sector by many fold.

Literature review

In this fast-paced, hectic world, many people struggle with health issues, yet it can be very challenging for them to frequently go for periodic check-ups due to their busy schedules and general laziness. In hospitals, nursing personnel is required to repeatedly collect readings of the same parameters. The field of IOT may hold one of the key solutions to this issue. These solutions have the potential to significantly reduce the number of patients who regularly visit hospitals for check-ups.

A device dubbed "Heart Monitor" was created by Alkareem Karajah and IsamIshaq[1] to assess a person's the critical parameter of the person such as his heart rate and the temperature of the body before sending the information to cloud services for storage. The concerned authorities can then quickly access the cloud service from anywhere at any time. A mobile alarm is sent if the heart rate value starts to fluctuate abnormally. A call is placed to the doctor and the concerned party, whose phone number is stored in the database if the aberrant reading is continually recorded for five consecutive occasions.

K. Manasa and S. China Venkateswarlu [2] created a gadget that measures the body's temperature, blood oxygen levels, heart rate, and humidity before sending the data to Thingspeak. A buzzer is turned on if the measured value exceeds a predetermined threshold. The patient may experience a vibration if the buzzer is inoperative. The physician can view the information from the Thingspeak platform and take the necessary action.

Biosensors are utilized in a device created by NaregalkarAkshay and G Vamsi Krishna [3] to monitor the parameters like heart rate of the individual, the pressure of blood, thebody temperature of the individual,

monitoring the oxygen during respiration, force of the handgrip, and volume of air in the lung. The electrical impulses are then transformed such that they may connect with an Arduino Mega 6250 which further can be sent to the computer. The obtained results in the form of bio signals are processed using asoftware called LabVIEW, and specifically created an algorithm to search for abnormalities. This data is then sent to the database of the hospital and a storage provider using LabVIEW's online publishing toolkit.

A gadget created by Pratik Kanani and Dr. MamtaPadole [4] allows medical staff to track a patient's precise position using GPS coordinates and transmit that information to a Thingspeak server.

An app called Carepro was created by Rohan Sarkar [5] and his team to remind patients of timely alerts for check-ups, regular medications, online medication purchases, the emergency doctor calls, and message services. Also, it gauges the patient's body temperature and numerous health factors including heart rate. The database contains the measured data and is continually updated. The primary benefit of this band is that it tells the appropriate authorities where the patient is. If the patient has a mental illness of any type, this function is quite helpful.

A nodeMCU, an Arduino, a sensor which measure the heart rate of the person, a temperature sensor, and a highdefinition camera were used to construct an interface by Taisir Hasan Abdulameer, Abdullahi Abdu IBRAHIM, and Alaa Hamid Mohammed [6]. The sensors directly record the temperature and heartbeat data. The highdefinition camera uses an image processing technique to identify the person's blood type. Doctors may access the data at any moment using a web-based application that uses PHP since it is continually saved.

After performing a survey on the senior population in Hong Kong in which they continuously measured the parameters like body weight, blood pressure, etc. at their center. Lisha Yu[7] and the team developed an app. The subject of the study was also given a health band so that they could monitor their heart rate, walking distance, and sleep. Based on these criteria, they created an app that allows clinicians to quickly access patient data, reducing the possibility of human mistakes during measurement and preventing time wastage. The software also offers users personalized recommendations based on their health.

Malcolm Clarke [8] has described the implementation of remote monitoring platform for personal health devices. It explains the optimization of standards for the devices which are small in sizebecause of which their processors can perform limited operatons, and a limit on thesize of the memory which also results in limiting the power. Abdul Qadir Javaid, Hazar Ashouri, SriniTridandapani, and Omer T. Inan [9] concluded that the BCG signals may be more accurately measured at home with unobtrusive and inexpensive hardware, such as a modified weighing scale, than with the most sophisticated ICG and ABP devices, which are expensive and intrusive for use at home. BCG signals are more closely related to blood flow than pressures.

A method that captures the behavior and activity patterns of the study subjects using embedded sensors in the surroundings was proposed by Marjorie Skubic, Rainer Dane Guevara, and Marilyn Rantz [10]. Pattern modifications were thought to be potential health indicators. The results were forwarded to the clinicians, who analyses the information and forwarded suggestions to the team conducting the field testing for improvement. Then, following the study's conclusion, it was discovered that implanted sensors in the environment assisted in the disease's early prevention.

Paul Raj Devadoss, Shan Ling Pan, and Shreyan Singh [11] examined the responses made to the Singaporean crisis from the standpoint of knowledge integration. This viewpoint has intriguing ramifications for HCIS.

Julie Barnett, Michelle Harricharan, Dave Fletcher, Becky Gilchrist, and Jane Coughlan [12] developed an app called myspace, which connects the patient and dietician face-to-face on mobile as well as PC. A thorough study was conducted on weight loss by the team and a study was also conducted on the psychological changes in the patient during weight loss. The psychological readings of the patients helped the dietician to give tailored diets to individual patients.

V. Baby Shalini [13] created a health monitoring system using data gathered from blood pressure and heart rate sensors that are managed by an Arduino board. The system is set up such that if the heart rate or blood pressure readings show unexpected changes, an SMS is sent to the doctor, and the GPS coordinates are also shared, allowing the appropriate authorities to quickly locate the patient and save their precious lives.

Vaishnavi Patil, Sanjay Singh Thakur, and Vaibhav Kshirsagar[14] developed a health monitoring system so that the data of the patient can be measured at every possible time. They used Arduino mega and ESP8266 WI-FI modules so that the collected data through the sensors can be shared through the cloud. Heartbeat, temperature, ECG, blood pressure, etc sensors were connected to the Arduino mega and the readings were displayed on LCD as well as things speak.

The health monitoring system that Pratiksha W. Digarse and Sanjaykumar L. Patil [15] devised measures the patients' biological data over 24 hours. The Arduino UNO was integrated with a heart rate sensor, a temperature sensor, and a salinity level sensor. A message is delivered to the relevant authorities if the data collection reveals any sort of abnormality.

P. Saleem Akram, Ramesha. M, Sai Aamani Sindhu Valiveti, Shaik Sohail, and K. Teja Samba Siva Rao [16] designed a system in which they integrated various health monitoring systems like Pulse monitoring sensor, ECG sensor, body temperature, WI-FI ESP8266 module, and GPS module was integrated with the Arduino. If the readings crossed a certain threshold then the data was sent to the doctor with the exact location of the patient and the current reading via SMS.

Shubha Majumder[17] and the team deployed a system in which they integrated blood pressure, heart rate, and body temperature and Bluetooth HC05 module with Arduino. So, that its data can be sent directly to the concerned authorities on the android mobile phone.

Nur HidayahBinti[18] and his team proposed a system in which they integrated a temperature sensor and heart rate sensor, and a GSM module to the Arduino such that the data is transferred to the ten numbers which are fed in the GSM.

The team of Ananda Mohon[19] developed a “Hospital management system” through which the caretaker of the patient can help the hospital administration to monitor the patient without the requirement of physical presence in the Hospital. Various sensors were attached, and the data of their readings were collected.

Niket Patil and Brijesh Iyer[20] deployed a system in which a Pulse rate sensor, body temperature sensor, oxygen level sensor, LCD, GPS, GSM module, and buzzer were integrated. If the value of any sensor crosses a certain mark, then the location of the patient and a short SMS is sent to the numbers fed in the module.

Methodology and model specifications

The idea is to develop a health monitoring system that takes the data from an Oximeter (MAX30100) to give the reading of heart rate and oxygen in hemoglobin, body temperature (MLX90614) to measure the body temperature, humidity, and room temperature by using DHT11 sensor. The sensors are integrated with the Arduino UNO. The LCD screen is also integrated with the Arduino to show the result of various health parameters. Bluetooth module HC05 is integrated with the Arduino to control the sensors by voice. The proposed system has four layers Controlling, Detecting, and Transporting the data, and the Application layer.

a. In the Controlling layer, the device has to be controlled. In the proposed system the voice of the user acts as the controller.
b. In the Detection layer, various parameters related to the patient are measured like body temperature, heart rate, and blood oxygen, and outside parameters like room temperature and humidity are also measured.
c. In Transporting layer, the process of sending the information to the cloud server is done. The information was transferred using NodeMCU by using its inbuilt Wi-Fi module. To access the information sent we have used an open cloud server called “Thingspeak”. In Thingspeak one has to create an account and a new channel has to be created with the name of the project and add the required number of fields to read the data from the sensors.
d. In the Application layer Information can be retrieved by using the Read API Keys.

BLOCK DIAGRAM

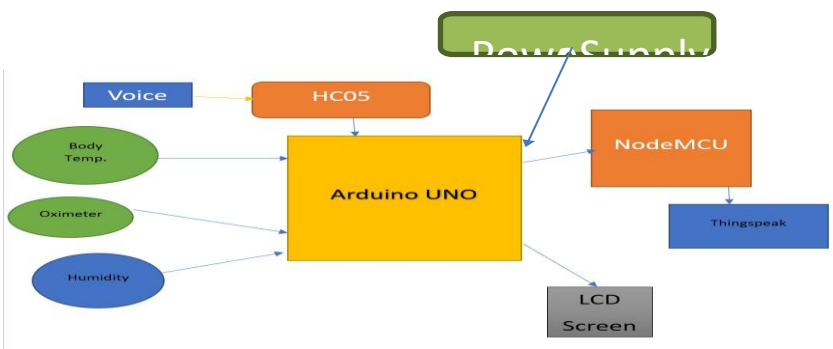

Figure 1: Block diagram of the proposed system

Figure 1 explains the block diagram of the proposed system. The system reads the input from the temperature sensor MLX90614, pulse oximeter (SPO2 sensor) MAX30102 sensor, DHT 11 humidity sensor. The data collection is controlled by a voice which is done by the HC05 Bluetooth module. Then Arduino receives the data and transfers the data to the NodeMCU. After receiving the data from the Arduino, NodeMCU sends the data to the Thingspeak cloud server because of the inbuilt wi-fi module in it which enables it to communicate directly. Then the data is also shown on the LCD screen for the user. In the end, a doctor can get the result at Thingspeak and the patient can get the result on the LCD screen.

Components Used

Arduino Uno

Figure 2 shows the Arduino Uno used to develop the model. Arduino can be used in the health monitoring system to collect and process data from sensors that measure various physiological parameters.

Specifications:

It uses Atmega328p microcontroller

It operates at 5V

Input voltage varies from (7-12) V

There are 14 digital input and output pins

There are 6 analog pins for various readings

Figure 2: Arduino UNO used in the system

NodeMCU

It is an open-source IOT platform based on ESP8266 wi-fi module. It uses Lua scripting language.

Specifications of NodeMCU are as follows

It is based on ESP8266, integrates GPIO, PWM, IIC, 1-Wire, and ADC

It includes USB-TTL

It is a low-cost microcontroller with wi-fi enabled in it

It is programmed with Arduino IDE

A health monitoring system, can be used to collect and transmit data to the central server. The system proposed by us uses it to transmit the data which it gets through from the Arduino and transmit it to the central server i.e., Thingspeak for further analysis and better outcomes.

Figure 3: NodeMCU used in the development of the system

Humidity and temperature sensor –

Sometimes the humidity and room temperature around the patients need to be monitored for their effective care, especially for respiratory health and diabetes management. For this purpose, the humidity and temperature sensor (DHT11) as shown in Figure 4 was introduced in the work. It is a sensor that measures the humidity and temperature around the patients.

It can be easily interfaced with Arduino. It has a temperature measuring range from 0-50 degree Celsius and 20-90 percent for humidity. The sensor measures with an accuracy of +/- 2 degree Celsius and +/- 5 percent when measuring the humidity. The data of DHT11 can be read after connecting it to the

microcontroller through its digital pins. To read the data of DHT11 its library needs to be installed in the Arduino IDE software.

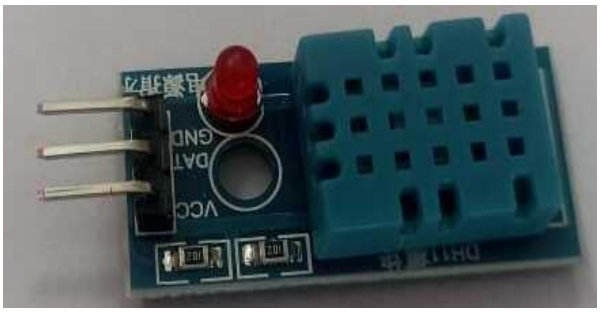

Figure 4:DHT11 sensor used in the model

- Pulse oximeter and heart rate sensor-

A pulse oximeter and heart rate sensor (MAX30100) as shown in Figure 5 is used in many health monitoring systems to measure the blood oxygen and heart rate of the person. It has two LEDs and one photodiode. The two LEDs emit lights that are monochromatic and infrared. The photodiode receives the intensity of light received after emitting the light. Based on this principle, it shows the reading of heart rate and blood oxygen. The red LED present is used to measure the heart rate of the patient and for measuring the blood oxygen both the LEDs are used.

To use the MAX30100 sensor, its Vin has to be connected with 3.3V and its SCL and SDA pin has to be connected so that it can read the data from the sensor.

Readings may vary because of variations in the movements of the finger placed or because of the color of the skin of the user.

Figure 5: Pulse oximeter sensor for measuring oxygen and heart rate

Sensor for measuring the body temperature-

The body temperature sensor (MLX90614) as shown in Figure 6 is a sensor used for the contactless reading of the temperature. It can be very effective in developing the health monitoring system because it can provide very accurate readings without coming into proper physical contact with the patient. The COVID 19 pandemic has already proven the importance of contactless systems. It uses infrared light to measure the temperature. It has a range between -70 to +380 degrees Celsius and because of its small form factor, it can be integrated very easily into the model. It communicates with the microcontroller by I2C interface. It works in the power range between (3.3-5) V. The SCL and SDA pins are connected to get the reading.

Figure 6

Bluetooth

Bluetooth (HC-05) as shown in Figure 7 is a commonly used Bluetooth module used in various IOT applications. It is an easy-touse Bluetooth module that allows two devices to communicate with each other via wireless technology. The module has 6 pins namely Key/En, state, Rx, Tx, Vcc, and GND. It has a variety of applications such as data transfer, audio transmission, and control as a remote. Here, we used it for the audio transmission so that it can be controlled by voice. It has a range of 10 m. It works between (3.3-5) V.

Figure 7:HC05 module

Jumper wires

These are simple electrical wires which are used to make the connections on the breadboard or PCB and sometimes direct connections are made. They are of three types male-to-male, male-tofemale, and female-to-female.

Figure 8: Jumper wires used in the model

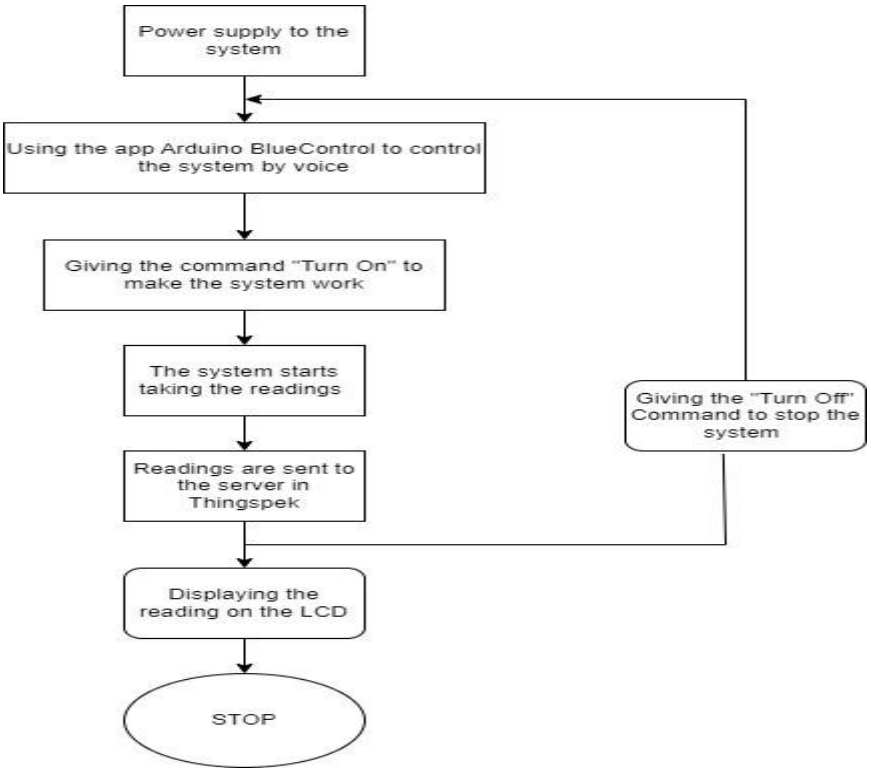

Figure 9: Flowchart

The flowchart in Figure 9 explains the working of the developed model. A 12V power supply is given to the system. Then, the system is connected to an app called

"Arduino BlueControl" to control the system by voice. Then the instruction "Turn On" is passed to the system to collect the readings of the patient. Then the system collects the readings and sends them to the server in Tingspeak and the readings are also displayed on the LCD screen. If the user wants to stop the process, then he/she can instruct "Turn Off" to stop the system from taking the readings.

Empirical results

Controlling by Voice

The module was controlled by voice by using the HC05 Bluetooth module. An app called Arduino BlueControl was used to provide the instruction for turning on and turning off the entire system. Figure 10 and 11 shows the control of the system voice.

Figure 10: It shows that the system is taking the reading through voice command

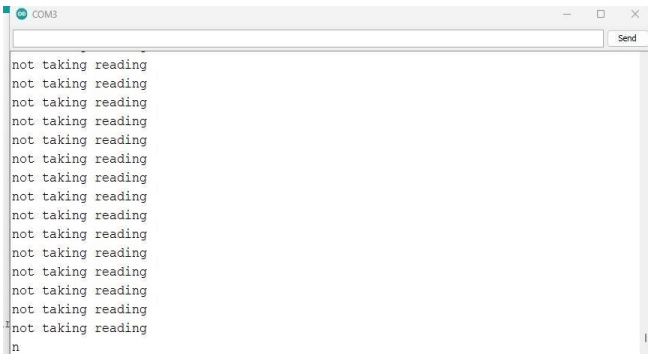

Figure 11: The system is not taking the by-voice command

Collection of Heartbeat Reading

The heart rate reading was collected by MAX30100(sp02) sensor. The readings were transferred to the cloud. The API keys were used to read the data. Figure 12, 13, and 14 shows the heart readings collected at various time intervals.

Figure 12: Heart rate reading on thingspeak

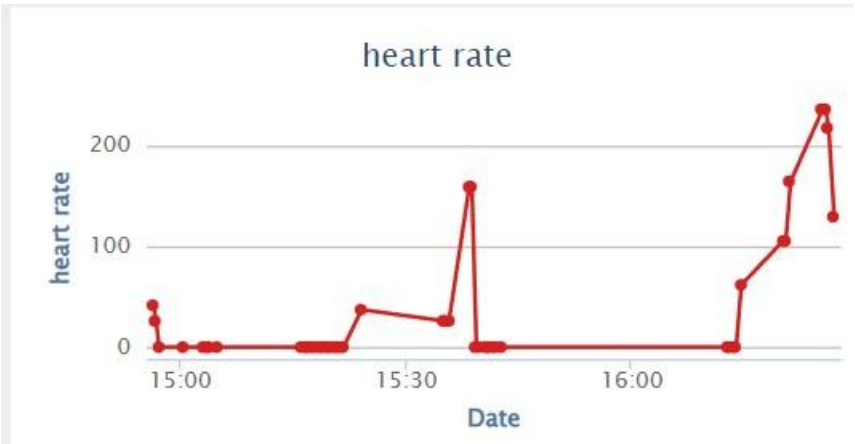

Figure 13: Heart rate reading on thingspeak

Figure 14: Heart rate reading on thingspeak

Collection of Humidity reading

The reading of humidity was collected by DHT11 sensor. The presence of Wi-Fi in NodeMcu makes it easier to send the data on the thingspeak and observe the outputs. The API key of the created channel was used to read the data. Figure 15, 16, 17, 18, and 19 shows the collection of humidity reading at different time intervals.

Figure 15: Reading of humidity on thingspeak

Figure 16: Reading of humidity on thingspeak

Figure 17: Reading of humidity on thingspeak

Figure 18: Reading of humidity on thingspeak

Figure 19: Reading of humidity on thingspeak

Collection of Temperature Reading

DHT11 sensor was used to obtain the humidity reading. The presence of Wi-Fi in NodeMcu makes it easier to send the data on the thingspeak and observe the outputs. The data were read using the created channel's API key. Figure 20,21,22,23 and 24 shows the reading of temperature collected at various instant of time.

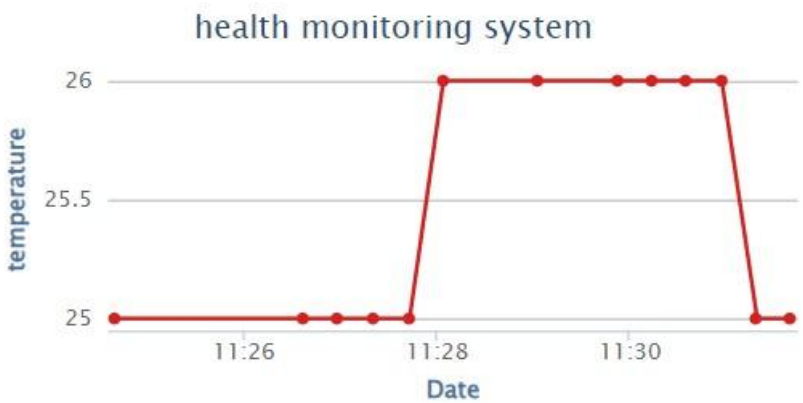

Figure 20: Reading of temperature on thingspeak

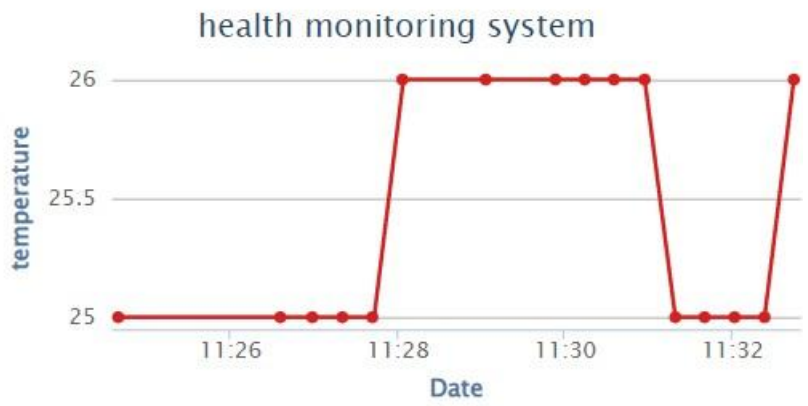

Figure 21: Reading of temperature on thingspeak

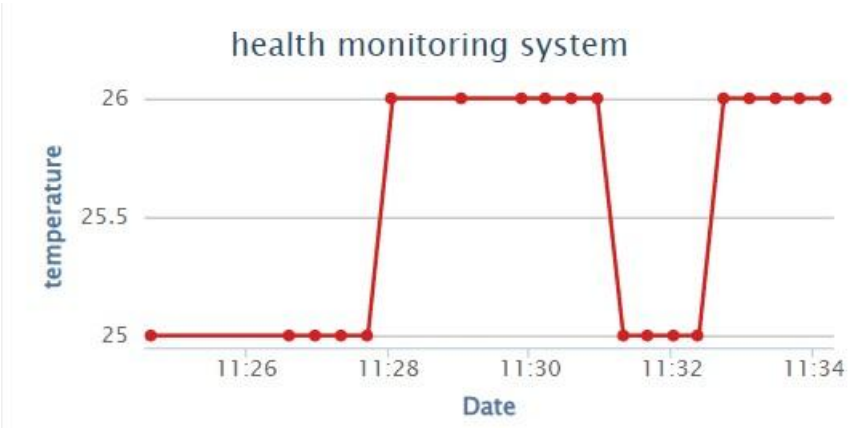

Figure 22: Reading of temperature on thingspeak

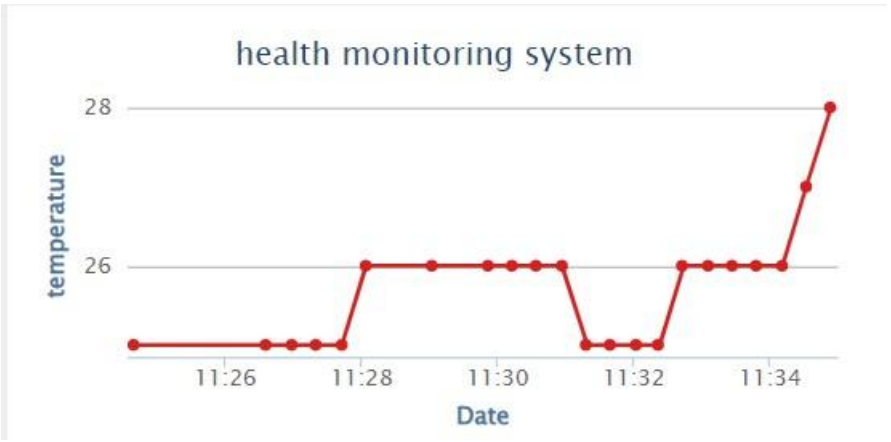

Figure 23: Reading of temperature on thingspeak

Figure 24: Reading of temperature on thingspeak

Collection of blood oxygen reading

MAX30100 sensor was used to collect the readings of oxygen in the blood. The sensor collects the data based on the emission of monochromatic infrared light. The presence of Wi-Fi in NodeMcu makes it easier to send the data on the server. The data were read using the created channel's API key. Figure 25,26 and 27 shows the collection of data in thingspeak cloud server.

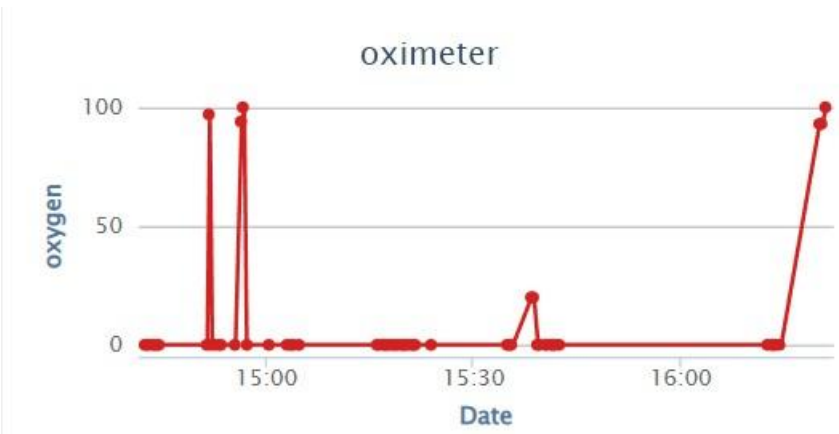

Figure 25: Reading of oxygen in blood on thingspeak

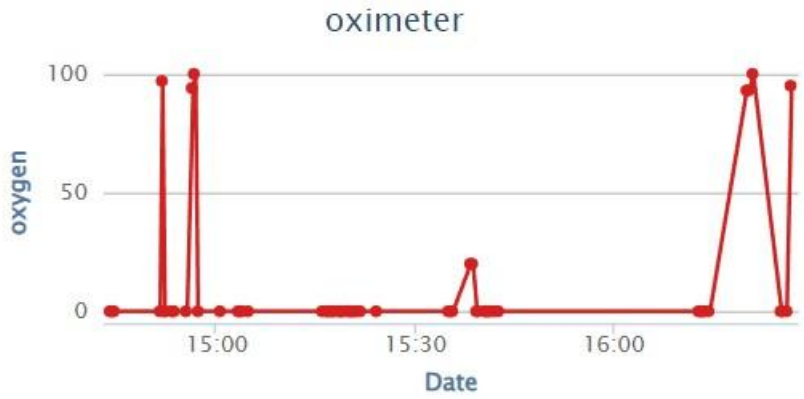

Figure 26: Reading of oxygen in blood on thingspeak

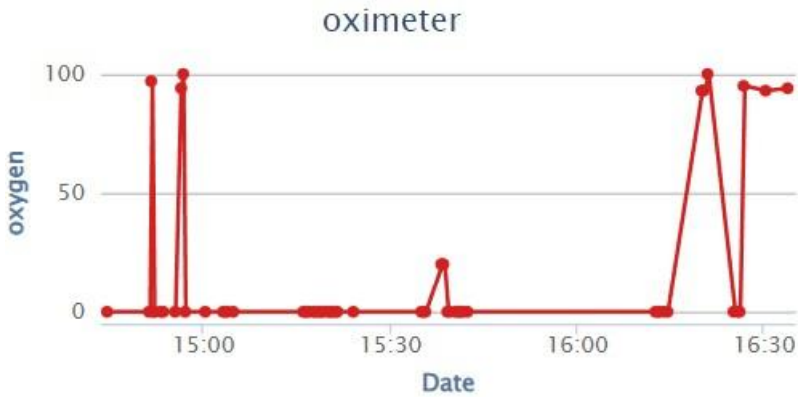

Figure 27: Reading of oxygen in blood on thingspeak

Conclusion

In this paper, we proposed the development of a health monitoring system that is controlled by voice by using the Internet of things. An efficient health monitoring system was deployed to examine the critical health parameters of the patients when there is an unavailability of the nursing staff. The projected method can be of great help in rural areas for the concerned authorities. The readings were sent efficiently to the doctors for monitoring purposes. The doctor can easily monitor the health status of the patient. The system can help drastically reduce the work pressure on the health staff when conditions like COVID-19 take

place. The proposed system is very user-friendly and cost-effective and can be of great help, especially to the elderly and rural people.

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