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IOMT-Based Health Monitoring System using Raspberry Pi Pico

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***Abstract*—An IoMT-based health monitoring system for coma patients ensures a secure environment by continuously tracking vital signs. It uses sensors such as heart rate, temperature, and vibration sensors to monitor the patient's condition. The system provides real-time data, allowing healthcare professionals to respond quickly to any critical changes. This approach enhances patient safety by enabling remote monitoring. The goal is to improve care for patients who cannot communicate their needs.IOMT based health monitoring system employ wearable sensors and medical devices to continuously collect and transmit real-time physiological data from patients.This data is securely transmitted to cloud servers for storage and analysis.Healthcare providers access insights through specialized platforms,enabling remote monitoring and personalized patient care.Challenges include data security and regulatory compliance,yet these systems promise improved patient outcomes,enhanced efficiency, and grater patient engagement in healthcare management.**

Keywords—NodeMCU ESP32, IoT, Temperature sensor, vibration sensor, pulse sensor, GSR sensor,blynk app.

1. INTRODUCTION

Modern healthcare has significantly enhanced patient care worldwide by providing more affordable solutions for health monitoring devices. One such development is the creation of a device that integrates a micro controller with biomedical sensors, such as temperature, pulse, vibration, and galvanic skin response (GSR) sensors. These sensors continuously monitor the patient's health on a single platform. When any critical changes occur, the data is automatically updated to the cloud, enabling prompt action to be taken. This not only helps address immediate health issues but also assists in predicting potential future health complications.

Healthcare professionals and clinicians utilize these technologies to advance medical services in clinical settings.

Health research is vital to society as it provides essential information on disease prevalence, risk factors, treatment outcomes, and healthcare practices. The system typically involves various sensors and communication devices essential for IoT-based health monitoring.The primary goal of patient monitoring systems(PMS)is to perform a quantitative analysis of key physiological parameters at crucial times in a patient's biological function.This system continuously and automatically monitors indicators like blood pressure, body temperature, and pulse rate.Biosensors play a key role by detecting a wide range of physiological parameters. A biosensor is a device used for chemical sensing that combines a transducer with a biologically derived recognition element, enabling the accurate analysis of complex biochemical markers. The primary aim of a health monitoring system is to standardize networking protocols and medical terminology, allowing for the seamless transmission of electronic medical records to healthcare providers. PMS keeps track of essential health data and promptly informs the medical team, significantly reducing the risk of delayed responses to critical health changes.

2. LITERATURE SURVEY

Patient health monitoring systems use the Internet of Things (IoT) to track patient welfare in real time. With sensors like pulse, temperature, humidity, toxic gas, and air quality sensors, these systems gather critical data. A GPRS/GSM module enables real-time transmission, allowing healthcare professionals to monitor patients remotely and efficiently[1].In 2020, Alshammari developed a system aimed at simplifying healthcare, minimizing hospital visits, and enhancing care quality. Through a user-friendly interface (GUI) and step-by- step instructions, it facilitates secure and easy collection of vital health data, such as heart rate, SpO2, and temperature, using various sensors. This project goes beyond just hardware and data—it's about revolutionizing healthcare delivery[2].In 2023, Muhammad Narzul Islam proposed an IoT and machines learning-based system to predicts the level of cardiovascular risk diseases.Research focuses on developing a wearable hardware device capable of accurately capturing essential heart health indicators, including pulse rate, blood pressure, and ECG data, in real time[3].In 2020, an ECG monitoring system was developed using an Arduino Uno, an Wi-Fi ESP8266 blynk IoT module and application. This system allows doctors remotely monitor patients' ECG signals via the Blynk app installed on their smartphones, enabling healthcare providers to track patient data from anywhere without requiring a hospital visit[4].In 2017, a new healthcare system was introduced that integrates the security features of both healthcare and cloud technologies. This system addresses various security challenges faced by health services, e.g such as eavesdropping, man-in-the-middle (MITM) attacks, and refusal. Additionally, there was the Scyther verification tool services to ensure the robustness and correctness of the system[5].In 2021, Kunjabihari Swain proposed "LI-Care: A LabVIEW and A health monitoring system based on the Internet of Things " which is a cost-effective and efficient solution for remote tracking of patients' vital signs. This user-friendly system detects abnormalities and sends alerts, ultimately improving patient outcomes and reduction health care costs[6].In 2021, a project was developed to detect symptoms and monitor an individual's basic health. Tracking vital signs such as heart rate and body temperature is crucial because discrepancies can signal a foundation like high or low blood pressure and flu. The significance of healthcare monitoring systems has become even more critical during pandemics[7].In 2024, Sayantan Bhattacharya proposed an "IoMT for Tratment of chronic Disease " highlighting the effectiveness of the Internet of Medical Things (IoMT) in managing chronic conditions like diabetes and hypertension. This study underscores how IoMT technologies can enhance monitoring and treatment strategies for patients with these long-term illnesses[8].By leveraging technology, healthcare professionals can monitor patients while minimizing resource usage. Future work will focus on enhancing sensor performance by using softer materials and facilitating information sharing among specialists, patients, and their family over the net approach. When irregularities are detected, the system employs a Wireless Body Area Network (WBAN) to emergency carers and doctor professionals[9]. Effectively manage both historical and physical records, integrated approach with digital health records is essential. This integration facilitates informed decision-making and supports further research into potential explanations for health reports Additionally, the architecture proposed by the ADR emphasizes smart health monitoring and drug therapy, enhancing decision-making processes in healthcare settings[10].Mobile technology enables effective communication between doctors and patients, allowing for easy access to data necessary for patient monitoring. The hardware is intentionally designed to be simple, ensuring it is user-friendly forhome environments. By leveraging real-time data, healthcare professionals can accurately identify critical conditions such as elevated blood pressure. The effectiveness and thoughtful design of the proposed system have been validated through various assessments[11].As wireless sensor nodes advance in biomedical applications, the insights gained from their adoption and implementation can inform the development of innovative smart sensors for new uses. Implanted smart sensors are continuously improving in their capacity to address various medical conditions, offering significant advantages for both individuals and society. The greatest benefits will be experienced by those with debilitating illnesses and their families, as these technologies can greatly enhance their quality of life[12].In 2020, Joshi introduced an innovative wearable, non-invasive device designed for consumers to monitor blood glucose levels continuously and accurately. This device uses a new short near infrared radiation spectroscopic technology and integrated with the Internet Medical Affairs (IoMT) to enhance smart healthcare solutions[13].

3. SYSTEM BLOCK DIAGRAM

A proposed IoT-based health monitoring system utilizes the Raspberry Pi Pico microcontroller as its central component. This setup collects real-time health data from various sensors: a pulse sensor that monitor heart rate in beats per minute (BPM), a temperature sensor for measuring body temperature, a vibration sensor to assess body movement, and a GSR sensor to evaluate skin conductivity.

One temperature sensor is dedicated to measuring room temperature, allowing adjustments based on the patient's health needs. The buzzer emits audible alerts when the heart rate falls below 60 BPM or exceeds 85 BPM, enabling quick assessments by healthcare professionals through sound alone. For optimal accuracy, the pulse sensor is placed on the fingernails, while the GSR sensor uses electrodes positioned on the index and middle fingertips, where skin is thinner and less hairy for better readings.The vibration sensor is strategically placed on joints and limbs to accurately monitor body movements. The ESP32 IoT module connects the Raspberry Pi Pico to the internet, facilitating the transmission of health data to the Blynk application server for storage and remote tracking. This setup also features a 16×2 LCD display for real-time data visualization. Through the Blynk app, caregivers can monitor patient health information from anywhere, enhancing overall healthcare management.

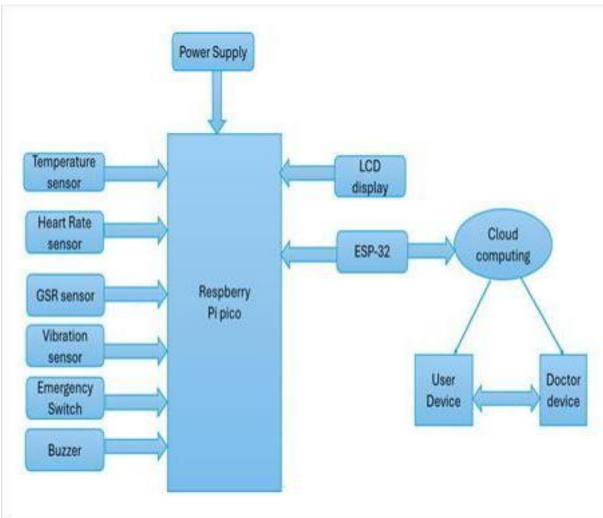


Fig 1:System block diagram

4. HARDWARE OVERVIEW

- Raspberry Pi Pico
- Heart Rate Sensor
- Temperature Sensor
- Vibration Sensor
- GSR Sensor
- Buzzer
- Emergency Switch
- ESP32
- LCD Display

4.1 RASPBERRY PI PICO

Fig 2: Raspberry pi pico.

The Raspberry Pi Pico microcontroller is a recent addition to the Raspberry Pi family, designed for low power consumption and high performance. It offers a cost-effective and efficient solution for IoT-based health monitoring systems. The Pico features multiple GPIO pins, making it easy to interface with various sensors and devices, allowing for seamless data collection and environmental monitoring.

4.2 ESP32

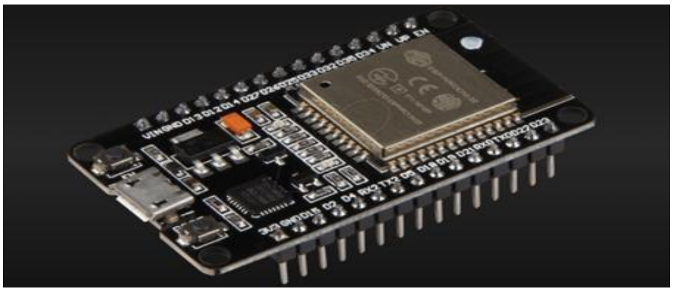


Fig.3: ESP-32.

The MAX30102 module integrates a dual-function sensor for both pulse saturation and heart beat monitoring. It features built-in LEDs,optical sensors,and high precision hardware with noise reduction,as well asambient light filtering to ensure accurate measurements. This module is used to calculate heart rate and blood oxygen levels. The ESP32 microcontroller is a versatile, dual-core unit with built-in RF capabilities, supporting both Bluetooth and Wi-Fi connectivity. This makes it ideal for applications requiring wireless communication and real-time data transmission in health monitoring systems.

Temperature sensor

Fig.3: Temperature Sensor.

Temperature sensors like the DS18B20 are designed to measure temperature and other environmental data within a room, transmitting this information directly to smartphones or other devices. This capability allows users to monitor, regulate heating, conserve energy, and optimize the ambient temperature in homes or offices. The sensor supports temperature measurements with a resolution ranging from 9 to 12 bits, ensuring accurate readings for various applications, including IoT-based health monitoring systems.

4.4 Pulse Sensor/Heart Rate Sensor

Fig.4: Pulse Monitoring Sensor.

The heart rate sensor is a device utilized to monitor and assess the rhythm of the heart, expressed in beats per minute (BPM). Normal heart rate, known as sinus rhythm, typically ranges from 60 to 90 BPM, varying according to an individual's physical needs and activity levels. Heart rate can be measured from various parts of the body, including the index finger, wrist, neck, elbow, and toes. In this study, the heart rate is specifically measured using the tip of the forefinger, which offers reliable readings.

4.5 Vibration Sensor

Fig.5: Vibration Sensor.

The vibration sensor is designed to accurately measure and analyze body movements. When placed near joints or2

limbs, it effectively monitors movement patterns, including gestures, posture changes, and gait. It can also detect tremors or abnormal movements, which is valuable for diagnostics and enhancing treatment strategies. The sensor operates within a voltage range of 3 to 5V, making it suitable for integration into various health monitoring systems.

4.4 GSR Sensor

Fig.6: GSR Sensor.

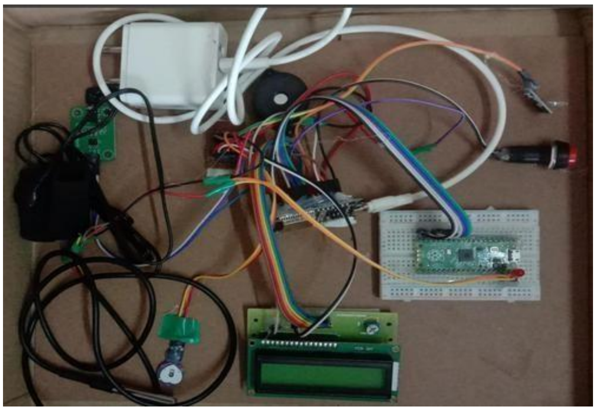
The GSR (Galvanic Skin Response) sensor detect the skin’s electrical conductivity,which varies according to moisture levels levels caused by sweating. This sensor operates within a voltage range of 3.3V to 5V. The variations in conductance are linked to the body's mental or physiological arousal, providing valuable data on stress or emotional responses. The GSR sensor is commonly used in health monitoring systems to assess emotional states and reactions.

as biomedical pads and sensor cables, with the Raspberry Pi Pico and a Wi-Fi adapter. The connections between the sensors, Raspberry Pi Pico, Wi-Fi module, and power supply are clearly visible in the setup.This IoT-based The health monitoring system enables authorized individuals to access stored information through an IoT platform. Depending on the collected data doctors can diagnose health conditions remotely. The temperature sensor measures the room temperature, the pulse sensor records heart rate, the GSR sensor monitors skin conductance, and the vibration sensor detects body movement changes.

The Raspberry Pi Pico processes the data and displays it on an LCD screen. The corresponding data is also transmitted to mobile devices, as shown in Figure 9.The ESP32 Wi-Fi module provides internet connectivity, enabling real-time monitoring of patient

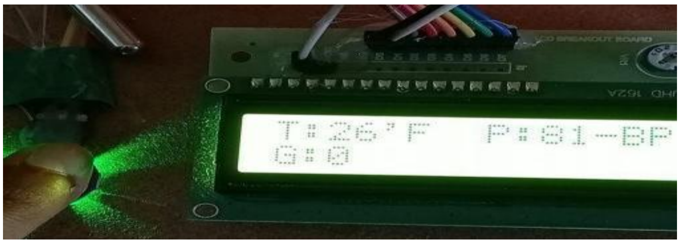
4.5 LCD Display

5 health data on the IoT server. Doctors and family members can remotely access this information, allowing them to monitor the patient's condition and take appropriate action when necessary.

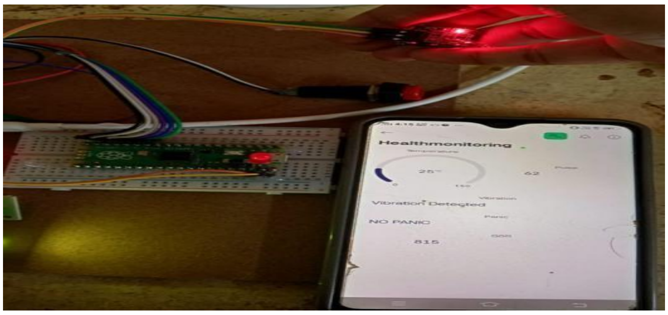


6 Fig8: Complete prototype of the system.

Fig.7: LCD Display.



A 16×2 LCD screen with I2C interface is capable up to 16f displaying characters per line across 2 lines. This compact display only requires four connection pins: VCC for power, GND for ground, SDA for data, and SCL for clock. The I2C interface simplifies wiring and reduces the number of required pins, making it an efficient choice for displaying real-time data in IoT-based health monitoring systems.



5. ***Experimental Setup***

The test arrangement for our system is illustrated in Figure 8, showing the integration of sensors and their accessories, such Fig9: Result.

When the circuit is powered on, as shown in Figure 8, all the LEDs on the PCBs light up, confirming the proper functioning of the circuit. The system includes a room temperature sensor, the LM35, which measures the temperature in either Fahrenheit or Celsius. This temperature reading is displayed on the LCD screen, as illustrated In Figure 9, the simulation outcomes of the system illustrate the sensors' efficiency and performance.The LM35 accurately monitors room temperature. The heart rate sensor measures heart rate by detecting the reflection of LED light on the skin, with optimal accuracy achieved when the sensor is placed on the fingernails. The GSR sensor evaluates skin conductance by positioning electrodes on the index and middle fingertips, where thinner skin and minimal hair ensure more reliable readings. Additionally, the vibration sensor, placed near joints and limbs, precisely tracks body movements, aiding in monitoring motor activity. These results are visualized in Figure 9.

Fig10:Result in blynk app view.

7. Future Scope

In the future, this system could be enhanced to allow doctors to create personalized patient reports and add comments directly within the app. The app can also be designed to remind patients to take their prescribed medications and perform daily exercises. These additions will make the system more compact, accessible, and user-friendly, ensuring that it is easy for everyone to use.

8. Conclusion

The suggested IoT-driven health monitoring system for patients is highly useful in emergency situations, enabling daily monitoring, recording, and storing of health data in a centralized database. Looking forward, integrating this system with cloud computing will allow seamless data sharing across intensive care units and hospitals. During pandemics or other situations that limit physical visits to healthcare facilities, this system can significantly reduce the need for frequent hospital visits by allowing patients to monitor their health from the safety of their homes.

9. Acknowledgement

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