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IoT Based Health Monitoring System

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ABSTRACT

In recent times, there has been a lot of diseases arising day by day as a result of which people have become much concerned about their health. Thus, it has become quite important to monitor the health. To address this, a real time health monitoring system has been proposed based on IoT. It has various sensors such as pulse oxi-meter, ECG, Temperature sensor. This device also has GSM module and it can send messages in case of emergency. This mobile health monitoring system can be used to check patient's health and the data can be stored on IOT cloud which can be fetched as and when required. This simple device monitors patient's health where big medical equipment's cannot reach such as in rural areas and in this situation, this device serves as a boon. It is a compact device that can provide real time online information about patient's health conditions. The device stores the information about various health parameters which can be monitored by family members and doctor so that immediate action can be taken in case of an emergency.

1. INTRODUCTION

The increasing population has resulted in a rise in the number of patients and the need for health monitoring. The quality and affordability of healthcare have become major issues, with a large portion of the population facing problems due to the increasing cost of healthcare many patients lose their lives due to a lack of awareness and negligence on the part of doctors regarding the critical condition of their patients. This occurs because doctors cannot continually monitor their patients. Even if patients are closely monitored, particularly those who require constant monitoring, there may be situations when doctors need to step away, even for a brief moment, and during that time, the patient's condition may change, leading to an emergency. By the time the doctor returns to treat their patient, it may be too

late, and the patient's life may have been lost due to the delay in treatment. Therefore, there is an urgent need for a system that continuously monitors the patient's status and alerts the doctor if there is any variation in the patient's condition, such as when it becomes critical. This would prevent the loss of many lives and save doctors' time. This paper proposes a system that uses temperature, ECG and pulse rate sensors to measure the critical parameters for patients. The patient's body is connected to sensors, and the data that is collected from sensors is fed to a microcontroller. All of this data is then stored in a database, and the doctor can access them from a distant place at all times. The patient's health information is shared with the help of IOT with the doctor. In case of emergency, an alert message is also sent through SMS with the help of GSM module. As a result of which the need for human intervention is reduced and it provides precise and better health care. In the past years, different instruments were required to monitor the patients for different parameters. This is addressed by assembling different instruments into a single module to monitor the patient's required conditions. The IoT technology now widely used to recorded data from each sensor which is finally uploaded to a server

2. Material And Methods

In this section, all the hardware and software used in present model has been discussed briefly.

ESP32; The proposed model has a MCU node along with Wi-Fi and Bluetooth connectivity that makes it a very ideal and reliable option for a wide range of applications. Its features include ultra-low power consumption and high level of integration making it a versatile choice for Internet of Things (IoT) applications, mobile electronics and wearable technology. The MCU is so designed that is occupies a very minimal space on a Printed Circuit Board (PCB).

Figure 1: ESP32

The ESP32 serves here as the main central processing unit. It interfaces all sensors, processes data, and communicates with the GSM module to send SMS alerts. There is also a built-in Wi-Fi module which enables data to be sent to the IoT cloud. The data here can be accessed remotely as and when required.

Liquid Crystal Display A 16 x 2 LCD displays parameters and provides a simple and reliable solution. The LCD is commonly used and has a wide range of applications. The voltage rating of LCD is of 5V and has a green backlight.

Figure 2. Liquid Crystal Display

AD8232 DHT11 Sensor: The DHT-11 sensor is a digital sensor. It is very cost-effective and measures both temperature and humidity. Interfacing with any microcontroller, such as Arduino or Raspberry Pi, is very easy for instant readings. Temperature is measured in Celsius and humidity is measured in percentage relative humidity (%RH). This data is then displayed on the serial monitor.

In this model, the DHT-11 sensor measures the ambient temperature and humidity and sends data to the NodeMCU ESP32 module. The module further processes it and sends the information to Arduino IoT Cloud.

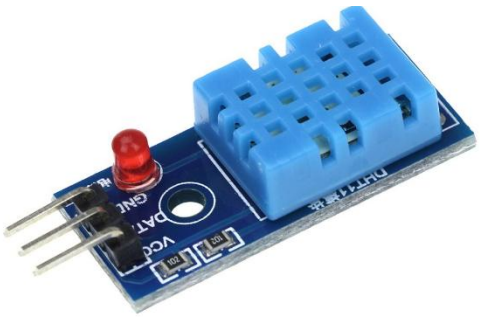

Figure 3. DHT11

ECG Sensor: The AD8232 ECG sensor is a small precise chip. It actually behaves like an electrocardiogram. It measures the electrical activity of the heart that can be graphed like an

electrocardiogram (ECG). It is utilized in diagnosing various heart conditions can be diagnosed with the help of the sensor. It is a method for collecting electrical signals produced by the heart.

The AD8232 detects the electrical signals that the heart produces and monitors the patient's heart activity. It provides ECG (Electrocardiogram) data.

MAX30102 Sensor: This sensor measures blood oxygen saturation (SPo2) and the heart rate of the patient. Infrared light is used to detect changes in blood absorption.

During a pulse oximetry reading, a small clamp-like device is attached to a person's finger, earlobe, or toe. A beam of light is passed through the finger, which is used to measure the oxygen saturation level in the blood.

Figure 4. MAX30102 Sensor

MLX90614 Sensor: It is non-contact type temperature sensor. It is an infrared thermometer for temperature measurements. It has temperature range of -40 degree Celsius to 125 degrees Celsius. It is small in size and low cost.

The MLX90614 uses infrared radiation and measures the body temperature of the patient without coming into physical contact.

Figure 5. MLX90614 Sensor

SIM800L GSM Module: This module enables the ESP32 to connect to cellular networks and send SMS messages to designated recipients such as doctors, if any health parameter reaches or crosses the threshold value.

Arduino Cloud: Arduino Cloud is an online platform. It is used for creating and monitoring IoT projects. It is an ideal choice for IoT projects that use ESP chips. It supports a wide range of ESP32 and ESP8266 based development boards.

High end features such as data monitoring, variable synchronization, scheduler, and dashboard sharing are offered by ESP8266 AND ESP32 boards. Arduino Cloud can be used to share this data. In this system, all data are stored in the Arduino IoT cloud, which can be accessed and used as and when needed. It can store data for up to 15 days and allows for live data monitoring. Arduino language is used to program these chips.

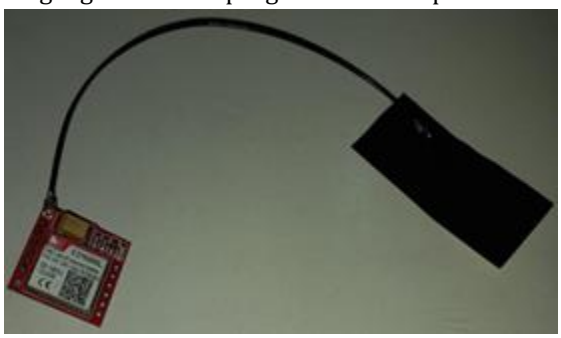

Figure 6. SIM800L GSM Module

3. PROPOSED MODEL

In our proposed system, four sensors are utilized: an ECG (AD8232), ambient temperature and humidity sensor (DHT11), a pulse oximeter sensor (MAX30102) and a infrared temperature sensor (MLX90614) to monitor, electrical activity of the cardiac muscle, the room temperature and humidity, oxygen level and body temperature of patient respectively.

The ESP32 will read data from the MAX30102 (SPo2 and heart rate), MLX90614 (body temperature), AD8232 (ECG signals), and DHT11 (ambient temperature and humidity). Each sensor communicates with the ESP32 via their respective interfaces (I2C, UART, or analog/digital pins). Upon receiving sensor data, the ESP32 will process it to detect any abnormalities. For example, it may compare SPo2 levels with predefined thresholds.

Temperature readings from MLX90614 can also be compared to normal body temperature ranges. If any sensor data indicates a potential health concern (e.g., low SPo2, high temperature), the ESP32 triggers an alert. Alerts can be based on configurable thresholds or algorithms that detect

patterns indicative of health risks. When an alert is triggered, the ESP32 uses the GSM module to establish a connection to the cellular network. It formats the alert message (sensor data, and a brief description of the issue) into an SMS format. The SMS is sent to one or more predefined phone numbers (e.g., a doctor's phone number). The ESP32 continues to monitor sensor data at regular intervals. It updates the doctor with subsequent alerts if the patient's condition changes or persists. The sensors that transmit their values to ESP32 can be accessed anywhere and anytime with the help of IoT. The data can be viewed in the form of values and graphs in arduino IoT cloud and it can be used when needed.

Figure 7: Experimental Setup

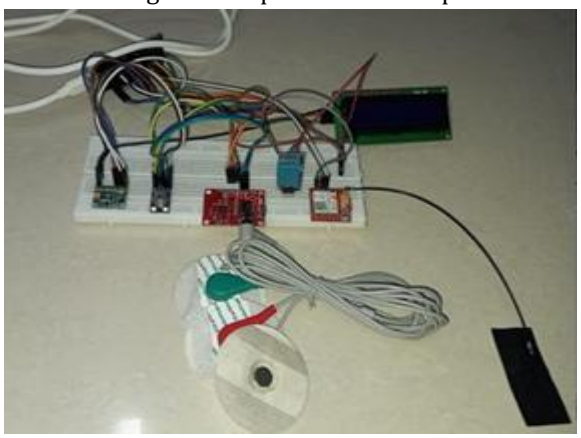

Figure 8: Connection

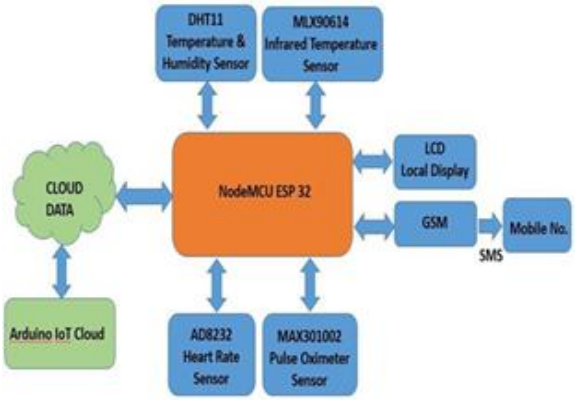

Figure 9. Block diagram of proposed system

Figure 7 shows experimental setup and it consists of ESP32, sensors, LCD and GSM Module. The VCC pin of the sensors MAX30102, MLX90614, AD8232 is connected to 3.3V power supply. VCC pin of the sensor DHT11 is connected to 5V power supply. Ground of all the four sensors and ESP32 are connected The MAX30102 Pulse Oximeter and Heart-Rate sensor usually communicates via I2C or SPI. For simplicity it is connected using I2C. The SCL (Serial Clock Line), SDA (Serial Data Line) of the sensor is connected to ESP32 to GPIO pin D22 and D21 respectively. The MLX90614 infrared temperature sensor also communicates via I2C. The SCL (Serial Clock Line), SDA (Serial Data Line) of the sensor is connected to ESP32 to GPIO pin D22 and D21 respectively. The AD8232 ECG sensor typically interfaces through analog signals. It uses an analog input pin D36 of the ESP32 to read ECG data. The temperature and humidity sensor, DHT11connects using a single digital pin D15 to ESP32. The GSM module communicates through UART for sending and receiving data. Connect TX of GSM module to RX2 of ESP32. Connect RX of GSM module to TX2 of ESP32. Connect VCC and GND to the battery. The LCD display module uses I2C to communicate with ESP32. Connect SCL to ESP32 GPIO pin D22. And connect SDA to ESP32 GPIO pin D21. Connect VCC and GND.

4. RESULT ANALYSIS

Figure 10: LCD Data

The prototype implementation of health monitoring system has been done. Figure 11 shows the readings of body temperature and oxygen level in blood taken from the sensors and it is displayed on an LCD screen. Figure 12 shows the LCD readings of humidity and ambient temperature. It

shows the real time monitoring of all the parameters.

Figure 11: Arduino Cloud Dashboard

Figure 11 shows the real time monitoring in Arduino IoT cloud showing live data of four parameters namely SpO2, body temperature, humidity and ambient temperature. This data can be viewed on mobile or computer.

Figure 12. Alert Messages

Figure 13. ECG Graph

The threshold value set for body temperature is 35 degrees Celsius and the SPO2 level is 97%. The doctor is not informed if the readings are within acceptable limits. It the readings from the sensor increases or decreases with the threshold value, the message notification is sent as shown in the figure 14. It shows the alert message as the SPo2 level has decreased from 97%. A warning message is also seen as the body temperature has increased from threshold value 35 degree Celsius. Figure 11 shows the ECG graph which can be obtained from Arduino serial plotter. Electrodes are positioned on the patient's right leg, left arm, and right arm to record ECG data.

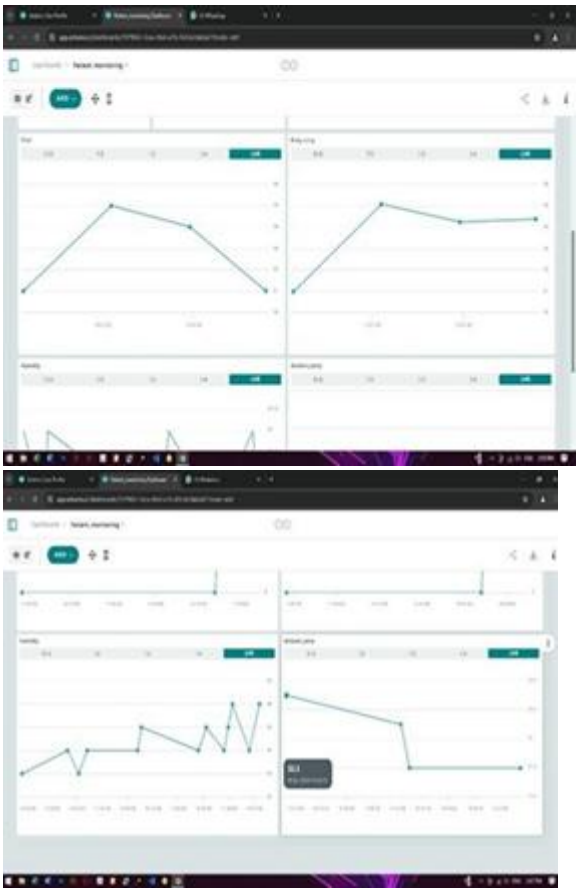

Fig 16. Different graphs consisting of real time health parameters in cloud

Graph 1. It shows of real time monitoring of SpO2 in cloud.
Graph 2. It shows real time monitoring of body temperature in cloud
Graph 3. It shows real time monitoring of humidity in cloud.
Graph 4. It shows real time monitoring of ambient temperature in cloud.

CONCLUSION

The prototype which is proposed can be ideally used in hospitals. Medical professionals, such as doctors and nurses, can constantly monitor a patient's temperature, ECG, oxygen level in the blood from all locations and at all times. By doing so, our system can prevent critical loss of life and enable doctors to take appropriate action in a timely manner. The Internet of Things (IoT) is now considered a very effective solution for tracking data of remote places, especially in health monitoring. It ensures that individual health data is securely stored in the cloud, hospital visits are reduced for everyday examinations, and the most important factor is that health can be monitored and disease can be diagnosed by any doctor from any remote place. The system leverages ESP32's capabilities along with specialized sensors and GSM communication to provide real-time health monitoring and emergency alerting for patients. By integrating sensors for vital signs monitoring and GSM for immediate communication, the system enhances patient care by enabling prompt medical intervention when abnormalities are detected. This setup not only supports remote patient monitoring but also improves healthcare delivery by ensuring timely responses to critical health events.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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