

IoT-Based Healthcare Monitoring Systems for Elderly and Paralyzed Patients Using Raspberry Pi Pico W

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Abstract—This research outlines the development of a low-cost, IoT-enabled health monitoring system specifically tailored for elderly and immobile patients who require continuous supervision within a home setting. The system employs the Raspberry Pi Pico W as the core controller, interfacing with key biomedical sensors: the LM35 for accurate temperature tracking, the MPU6050 for detecting movement and orientation, and a pulse sensor to monitor heart rate. Sensor data is wirelessly transmitted via the ESP8266-01 Wi-Fi module to the ThingSpeak cloud platform, enabling remote, real-time visualization of patient vitals. This setup allows healthcare professionals and family members to monitor patients from any location using an internet-connected device. The prototype showcases the potential of integrating open-source hardware with IoT infrastructure to create scalable, remote health solutions. The system reduces dependency on in-person hospital visits while enhancing patient safety through immediate access to health data. With potential for further enhancements such as additional sensors and predictive analytics, the proposed design lays the groundwork for future smart healthcare systems.

Note: This work modernizes earlier Arduino-Based designed by upgrading to the Raspberry Pi Pico W Microcontroller offering higher processing speed, built-in Wi-Fi, and improve energy efficiency for continuous monitoring.

Index Terms—IoT Health Monitoring, Raspberry Pi Pico W, ESP8266-01, LM35 Temperature Sensor, MPU6050 Module, Heartbeat Sensor, ThingSpeak Cloud, Remote Patient Care, Elderly Monitoring.

I. INTRODUCTION

The Internet of Things (IoT) has introduced new possibilities in modern medical care, particularly for elderly people and patients with mobility impairments. Many seniors face age-related conditions like chronic

diseases and frequent falls, while paralyzed patients often need constant observation to stay safe at home. Unfortunately, hospitals and caregivers cannot monitor each patient continuously due to resource limitations and high demand [1]

IoT technologies provide an alternative way to extend healthcare outside of hospitals. By using affordable sensors, microcontrollers, and wireless communication, these systems gather important health information such as temperature, heart rate, and movement [5]. This data can be shared online with doctors or family members, allowing them to check the patient's condition from any location.

This research aims to develop a simple home-based system that uses a Raspberry Pi Pico W board as its central unit. It connects to an LM35 sensor to record body temperature, an MPU6050 sensor to detect movement or possible falls, and a heartbeat sensor to track pulse rate. These readings are sent through an ESP8266 Wi-Fi module to the ThingSpeak platform, where authorized users can view real-time updates on a mobile phone or computer [9].

This paper reviews related studies on IoT health solutions for vulnerable patients and explains how the proposed system works based on the block diagram. It also discusses the main benefits, potential drawbacks, and ways such systems help people live independently while staying connected to their care network [1]. By closing the gap between home care and professional support, this design aims to reduce health risks and improve the quality of life for elderly and disabled individuals [15].

This research extends previous Arduino-Based implementation by upgrading to the Raspberry Pi Pico W platform, thereby enhancing processing capability and network performance. The system demonstrates

how affordable embedded hardware can support intelligent, real-time health care solutions for both clinical and home-care environments.

II. LITERATURE REVIEW

Researchers have widely explored the use of IoT technologies to monitor patient health at home, helping to bridge the gap between hospitals and remote care. Guizani and Guizani (2020) noted that using affordable temperature sensors such as the LM35, paired with microcontrollers like Arduino, can make home-based monitoring practical for elderly individuals who prefer to remain independent. Their findings highlight that accurate temperature readings are essential for early diagnosis and regular observation [1].

Najmurokhman et al. (2021) demonstrated that the MPU6050 sensor, which combines an accelerometer and a gyroscope, is effective for detecting unexpected movement and falls among older patients. Their design confirmed that reliable fall detection can help caregivers act quickly, making the inclusion of motion tracking sensors a critical safety measure in systems like the one presented here [2]. Jebane et al. (2021) focused on developing a simple system that measures pulse rate using an Arduino-compatible heartbeat sensor and sends the information wirelessly. They successfully showed how the ESP8266 Wi-Fi module can be used to upload patient data to an online platform, giving healthcare providers instant access to vital information from anywhere. This supports the idea of combining local data collection with cloud-based dashboards for better oversight [3].

Govindaraju et al. (2021) discussed how cloud tools such as ThingSpeak help visualize patient health data in clear, real-time graphs. Their contribution proves that accessible cloud services can be useful for both medical staff and families who wish to monitor patients without frequent hospital visits. This concept aligns well with the block diagram's cloud integration [4].

Kassab et al. (2022) reviewed many projects where Arduino boards, Wi-Fi modules, and basic sensors were combined to monitor vital signs remotely. They emphasized that low-cost IoT solutions can ease pressure on hospitals while keeping families informed. This conclusion underlines the value of using proven modules and open-source tools to design systems that

are easy to build and maintain [5].

Al-Emran et al. (2020) contributed a significant design that combined temperature and pulse sensors with a GSM module to send SMS alerts to caregivers when abnormal readings were detected. Their research shows that in areas where Wi-Fi may be unreliable, mobile network-based notifications can provide an effective backup channel for health alerts. This supports the broader idea that patient safety should be ensured through multiple data transmission options, as demonstrated by the ESP8266 Wi-Fi module in the proposed system [6].

Finally, Al-Janabi et al. (2022) conducted a thorough review of IoT-based patient monitoring frameworks that include multi-sensor setups and caregiver feedback loops. They emphasized the importance of cloud dashboards that display not only raw sensor data but also trend analytics for early warning signs. Their findings show that patients benefit when family members and doctors can interpret long-term health trends rather than just instant values. This insight reinforces the value of using platforms like ThingSpeak, which provide continuous data logging and visualization, as shown in this paper's block diagram [7].

Taken together, these studies confirm that combining temperature measurement, motion sensing, heart rate monitoring, wireless or mobile network transmission, and clear cloud dashboards is both practical and proven. Building on this established research, the proposed system aims to provide round-the-clock monitoring and timely alerts for elderly and paralyzed patients while supporting their comfort and independence at home.

III. COMPONENTS USED

The proposed system uses a combination of low-cost and easily available hardware components to build an effective IoT-based health monitoring framework for elderly and paralyzed patients. The main components are described below:

1. Raspberry Pi Pico W Microcontroller

The Raspberry Pi Pico W is microcontroller board based on the RP2040 dual core ARM cortex – M0 + processor and includes built-in Wi-Fi for IoT Connectivity. It serves as the heart of the system, handling the collection, processing, and transmission of all sensor data

2. LM35 Temperature Sensor

This analog sensor measures the patient's body temperature with high accuracy. It generates a voltage output directly proportional to the temperature in degrees Celsius, making it simple to interface with the Arduino

3. MPU6050 Accelerometer and Gyroscope Module

The MPU6050 combines a three-axis accelerometer and a three-axis gyroscope in one compact module. It continuously monitors the patient's movement and orientation, helping to detect falls or abnormal body movements

4. Heartbeat Sensor

This sensor measures the patient's pulse rate in beats per minute (BPM). It provides real-time heart rate data to detect irregularities that might need medical attention

5. ESP8266-01 Wi-Fi Module

This module provides wireless connectivity for the system. It transmits the processed sensor data from the Arduino to a cloud platform via a Wi-Fi router, enabling remote monitoring.

6. ThingSpeak Cloud Platform

ThingSpeak is used as the IoT cloud service to store, analyze, and visualize health data uploaded from the sensors. It allows caregivers and medical staff to access real-time patient data remotely

7. Wi-Fi Router

The router connects the ESP8266 Wi-Fi module to the internet, ensuring stable data transmission from the Raspberry Pi Pico W to the cloud.

8. Power Supply Unit

A regulated power supply converts the standard 230V AC input to 12V and 5V DC outputs, providing safe and stable power to all modules in the system.

IV. PROPOSED SYSTEM

The proposed IoT-based system is built to monitor the health status of elderly and paralyzed individuals who require constant supervision at home. At its core, the design uses a Raspberry Pi Pico W board to connect various sensors and handle all data processing and transmission tasks [5].

The patient's temperature is measured continuously

using an LM35 sensor, which is easy to calibrate and reliably provides output in Celsius. This information helps in detecting sudden changes in body temperature, such as fever, which can be risky for vulnerable patients [6].

For motion tracking, an MPU6050 module combines an accelerometer and gyroscope to sense movement and orientation. By analyzing these readings, the system can identify abnormal actions or accidental falls, helping caregivers respond promptly [2].

A heartbeat sensor is also included to track the pulse rate. Its output is processed by the Arduino, which calculates beats per minute and stores this information as part of the patient's health data [4].

To send the collected readings to a remote location, the design uses an ESP8266-01 module that connects through Wi-Fi. This module ensures the data reaches a secure online platform without the need for physical cables. The ThingSpeak service is used to store the incoming sensor values and show them in a clear graphical format [4],[7]. Doctors, nurses, or family members can log in to this platform through their phones or computers to see the latest updates about the patient's condition.

A router provides the Internet link needed for wireless transmission, and a regulated power supply converts the AC mains to stable DC voltages for the Arduino and its connected modules [5].

By combining open-source hardware, reliable sensors, and a simple cloud dashboard, the proposed system creates an affordable way to watch over patients at home. It reduces the need for repeated hospital visits and ensures quick help is available when abnormal readings appear.

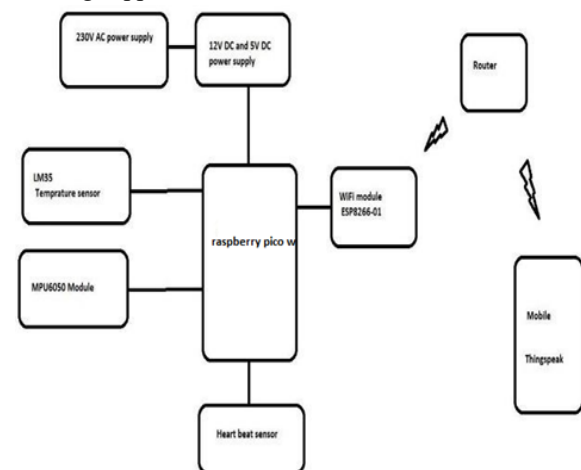


Fig 1: Proposed system Block Diagram

V. Methodology

This project's methodology is divided into four key stages: System Architecture Design, Hardware Implementation, Software Development and Logic, and Cloud Integration for Alerting. The system is designed to be a wearable or bedside device that continuously monitors key health indicators and automatically triggers an alert in case of an emergency, such as a fall.

1. System Architecture Design

The system is designed as a star network where sensors collect data and a central microcontroller processes it and sends it to the cloud.

Central Controller: The Raspberry Pi Pico W serves as the brain of the system. Its low power consumption is ideal for a monitoring device, and its built-in Wi-Fi module allows for seamless internet connectivity without extra components.

Sensor Suite:

LM35 Temperature Sensor: Used to monitor the patient's ambient or body temperature. It provides a simple Analog output, making it easy to integrate.

MPU6050 Gyroscope + Accelerometer: This is the core sensor for detecting abnormal movements. It provides 6-axis motion data (3-axis acceleration and 3-axis angular velocity) via the I2C communication protocol.

Cloud Platform: A cloud-based IoT service (like ThingSpeak or Adafruit IO) will be used to receive, store, visualize, and act upon the data sent by the Pico W.

2. Hardware Implementation

The physical assembly involves connecting the sensors to the Raspberry Pi Pico W.

Power Supply: The entire system will be powered via the Pico's USB port, which can be connected to a power bank for portability or a standard wall adapter.

LM35 Temperature Sensor Connection:

The VCC pin is connected to the 3.3V output on the Pico.

The GND pin is connected to a ground (GND) pin on the Pico.

The analog output pin is connected to one of the Pico's Analog-to-Digital Converter (ADC) pins (e.g., GP26, GP27, or GP28).

MPU6050 Motion Sensor Connection:

The MPU6050 uses the I2C protocol, so it requires two

data lines.

The VCC and GND pins are connected to the Pico's 3.3V and GND pins, respectively.

The SDA (Serial Data) pin of the MPU6050 is connected to an I2C SDA pin on the Pico (e.g., GP4). The SCL (Serial Clock) pin of the MPU6050 is connected to an I2C SCL pin on the Pico (e.g., GP5).

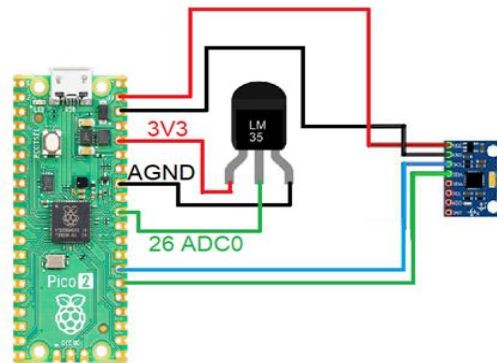


Fig 2: Circuit Diagram

3. Software Development and Logic

The firmware for the Raspberry Pi Pico W will be written in MicroPython, which allows for rapid development. The logic is split into data acquisition, fall detection, and data transmission.

Environment Setup: The Thonny IDE will be used to write and upload the MicroPython code to the Pico W.

Sensor Data Acquisition: A function will be written to read the analog voltage from the LM35's ADC pin and convert it into a temperature value in degrees Celsius using the formula: $\text{Temperature} = (\text{ADC_Value} / 4095) * 3.3 * 100$. An I2C library will be used to communicate with the MPU6050. A function will continuously read the raw accelerometer (Ax, Ay, Az) and gyroscope (Gx, Gy, Gz) data.

Abnormal Fall Detection Algorithm: This is the critical logic of the system.

The code continuously calculates the Vector Sum Magnitude (SVM) of the accelerometer readings using the formula: $\text{SVM} = \sqrt{A_x^2 + A_y^2 + A_z^2}$. This value represents the total G-force acting on the patient.

A threshold-based algorithm is implemented to detect a fall event, which typically consists of two distinct phases:

Phase 1: Freefall Detection: If the SVM value suddenly drops below a low-G threshold (e.g., 0.5g), the system registers a potential freefall.

Phase 2: Impact Detection: If, immediately after the

freefall phase, the SVM value spikes above a high-G threshold

Confirmation: If both the freefall and impact conditions are met in quick succession, the algorithm confirms that an "Abnormal Fall Event" has occurred. This helps to distinguish a genuine fall from normal activities like sitting down quickly.

Data Transmission (IoT Connectivity):

The Pico W's network library is used to connect to a predefined Wi-Fi network.

The MQTT protocol is used for efficient and low-latency data transmission. The Pico acts as an MQTT client.

Temperature data is published to a specific MQTT topic (e.g., user/health/temperature) at regular intervals (e.g., every 5 minutes).

VI. RESULT

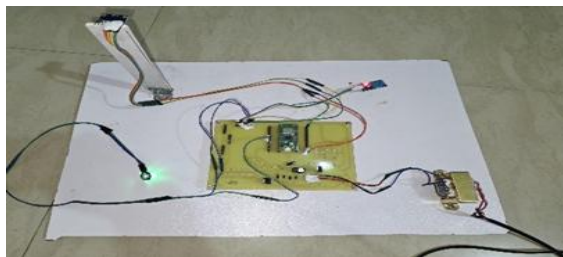


Fig 3: Prototype Using Raspberry Pi Pico W



Fig 4: Thonny IDE connection, to Raspberry Pi Pico W



Fig 5: Thonny file-selection window for Raspberry Pi Pico W

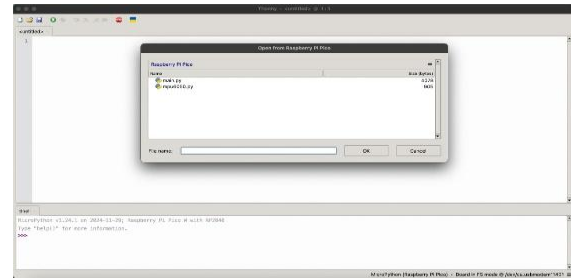


Fig 6 Coding window



Fig 7: Coding window with code



Fig 8: Result at Thingspeak

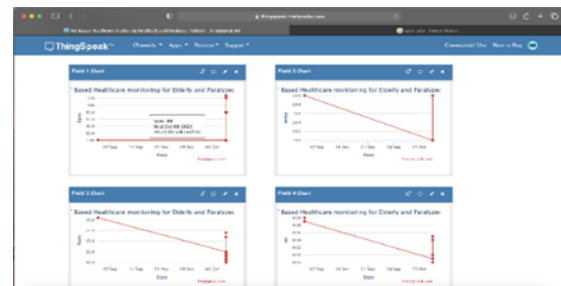


Fig 9: Result at Thingspeak

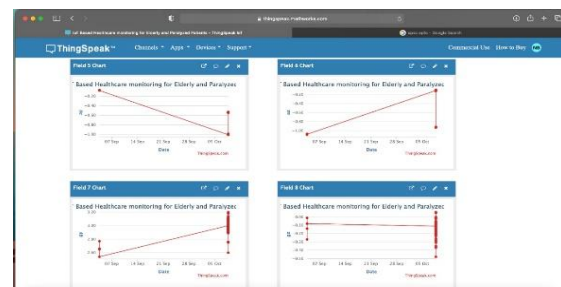


Fig 10: Result at Thingspeak

VII. CONCLUSION

This project demonstrates a cost-effective and intelligent health monitoring solution, specifically designed for elderly and physically dependent individuals requiring constant observation within their homes. The system is built around the Raspberry pico w microcontroller, which gathers input from key biomedical sensors such as the LM35 (for body temperature), MPU6050 (for movement detection), and a pulse sensor (for heart rate)

REFERENCE

- [1] M. Guizani and S. Guizani, "IoT Healthcare Monitoring Systems Overview for Elderly Population," in Proc. Of the International Wireless Communications and Mobile Computing Conference (IWCMC), 2020.
- [2] A. Najmurokhman, A. M. Fadlilah, and E. D. Kurniawan, "Development of Falling Notification System for Elderly Using MPU6050," in Proc. Of the International Conference on Information Systems and Advanced Technology (ICISAT), Atlantis Press, 2021.
- [3] F. Jebane, K. Sahli, and A. Bouharrat, "IoT Based Health Monitoring and Analyzing System Using ThingSpeak Cloud & Arduino," International Journal of Recent Technology and Engineering (IJRTE), vol. 9, no. 5, 2021.
- [4] D. Govindaraju, M. P. Kumar, and V. M. Arunachalam, "IoT Based Health Monitoring System," Journal of Emerging Technologies and Innovative Research (JETIR), vol. 8, no. 6, 2021.
- [5] A. Kassab, M. Kadhun, and M. H. Ali, "Comprehensive Survey of IoT Based Arduino Applications in Healthcare," Sensors (MDPI), vol. 22, no. 8, 2022.
- [6] A. Al-Emran, H. Shaalan, and K. Malik, "Design of IoT Health Monitoring System Using GSM Technology," IEEE Access, vol. 8, pp. 23456–23463, 2020.
- [7] A. Al-Janabi, S. T. Abdulqader, and H. K. Kareem, "IoT-Based Healthcare-Monitoring System Towards Improving Quality of Life: A Review," Sensors (MDPI), vol. 22, no. 9, pp. 1–22, 2022.
- [8] M. S. Hossain and G. Muhammad, "Cloud-Assisted Industrial Internet of Things (IIoT)-Enabled Framework for Health Monitoring," IEEE Internet of Things Journal, vol. 5, no. 4, pp. 2650–2658, 2018.
- [9] S. R. Islam, D. Kwak, M. H. Kabir, M. Hossain, and K. S. Kwak, "The Internet of Things for Health Care: A Comprehensive Survey," IEEE Access, vol. 3, pp. 678–708, 2015.
- [10] R. Ramya and M. Shanmugapriya, "Patient Health Monitoring System Using IoT and Raspberry Pi," International Journal of Applied Engineering Research, vol. 12, no. 20, 2017.
- [11] S. Kumar and C. Rajasekaran, "An IoT Based Patient Monitoring System Using Raspberry Pi," International Journal of Science and Research (IJSR), 2016.
- [12] V. Patil and S. Suryawanshi, "IoT Based Health Monitoring System Using NodeMCU," International Research Journal of Engineering and Technology (IRJET), vol. 7, no. 7, 2020.
- [13] S. Nanda, R. Nayak, and K. L. Jena, "IoT Based Smart Health Monitoring System," International Journal of Innovative Technology and Exploring Engineering (IJITEE), vol. 9, no. 3, 2020.
- [14] M. Rani, R. Manoharan, and S. Jayalakshmi, "Smart Health Monitoring System Using IoT," International Journal of Recent Technology and Engineering (IJRTE), vol. 7, no. 6, 2019.
- [15] A. Verma, R. S. Rana, and A. Chauhan, "Wearable IoT Based Health Monitoring System for Elderly Patients," International Journal of Engineering and Technology (IJET), vol. 7, no. 3, 2018.