Health Monitoring of Critical Care Patients Using Internet of Things

Y. Sri Lalitha, Varagiri Shailaja, K. Swanthana, M. Trivedh, and B. Chaitanya Kumar

Abstract The Internet of Things is required for patient health monitoring. As many as 60% of human lives can be saved by detecting diseases at their earliest stages. The primary purpose of the device was to track vital signs in patients with a wide range of health conditions in real time. It is more appropriate to recognise the patient's status or health through the usage of GSM and IoT. Body temperature, coronary heart rate, eye movement, and oxygen saturation % can all be measured using sensors such as temperature, pulse metre, and blink sensors. The ESP32 microcontroller and the cloud computing idea are used in this system. The motion detection sensor is used to depict the coma patients' bodily movement. The patient's important factors are communicated to the legal individual's smart phones and laptops via a cloud server and GSM module. These recordings can be retained and evaluated for future comparisons and decisions.

Keywords Sensors · ESP32 · ThingSpeak · Health care · IoT monitoring system · Wearable devices

1 Introduction

Improved health is inextricably linked to a better quality of life. Many factors have contributed to the growing concern about the Global Health Issue, including: inadequate healthcare services, wide disparities between rural and urban areas, and a lack of doctors and caregivers at critical junctures. WHO defines health as "a condition of complete physical, mental, and social well-being, rather than the absence of diseases". Technology and medical research are merging at breakneck speed. As a result, medical professionals are utilising these technologies [1] to achieve that state. The Internet of Things (IoT) has arrived. Connecting things via sensors and a suitable platform is known as the Internet of Things. These microchips can be embedded in medical equipment. The data acquired by these microchips is then communicated via

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M2M. This is a more intelligent, flexible, and interoperable technique for monitoring any health concern that enhances therapy and responsiveness. This also aids in the tracking of data for each patient.

2 Literature Survey

In the field of medicine, IoT has been used to track patient health in several major ways. The works listed below are all relevant to this field.

According to the search scope, the microcontroller and gateway are used to upload data in IoT-based remote healthcare systems. There are two methods for storing data. One method is to store data in a Web-based database like MySQL or Google Firebase Database [2, 3].

In addition, a smart healthcare system dependent on the Internet of Things will be discussed, which will monitor the physical and environmental well-being of patients. This scheme's error proportion is within a particular range using sensors and the Internet [4].

Himadri et al. developed an alert system to notify loved ones if there is an issue with their loved one's health [4]. An IOT alert will be dispatched to the doctor if the system detects any variations in the patient's well-being that are not expected.

Heartbeat, SpO2, and eye blink sensors were used to measure a patient's heart rate, percentage of oxygen saturation (PO_2), body temperature, and eye movement, but no specific performance metrics were assigned to a patient. A prototype of Barger et al. smart's house facility, which use a sensor network to track and monitor the patient's movements at home, is now being tested. Their primary goal in their research is to discover if their system can outsmart behavioural patterns, which they have detailed in detail.

Lopes et al. [5] suggested an IoT framework for disabled individuals in order to research and uncover IoT innovations in the healthcare sector which benefits them as well as their community. In order to better understand the latest Internet of Things (IoT) technology and its applications, they examined two case studies.

Tamilselvi et al. [6] designed an Internet of Things health monitoring system that can measure basic symptoms including heart rate, oxygen saturation percentage, and body temperature. To capture the data from all of the sensors utilised in the experiment, an Arduino Uno was employed as a processing device. Despite the fact that it has been implemented, no precise performance measures for any of the patients have been defined.

Acharya et al. [7] proposed a healthcare monitoring kit [7] in the context of the Internet of Things. The system designed to keep tabs on vital signs like heart rate, ECG, body temperature, and respiration rate was able to keep track of these and other basic health indicators. An ECG sensor, a temperature sensor, a blood pressure sensor, and a Raspberry Pi are all present here. Using a Raspberry Pi, sensor data was gathered and processed before being sent back to the IoT network. The lack of data visualisation tools is the biggest problem with the system.

Banerjee et al. [8] proposed a non-invasive technique for detecting pulse rate. Real-time monitoring was achieved by using plethysmography and delivering results digitally. As with other intrusive therapies, the approach is safe for the patient. A smartphone-based heart rate monitoring system was developed by Gregoski et al. [9]. The technology tracked finger blood flow using a mobile light and camera and computed cardiac output based on blood flow. As a result of the system's development, people can now check their heart rate by merely by staring at their phones and receiving it wirelessly via a computer. As a beautiful concept, it is not possible to use this if continuous heart monitoring is necessary.

Mobile phone-based cardiovascular disease sensing was described by Oresko et al. [10] as a system that could be built if enough time and money were available. The prototype was only able to detect cardiovascular disease by monitoring heart rate in real time, rather than over a longer period of time.

An Arduino-based health factor controlling system controlled by a mobile device was proposed by Trivedi et al. [11]. The Arduino Uno board received the data from the analogue sensors. The built-in analogue to digital converter converts the collected analogue values into digital data. The physical characteristics of the gadget were transferred to it via Bluetooth. In order to use Bluetooth, the device had to rely on a small module.

Jennifers Raj et al. [12] established a model for developing a revolutionary information processing system in an IoT platform via a dependable healthcare monitoring system.

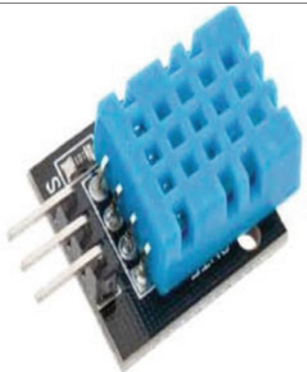
Proposed System: The major goal of this project is to develop a smart patient health monitoring system with a GSM module. Can we send an alert to the care taker or concerned doctor automatically, on the developing abnormal conditions of the patient, when the care taker is not near by the patient. Build an efficient system using low-cost sensors and record the sensor reading of the patient periodically in cloud for further analysis.

3 System Design

The IoT system makes use of the hardware components of some form. Table 1 describes the components that were used to create the proposed system.

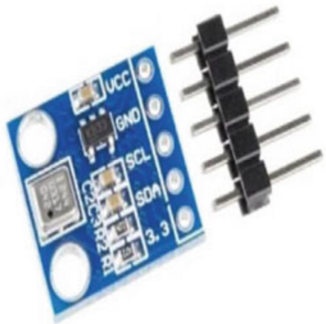
The project's primary goal is to develop and implement a patient health tracking system. The IoT sensor board for critical care of patients is shown in Fig. 1. Temperature, mobility, pulse monitoring, and eye blink are all sensed by the sensors inserted in the patient. These sensors are linked to a control unit that adds up the results from all four sensors. These determined values are then sent via the Internet of Things to the base station (IoT). The values from the base station can then be accessed by the doctor from any place. The patient's condition can be diagnosed and treated based on the patient's temperature, heart rate, and room sensor data. The kit can also be used at homes and can be embedded in the rooms of the patients who need constant monitoring. If the condition of the patient turns out to be abnormal, then the family

Table 1 System components

S. No.	Name	Image	Description
1	*ESP32 Processor*		One of the best-designed microcontrollers on the market today has an array of features that make it ideal for use in a wide range of applications. Sensors and controls can be connected to the ESP32's GPIO pins. Healthcare delivery could be transformed by ESP32 and the Internet of Things (IoT)
2	*Temperature sensor (DHT11)*		The DHT11 temperature and humidity sensor is widely used. Serial processing of temperature and humidity measurements is accomplished using an 8-bit CPU and a non-volatile memory (NVRAM). As a result, other microcontrollers can easily be connected to the sensor

(continued)

Table 1 (continued)

S. No.	Name	Image	Description
3	*Pulse monitoring sensor*		The heartbeat sensor was created using the plethysmography principle. Blood volume changes in any organ cause changes in the light intensity, which can be detected using this technique Pulse timing is critical in systems that monitor heart rate
4	*Motion sensor*		Any security system would be incomplete without motion detectors. When a motion sensor detects movement, it notifies your security system and, in some situations, your phone

(continued)

Table 1 (continued)

S. No.	Name	Image	Description
5	*Eye blink sensor*		In this eye blink sensor, infrared is employed to detect the eye blink. The variance throughout the eye will fluctuate when the eye blinks. There is a difference in output between blinks when the eye is closed and open

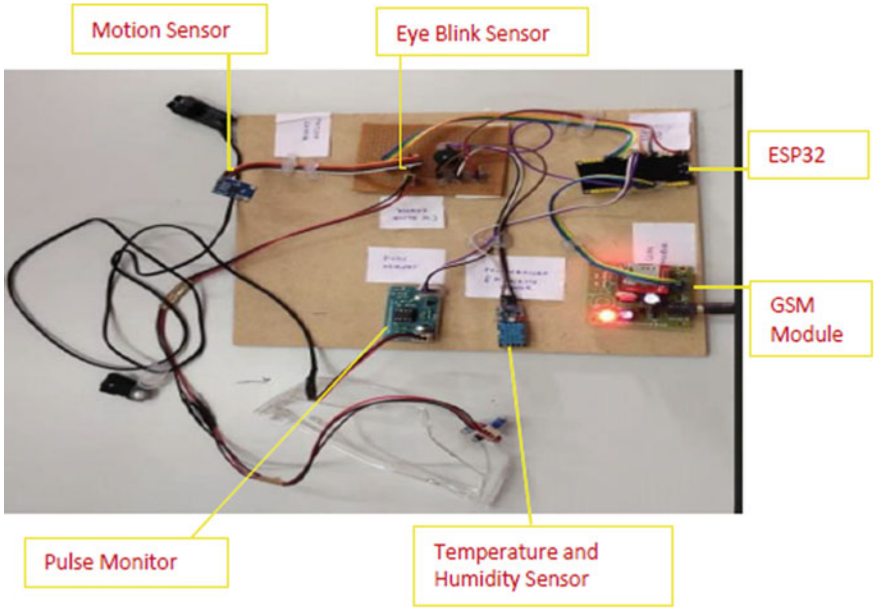


Fig. 1 IoT sensor board for critical care of patients

members of the patient will be informed immediately regarding the patient's health through a mobile message using GSM technology.

For all of the sensors and devices, ESP-32 serves as the main processing unit, which is connected to the sensors and devices via the ESP32. In order to retrieve data, perform analysis, and upload it to the cloud via a Wi-Fi module, the sensors are connected and controlled by an ESP32.

4 Methodology

The proposed system's fundamental premise is to continuously monitor the patient's condition. As a result, the healthcare monitoring system's three-stage architectural features are utilised, namely (1) sensor module, (2) sensor readings are relayed to the cloud server, (3) the buzzer sounds an alert to the user.

The sensors are wired and collect data from the patient's body using physiological indicators. The data is processed using an ESP32 module before being transmitted to the cloud server. ThingSpeak is used to provide a visual representation of data in an online user interface. The current status and procedure of transactions are displayed in ThingSpeak. Wi-Fi modules and Web servers can communicate more easily thanks to the HTTP protocol. With a refresh rate of every 15 s, the HTML user interface allows for real-time monitoring of patients. System architecture is depicted in Fig. 2, which shows how all of the sensors are used to gather information.

All of the sensors are connected to an ESP32 processor unit, which processes the data. The ESP32 serves as the system's beating heart when these sensors (temperature, pulse, eye blink, and motion) are connected. Sensor data is collected by the ESP32 and wirelessly transmitted to a cloud server. Intel's LX6 dual-core processor powers the board's Wi-Fi and processing. IoT portal is then linked to the sensor's output.

It is accessible to any network-enabled devices. The information can be viewed visually using a channel-based system that requires a password each time it is accessed.

Various hardware components are employed to implement the system. The hardware components are assembled during this phase. Figure 3 depicts the development

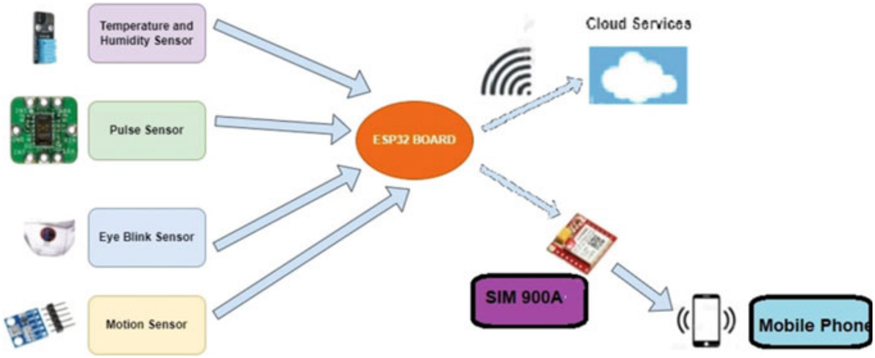


Fig. 2 Illustration of proposed model

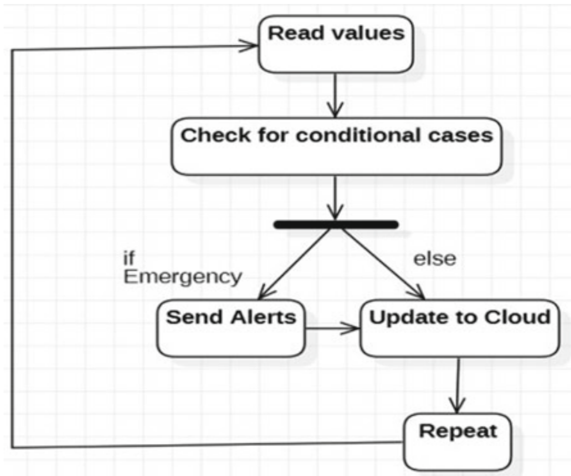


Fig. 3 Proposed system flow

process of the system. Sensors are connected to the ESP32 using physical pins. With its integrated Wi-Fi module, the ESP32 is used to process data. In order to connect all of the sensors, the ESP32's Vcc and GND pins are used. The ESP32's D26 pin is connected to the heartbeat sensor's signal pin. The LM35's data pin is mapped using the microcontroller's D35 pin (ESP32). With a specific patient, this is the case. Data from the DHT11 sensor is sent to the ESP32's D14 pin for room temperature monitoring. In this setup, the DHT11 is only used to monitor the room's humidity. The MQ-9 and MQ-135 each have two digital out pins that are connected to the ESP32's D27 and D34.

In this application, the user function is the one that uploads data to the ThingSpeak cloud and delivers text notifications using the GSM module.

The text messages are sent through GSM module to the patient's caretaker's phone.

The system continuously reads the raw data from the sensors, and in the code, we have defined critical cases with respect to every sensor and parameter. The data is validated with the conditions if any critical situation found the system sends the alert messages and also updates to the ThingSpeak cloud and this process repeats in a loop, which makes the system autonomous and flexible.

5 Results

5.1 Results in Serial Monitor Window

The result observed after uploading the program onto ESP-32 microcontroller (Fig. 4).

Fig. 4 Output viewed in serial monitor

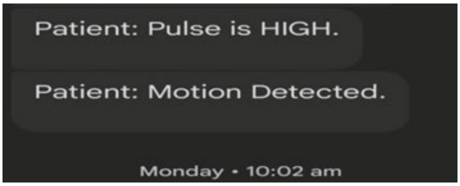


Fig. 5 View of alert in mobile

5.2 *Text Messages Viewed in Mobile*

These are the messages received by the caretaker's mobile. The format is quite similar to the typical mobile SMS and our system exclusively defines which parameter is in critical condition, which makes diagnosis much more easier (Fig. 5).

5.3 *Captured Readings in CSV*

One of the key feature of ThingSpeak cloud is that we can retrieve all the uploaded data in csv file format; the table as shown has all values of the respective parameter with respect to time, which will be very helpful in further advancements such as creating a specific health profile for every patient and also to create ML models to predict future complications, etc. (Table 2).

Table 2 Captured readings in CSV

Created_a	Entry_id	Temperature	Pulse	Motion
2021-11-1	7	25	74	204
2021-11-1	8	25	74	204
2021-11-1	9	25	74	204
2021-11-1	10	25	74	204
2021-11-1	11	25	74	204
2021-11-1	12	25	74	204
2021-11-1	13	25	74	204
2021-11-1	14	25	74	702
2021-11-1	15	25	74	354
2021-11-1	16	25	74	300
2021-11-1	17	25	74	534
2021-11-1	18	0	0	96

5.4 Data Analytics in ThingSpeak Cloud

As we update the sensors data to the ThingSpeak cloud, the respective sensor's data is plotted with respect to the time. These plots reveal the prominent findings such as the responsiveness of those parameters at particular time of day and many more insights (Fig. 6).

6 Conclusions

It is no longer a secret that the Internet of Things (IoT) is a useful tool for tracking remote values, especially in the healthcare industry. In recent days, monitoring a patient became tough for doctors and patient family too. This IOT-based monitoring system helps to monitor the patient health conditions at all times and send notifications via wireless communication system. It also enables the secure cloud storing of individual prosperity parameter data, as well as the remote monitoring of health and disease diagnosis by any doctor. This paper developed an IoT-based health monitoring system.

In this, we use GSM module, microcontroller esp32, heartbeat sensor, accelerometer, eye blink sensor, oximeter, buzzer sensors, and LCDs are used to measure and display body temperature, pulse rate, humidity, and temperature in the surrounding environment. A medical server receives the sensor values wirelessly. These data are then sent to a smartphone using an IoT platform owned by a designated user. The doctor makes a diagnosis and assesses the patient's overall health based on the test results. There are various system constraints, such as Internet connectivity and data storage.

Fig. 6 Analytics in ThingSpeak cloud

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