IoT-based Patient Vitals Monitoring System

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Abstract

Internet of Things (IoT) is a system of interrelated computing devices which are all connected to the internet, over the network. These devices have sensors which allow them to collect data and transfer over the network. In the modern industry, today, IoT is being implemented almost everywhere around us for better improved customer services & engagements, technical optimization, and faster workflow. Recent implementation of IoT in the health care sector is challenging but is still progressing because of the possible breakthroughs in sensors and data analysis, that it provides.

Since the last few years, we are seeing a big boom of technological innovations in the field of medicine. Be it hospitals or the pharmaceutical industry.

In this project, a patient vitals monitoring system integrated with various sensors has been developed. The purpose of system is to enable patients to monitor and track their vital parameters like temperature and heart rate. This data is sent to the cloud and the concerned doctor and the nearest relative of the patient can constantly track the patient. This system is useful for people who live away from their parents and also for soldiers who are based in remote locations where not many facilities are available.

Introduction-

The fundamental goal of the task was to plan a far-off medical services framework. It involves three primary parts. The initial segment being, discovery of patient's vitals utilizing sensors, second for sending information to distributed storage and the last part was giving the distinguished information to far off review. Distant survey of the information empowers a specialist or watchman to screen a patient's wellbeing progress away from clinic premises.

The sensors involved are – MAX30100 Pulse oximetry sensor giving use SpO2 and BPM values along with DS18B20 temperature sensor.

The microcontroller used is ESP32 NodeMCU.

Initially, the vitals are measured using the above following sensors. The data is uploaded on the analytics platform ThingSpeak and on the ESP webserver where this data is constantly available updated on the website where it can be accessed. In case of abnormality, certain notifications are also sent to the caregiver to get his/her attention to the patient immediately.

The data is analyzed constantly (for example- the number of times the heart rate exceeded the normal limit in a particular timeframe) and this analysis is available at all times.

Apart from the ESP webserver, the system has also been deployed onto the Firebase platform. The data, including temperature, SpO2 and BPM is displayed onto a website made from scratch using JavaScript.

The Firebase platform acts as a database which tracks the amount of data coming in along with providing analytics in association with Google.

Literature Survey-

In [1], the vitals of a patient are monitored using the microcontroller and displayed on an LCD. The data is then simply pasted onto a web server (wireless sensing node). Now this task has been performed using various microcontrollers and their performances have been compared. From their implementation, it is claimed that the Beaglebone performed the best in all departments. It is followed by the Raspberry Pi model A, then the Arduino UNO and finally the Intel Galileo. The result of ECG, BPM and temperature monitoring is computed in about a minute in this system. [2] Here the authors have created a similar system of wireless sensor networks wherein the service capability involves emergency response, outsource services and hospital services. [7] A total of 4 sensors are used in this system. For communication purposes between the sensors and gateway, LAN or Bluetooth or Powerline Communications can be used. To ensure message integrity, secure hash algorithm (SHA-1) is used. [3] The given IoT system made use of the measurement of oxygen saturation in the blood (SpO2) as the main medical parameter. [9] The use of authentication, authorization, and encrypted communication based on MQTT protocol and TLS Handshake Protocol caused that the connection was the operation that takes longer. It operates via Bluetooth. They also provided an analysis of the heart rate measurement made by the IoT system and the pattern instrument. From their analysed graphs, it can be seen that the results were quite comparable. As researched in [4], a smart, inexpensive, scalable, and efficient IoT-based cloud-assisted healthcare monitoring framework is developed. It provides remote monitoring of patient health status anytime, anywhere, and enables healthcare advisors to access, analyse, track, and monitor patient health status in a real-time manner. [5] In this paper Through a VR game, the viability of discreet and intelligent breathing training with biofeedback is demonstrated. Possibility on include adding sound effects and improving our game design also considered. Finally in paper [6] two non-absorber breathing systems—the Enclosed Afferent Reservoir (EAR) breathing system and the Bain breathing system—were. Here, trainee anaesthetists learn how to identify respiratory system issues using the capnogram's shape information. In [10], the authors outline a wearable sensor-based IoT-based healthcare monitoring device. A wearable component of the system tracks the patient's vital signs and transmits the information to a cloud-based platform for study. In [13] the writers suggest a wearable device and smartphone app-based IoT-based healthcare monitoring system for cardiac patients. Heart rate, blood pressure, and other vital indicators are continuously monitored by the system for the patient.

Methodology-

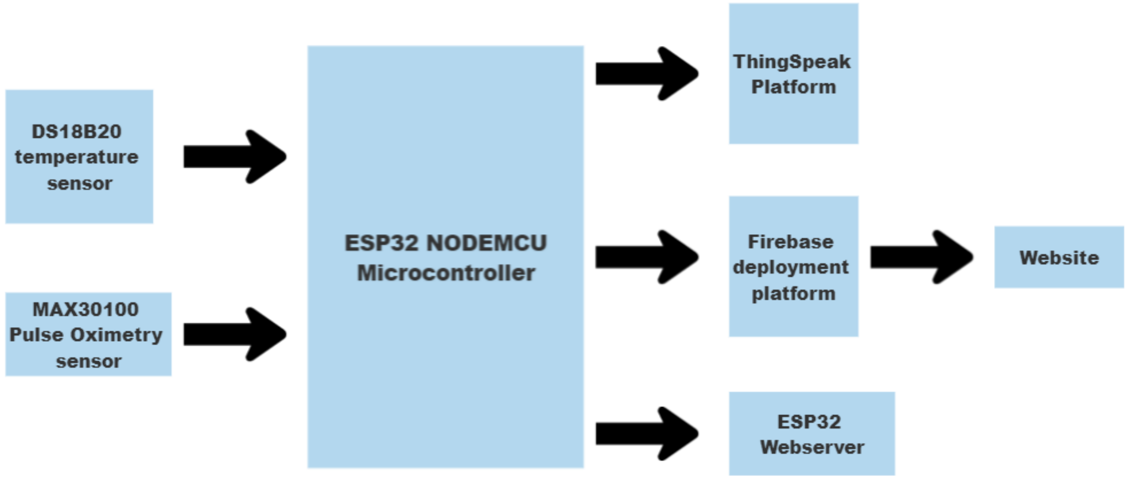

Fig. 1- Methodology flowchart

Working of MAX30100 pulse oximetry sensor- The sensor emits infrared light into the user's skin. Then, the amount of light reflected back by the user's blood vessels is then measured by the sensor. The sensor can then determine the user's heart rate and blood oxygen saturation level by examining the reflection's pattern. Now for accurate and dependable readings, the sensor employs a sophisticated algorithm to filter out background noise and other interference. To track a user's health and wellness, the MAX30100 sensor can be included into a variety of gadgets, including smartwatches, fitness trackers, and medical equipment. Overall, the MAX30100 sensor is a useful tool for both healthcare professionals and patients because it provides a non-invasive and practical approach to track crucial health data.

On sensing the values, the sensors will transfer it to the NodeMCU ESP32, the microcontroller which will collect the data and acts as WIFI module as well. The analytics platform used is ThingSpeak which will analyse the data based on specific parameters and give us certain outputs based on certain conditions. Apart from ThingSpeak, the other deployment platform used here is the Firebase platform of Google. The data will move to this platform in real time as well. In addition to the ESP32 inbuilt website, a new website has been built as well using the concepts of HTML, CSS and JavaScript. Hence the data, all in all, will be available on ThingSpeak and Firebase. Apart from this, the abnormalities can be monitored on the ESP web server as well as the deployed website that is created.

The NodeMCU ESP32 continuously transfers the pulse, heartbeat and temperature values to store it on the cloud. The Message Query Telemetry Transfer protocol is used here. The IP Address of the webserver used is 192.168.1.9. The data is constantly fed to this webserver where it is displayed. It can be used to get real time analysis of the parameters and monitors the vitals. In the cloud platform, there will be threshold values fed for each parameter. The HTML and CSS of the webserver was written within the IDE script using the inbuilt coding kits.

Now coming to the ThingSpeak platform for data analytics, using the write API key, the data from the sensor is updated onto the platform where it is stored and we can perform analytics and plot graphs. 3 field values are taken the graphs of all 3 are produced using the real time data. This makes it easier and more convenient to track the abnormalities in the fields. The 3 graphs are that of the Oxygen saturation level (SpO2), pulse level or beats per minute (BPM) and the third being the temperature.

The Firebase platform constantly tracks the amount of data coming in along with the values, which it forwards to the deployed platform.

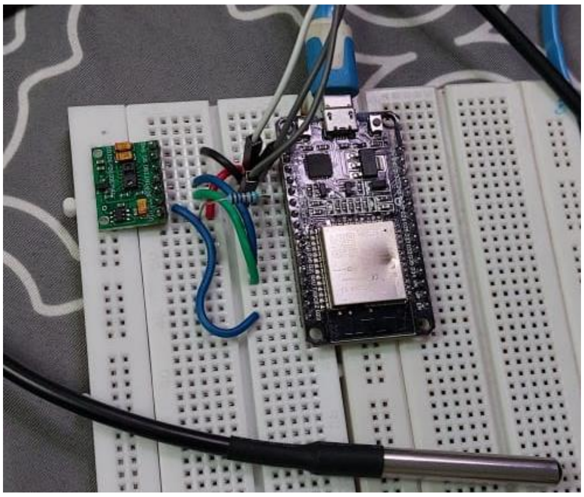

Fig. 2 – Hardware setup consisting of ESP32, MAX30100 and DS18B20 sensors

Results & Discussion-

Understanding Result Parameters-

SpO2- According to pulse oximetry, the normal oxygen saturation level falls between 95 and 100 percent. This indicates that a healthy person's blood has a high oxygen content. Thus, when the value drops down to below 95% levels is when the system would send an alert to the near ones of the patient and alert them.

BPM- At rest, the heart rate, or beats per minute (BPM), of an adult is usually within the normal range of 60 to 100 BPM. Above 130 is when the threshold is reached and the alert would go out.

Temperature- The DS18B20 temperature sensor measures the value in Celsius. A body fever in an adult is generally above the threshold value of about 37.8 degrees Celsius.

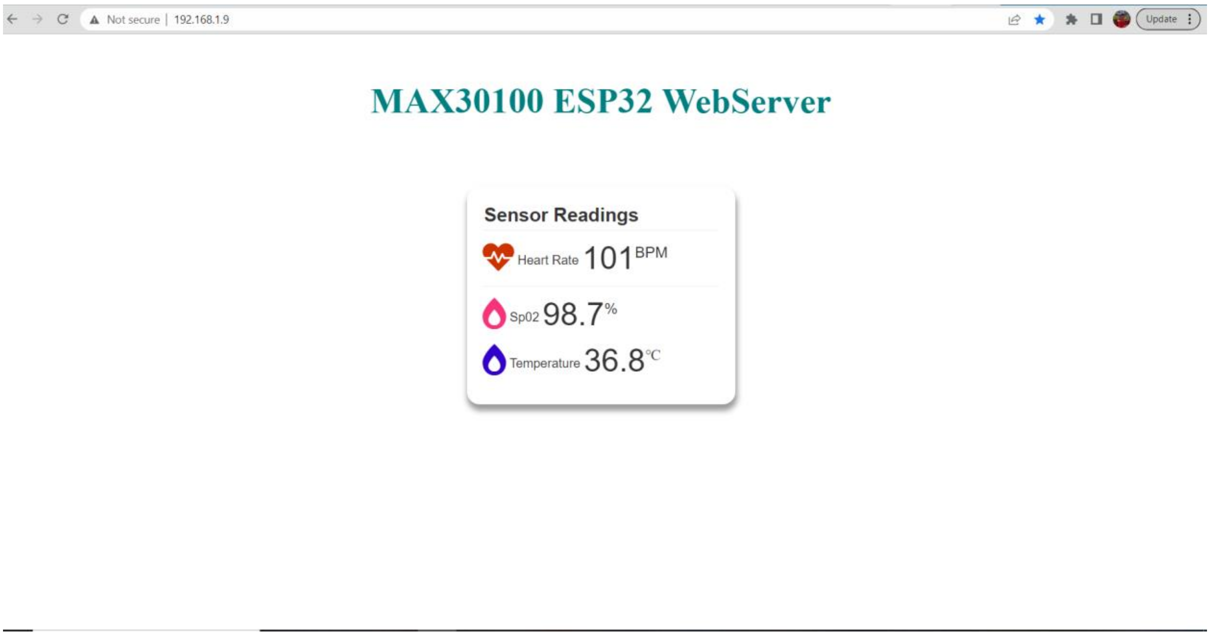

Fig. 3- ESP32 webserver display of readings

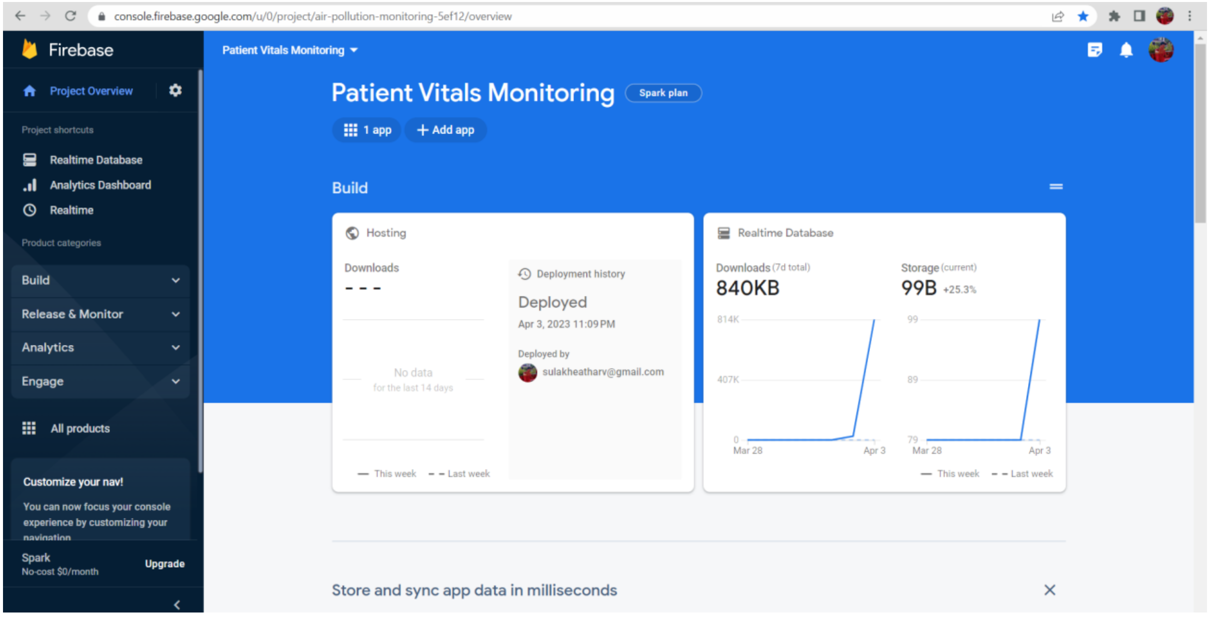

Fig. 4- Firebase dashboard

Fig. [4] shows the Firebase dashboard, wherein the deployment status of the system can be seen. In addition, the real-time database dashboard provides an overview of the amount of data uploaded along with storage information.

The figure below is that of the website created using JavaScript wherein the values from the Firebase are forwarded and displayed onto the screen in live time. Thus forms the monitoring platform as anyone with login access can log in to the website and track the vital parameters of the patient in real time remotely.

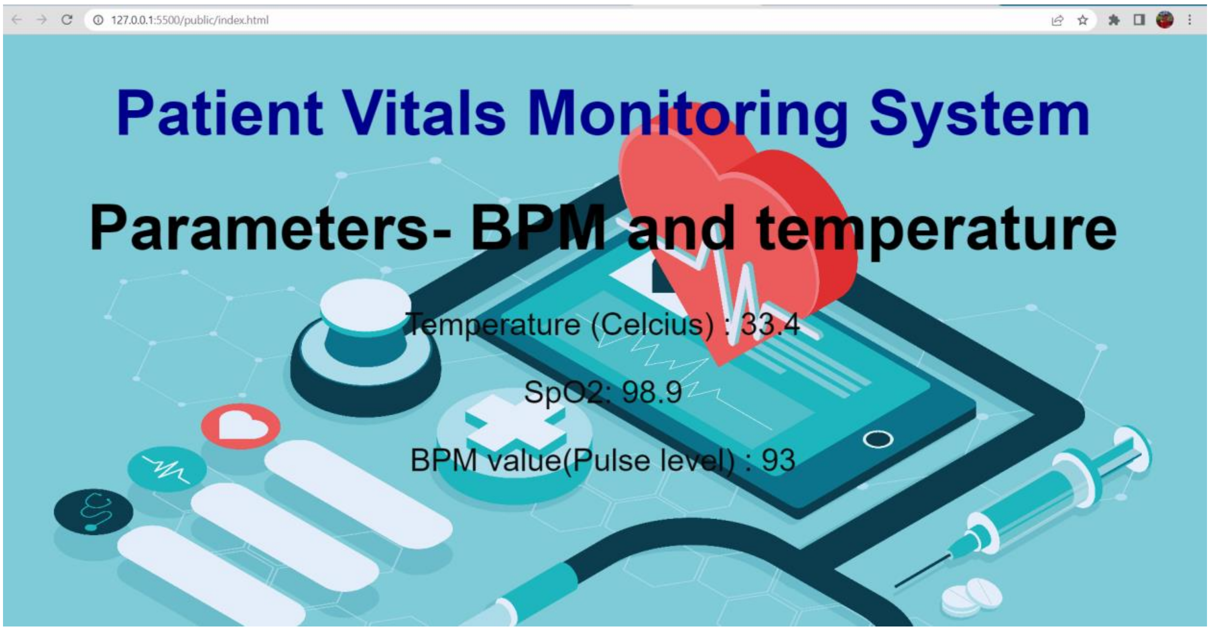

Fig. 5- Website created for real time monitoring

The figures given below show the ThingSpeak platform with the 3 fields.

Field 1- BPM

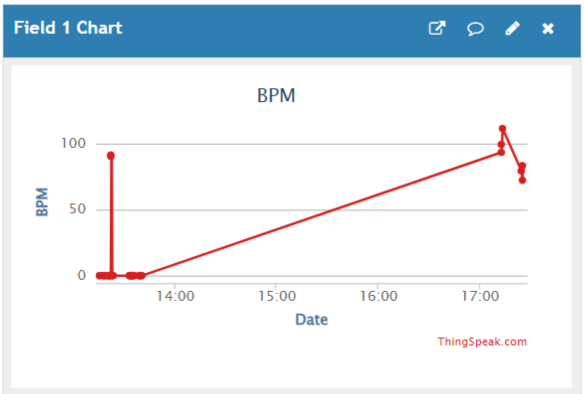

Fig. 6 shows the plot of the BPM data recorded through the pulse oximetry sensor

Field 2- SpO2

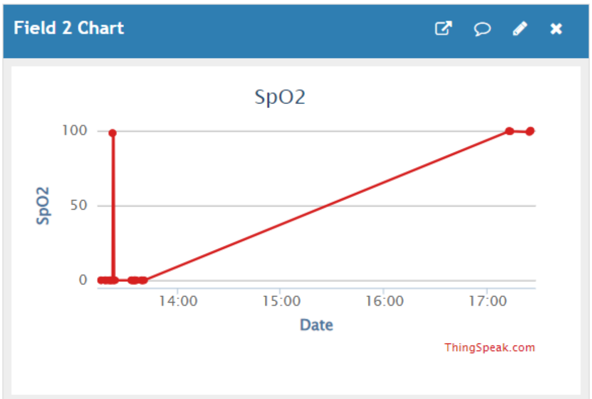

Fig. 7 shows the plot of the SpO2 data recorded. The values are recorded with healthy individuals and as known; the sensor accurately measures the oxygen saturation to be around 99%. Thus, the accuracy of the sensor can be verified.

Field 3- Temperature

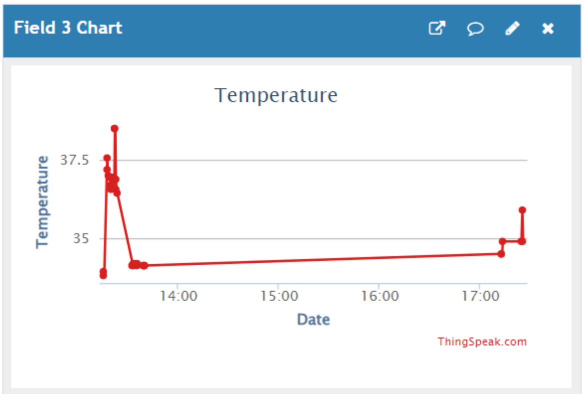

Fig. 8 shows the plot of the Temperature values recorded using the DS18B20

In [1], the LM35 sensor has been used for temperature sensing In reality, this module cannot be used on a patient and provides somewhat inaccurate results. Our system on the other hand uses the DS18B20 Temperature sensor which is more user friendly when it comes to practical use. The ECG sensor used here also provides just one value which is that of the pulse whereas in our system, we use the MAX30100 sensor which provides value of SpO2 or oxygen saturation in addition to the Beats per minute or BPM.

In [22], the paper shows the usage of the Raspberry Pi board as its main microprocessor. We use the ESP32 on the other hand. In the system used and developed here, ESP32 Wi-Fi module is used as it more convenient and easier to use. [22] also uses the database to store the values. They do not perform any analytics using any platform whereas we use the ThingSpeak website to store and plot the values. Along with this, our system also uses the Firebase platform as a database a website for monitoring.

In [20], the authors have provided a thorough process flow of collecting and analysing data obtained from the heart rate sensor. They use the Principle of Photoplethysmography to monitor the heart rate. The paper is mainly focused on analysing the real time data. In this system on the other hand, we use multiple sensors and monitor 3 fields, that is- SpO2, BPM and temperature.

In [10], the heartbeat and temperature values are monitored and printed in real time on the 16*2 LCD display. The authors have used the wireless Zigbee technology to transfer the data to the database whereas in our paper, we have used the webserver of the ESP Module to display the data fields. In [10], they also use the GSM module to provide SMS alerts to the near ones in case of abnormalities.

Conclusion-

In this paper, a system has been thus designed to monitor and analyse the vital parameters of patients including Oxygen saturation level, Beats per minute and temperature. The values are recorded using the necessary sensors following which they are wirelessly transmitted to 3 platforms. One is the ESP32 inbuilt webserver for display. Second being the ThingSpeak platform for data analytics and third being the Firebase deployment platform which acts as a database and also forwards the data onto the website that has been created using JavaScript. Hence, with a variety of softwares and sensors, a robust system has been developed which can easily help track abnormality in a patient's vitals and help relatives track the parameters and receive alerts regarding the health of their loved ones.

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