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IOT Based Patient Monitoring System Using Raspberry Pi

Dipali R. Khodake[1], Mohini S. Patil[2], Vijay Patil[3], Prajwal Patil[4] , Ishwar Jadhav[5]

[1,2,3,4]UG student, students, Dept of Electronics and Telecommunication Engineering, Godavari College of Enginerring, Jalgaon, Maharashtra, India

[5]Professor, : 0009-0003-2174-5669, Isjadhav247@gmail.com[5]

. dipalikhodake2003@gmail.com[1], mohinipatil679@gmail.com[2] ,vnp17040@gmail.com[3] ,prajwalrpatil19@gmail.com[4]

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Abstract – *Health has prime significance in our routine life. Internet of Things (IoT) in healthcare is now the prime research providing better medical facilities to the patients and facilitates the doctors and hospitals as well. The proposed system here consists of various sensors to capture patient data. The project monitors the patient's health condition with the help of heartbeat and temperature sensors. The status of these parameters is display on web. Web-based or mobile-based application located anywhere can communicate via Wi-Fi to our system consisting of Raspberry Pi and sensors which helps to monitor and record patients' health data and medical information wirelessly. We can also store the patent data on the cloud by using Wi-Fi to maintain the record while continuously monitoring it in the web-based application either on a mobile phone or PC globally anywhere in the world.*

Keywords- *Internet of Things (IoT), Patient Monitoring Raspberry Pi, Heartbeat Sensor, MCP3008,Fall Detection, Wi-Fi.*

I. INTRODUCTION

The continuous monitoring of patients in Intensive Care Units (ICUs) is critical to ensure timely medical interventions and improved outcomes. Patients admitted to ICUs are typically in critical condition and require constant supervision to detect any sudden changes in their vital signs. Traditional patient monitoring systems, while effective, often rely on expensive, bulky equipment and require dedicated staff for oversight. Moreover, these systems are typically confined to hospital settings,making them inaccessible for remote or under-resourced healthcare environments.

With the rapid advancement of Internet of Things (IoT) technologies, healthcare has begun to embrace more intelligent, cost-effective, and real-time monitoring solutions. IoT enables devices to collect, transmit, and analyze data over networks, offering new capabilities in terms of automation, remote access, and data-driven decision-making. In this context, developing a smart ICU monitoring system using IoT technologies presents a significant opportunity to enhance healthcare delivery—especially in remote, rural, or overwhelmed healthcare facilities.

This project focuses on designing and implementing an IoT-based patient monitoring system using the Raspberry Pi microcomputer. The system integrates vital sensors, including a blood pressure sensor and a fall detection module, to monitor essential health parameters. An analog-to-digital converter (MCP3008) is used to interface analog sensors with the Raspberry Pi. The collected data is processed and transmitted wirelessly to a custom mobile application, which displays real-time updates and issues alerts when critical thresholds are breached.

One of the primary motivations behind this project is the need for a low-cost, scalable monitoring system that can provide caregivers with constant access to patient health data without the need for direct physical presence. This not only reduces the burden on healthcare staff but also allows family members and remote doctors to stay informed and respond quickly in emergencies. Additionally, the system is designed to be easily portable

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and energy-efficient, making it suitable for deployment in home care settings, temporary medical camps, and low-resource hospitals.

2. LITERATURE REVIEW

The integration of Internet of Things (IoT) in healthcare, often referred to as the Internet of Medical Things (IoMT), has revolutionized patient monitoring by enabling connected, intelligent systems that gather and analyze health data in real time. These advancements have been widely researched and adopted, particularly in areas like remote monitoring, elderly care, and ICU systems. Several notable studies and implementations have contributed foundational knowledge to the development of IoT-based patient monitoring systems.

Kumar and Singh [1] developed an Arduino-based patient health monitoring system that tracked basic health metrics such as body temperature and heart rate. Though their system demonstrated the feasibility of using microcontrollers in health applications, it lacked advanced connectivity features and real-time mobile integration. This points to the need for more capable platforms like the Raspberry Pi, which offers better computational power and networking capabilities.

Yuce [2] explored the concept of a wireless body sensor network (WBSN) for healthcare monitoring. His study introduced a network of sensors that communicated wirelessly to a base station, providing a continuous stream of health data. Although this approach was efficient in transmitting physiological signals, the deployment complexity and high cost limited its usability in resource-constrained environments such as rural hospitals and home ICUs.

To address some of these limitations, Sharma and Singh [3] proposed a Raspberry Pi-based health monitoring system that collected and displayed glucose levels and ECG signals using a web-based interface. While this system showed how embedded Linux platforms could manage more complex computations and interfaces, it did not include a mobile application, which is increasingly essential for caregivers and healthcare providers on the go.

Patel et al. [4] took this a step further by creating a real-time health monitoring system using Raspberry Pi with cloud storage and alerts for abnormal readings. Their system effectively leveraged cloud infrastructure to ensure that medical staff received timely alerts. However, their design primarily focused on heart rate and temperature monitoring, leaving out critical parameters like blood pressure or postural information relevant in ICU settings.

Fall detection is another critical area in healthcare, especially in ICUs and geriatric care. Ramasamy and Rajendran [5] developed a fall detection system using wearable sensors and machine learning algorithms. Their research demonstrated the use of accelerometers to identify rapid changes in posture indicative of a fall. While their model was highly accurate in test environments, it required patients to wear devices continuously and had concerns related to battery life and long-term usability in clinical settings.

On the software side, the use of real-time databases like Firebase has grown in popularity. Li and Wang [6] highlighted how Firebase can be used effectively in IoT applications to facilitate low-latency data transmission between embedded devices and mobile applications. This makes Firebase a practical solution for ICU monitoring systems that require immediate alerts and quick access to vital health data.

Supporting these implementations is the Raspberry Pi platform, which provides a compact, affordable, and powerful computing base for health monitoring systems. According to the Raspberry Pi Foundation [7], the latest Raspberry Pi 4 Model B supports built-in Wi-Fi, multiple USB ports, and sufficient processing power to handle multiple sensor inputs and real-time data analytics.

Analog-to-digital conversion is an essential part of interfacing medical sensors with the Raspberry Pi, which lacks built-in ADCs. The MCP3008, an 8-channel 10-bit ADC with SPI interface, has been widely used for this purpose. Adafruit [8] provides detailed documentation for MCP3008 integration, making it an ideal choice for medical-grade analog signal acquisition.

In conclusion, previous research has demonstrated the feasibility of integrating IoT devices in health monitoring applications. However, many existing solutions lack a unified approach that combines essential ICU monitoring parameters, real-time alert systems, local data processing, and user-friendly mobile access. This project aims to fill that gap by building a cost-effective, scalable, and mobile-connected ICU patient monitoring system using Raspberry Pi, MCP3008, and a sensor suite including a blood pressure sensor and a fall detector.

3. PROPOSED METHOD

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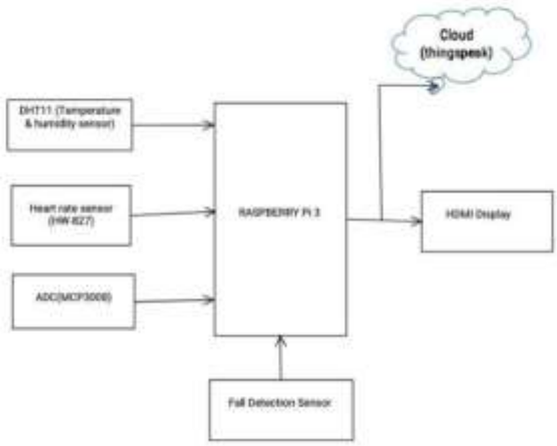

Figure 1 Block Diagram

The diagram of the project consists of Raspberry Pi 3, Temperature Sensor (DHT11), Heart Rate Sensor, HDMI Display,Wi-Fi, Thingspeak, and a Downfall Sensor.

The proposed method of the patient health monitoring system is to monitor the patient's body temperature, heart rate, and fall status using Raspberry Pi 3. The temperature sensor (DHT11) senses the temperature from the patient's body and sends the information to the Raspberry Pi 3. The Heart Rate Sensor collects the heartbeat from the patient. Since the output from the heart rate sensor is in analog form, it is converted into digital form using an Analog-to-Digital Converter (MCP3008). The digital output is then sent to the Raspberry Pi 3 through the serial data line of the MCP3008. A Downfall Sensor is integrated into the system to detect if the patient has fallen. If a fall is detected, the system automatically sends an alert email via Gmail to the doctor or designated family member, ensuring immediate attention to the patient's condition.

The data obtained from the Raspberry Pi 3 is displayed on the HDMI display and simultaneously transmitted to the Thingspeak platform through a Wi-Fi connection. Once connected to the internet, the Raspberry Pi 3 functions as a server and automatically sends the data to the website. anyone can monitor the patient's health status from anywhere in the world using laptops, tablets, or smartphones.

If any of the measured parameters, such as body temperature or heart rate, go beyond normal limits, an alert message is automatically sent to doctors and relatives.

4. IMPLEMENTATION METHEDOLOGY

4.1 HARDWARE DESCRIPTION

A. Raspberry Pi 3:

Raspberry Pi 3 is a credit card-sized single-board computer with a 40-pin extended GPIO, Broadcom BCM2387 chipset, 1.2GHz Quad-core ARM Cortex-A53 (64-bit), 802.11 B/G/N Wireless LAN, and Bluetooth 4.1. It includes a GPU (Dual Core VideoCore IV® Multimedia Co-Processor), a camera connector, a display connector, a memory card slot, 1GB LPDDR2 memory, an Ethernet port, USB host, and a Micro HDMI port. Raspberry Pi 3 is a general-purpose computer that usually runs a Linux operating system.

Figure 2 Raspberry pi 3b+

B. Temperature and Humidity Sensor (DHT11):

The DHT11 is a digital temperature and humidity sensor. It is widely used due to its low cost and reliable performance. It can measure temperatures ranging from 0 to 50 degrees Celsius with an accuracy of ±2 degrees, and humidity levels from 20% to 80% with an accuracy of 5%. The sensor provides readings at a sampling rate of 1Hz, or one reading per second. It operates on a voltage range of 3 to 5 volts and consumes a maximum current of 2.5mA during measurements. The DHT11 includes a humidity measurement component to measure relative humidity and an NTC thermistor for temperature measurement. It offers excellent quality, fast response, strong anti-interference ability, and is highly cost-effective.

Figure 3 DHT11 Sensor

C. Analog-to-Digital Converter (MCP3008):

The MCP3008 is a 10-bit, 8-channel Analog-to-Digital Converter (ADC) from Microchip Technology, used to convert analog signals to digital values for processing by microcontrollers or single-board computers like the Raspberry Pi. It uses the SPI (Serial Peripheral Interface) protocol for communication, which allows fast and efficient data transfer. The MCP3008 operates with a supply voltage between 2.7V and 5.5V, making it compatible with a wide range of microcontrollers and sensors. Each of the 8 input channels can measure a separate analog signal, enabling the Raspberry Pi (which lacks built-in analog input) to read analog sensor data such as from heart rate, temperature and humidity. The ADC has a maximum sampling rate of 200ksps and offers good accuracy for most embedded applications. Its ease of interfacing and affordability make it a popular choice in IoT and embedded systems projects.

Figure 4 ADC (MCP3008)

D. Heart Rate Sensor.

The heart rate sensor operates on the principle of photoplethysmography. It measures the variation in blood volume within a vascular region of the body, which causes a change in light intensity passing through that region.When the index finger is placed on the heart rate sensor, light from the sensor passes through the finger. As blood volume changes with each heartbeat, the light is absorbed or scattered differently. This variation in optical power is detected by the sensor, allowing it to measure the heart rate accurately

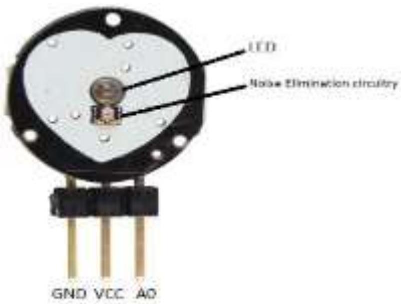

Figure 5 Pulse Sensor

4.2 WEB SERVER

A. ThingSpeak:

In our project, we display patient health-related parameters such as temperature,heart rate and downfall status on the ThingSpeak platform. By using an internet connection and the channel's API key, authorized users can monitor the patient's health status from anywhere in the world using laptops, tablets, and smartphones. ThingSpeak provides an easy-to-use web interface to visualize and analyze real-time data, making it convenient for remote patient monitoring.

5. RESULT AND OBSERVATIONS

Figure 6 Implemented Board

Figure 6 shows the implemented board. It consists of a Raspberry Pi 3 board, a DHT11 temperature sensor, a heart rate sensor, an MCP3008 analog-to-digital converter, and Downfall sensor

Figure 7 Display Temperature ,humidity and pulse rate on web server

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Figure 7 illustrates the display of body temperature, humidity and heart rate on the web server. The temperature, humitidy and heart rate is represented in the form of a line chart, providing a visual trend over time.

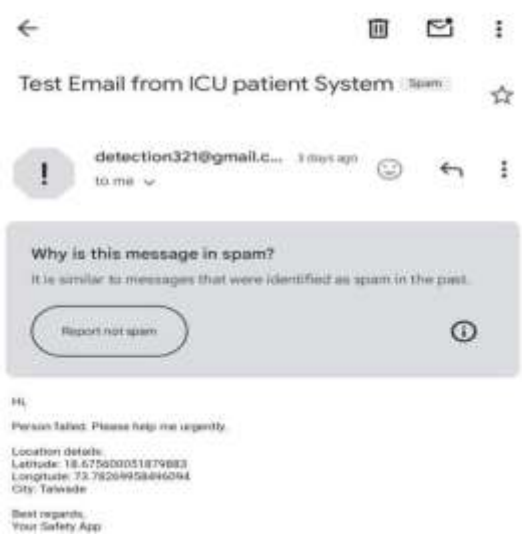

Figure 8 Alert notification through Gmail

CONCLUSION

The proposed IoT-based patient health monitoring system using Raspberry Pi 3 successfully demonstrates an efficient, real-time solution for continuously monitoring vital health parameters such as body temperature, heart rate, and fall detection. By integrating sensors like DHT11, heart rate sensor, downfall sensor, and an ADC (MCP3008), the system collects accurate data and transmits it to the cloud via Wi-Fi using the Thingspeak platform. The use of an HDMI display provides immediate on-site visualization, while alerts hrough Gmail notifications ensure prompt response in case of any abnormalities. This system enhances patient safety, especially for elderly or critically ill individuals, by enabling remote monitoring through smartphones, tablets, and computers from anywhere in the world. It proves to be a cost-effective, scalable, and reliable solution that can be implemented in homes, hospitals, and care centers to assist healthcare professionals and caregivers in providing timely interventions.

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