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Real-Time Monitoring and Fall Detection for Alzheimer's/Dementia Patients Using Internet of Thing (IoT) Technology

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Abstract

Alzheimer's disease and dementia significantly impair cognitive and physical abilities, increasing the risk of falls among elderly patients. Falls often result in severe injuries, further deteriorating patient health and imposing challenges on caregivers. This study presents a real-time monitoring and fall detection system utilizing Internet of Things (IoT) technology to enhance patient safety and caregiver response. The system integrates wearable sensors, including the MPU6050 accelerometer and gyroscope, along with GPS tracking via the Blynk application. It continuously monitors patient movements and provides instant alerts with precise location data to caregivers in the event of a fall. The system was tested for various activity statuses, including no movement, walking, jogging, running, and falls. The results demonstrated accurate differentiation between normal activities and fall events based on accelerometer and gyroscope readings. When a fall was detected, the system successfully triggered immediate notifications and shared GPS coordinates, enabling prompt intervention. The real-time data visualization in the Blynk application further enhanced usability for caregivers. By addressing the limitations of existing monitoring systems and leveraging IoT advancements, this project improves patient safety, promotes independent living, and reduces caregiver burden.

1. Introduction

Alzheimer's disease and dementia are prevalent neurodegenerative conditions that significantly affect cognitive and physical abilities. These conditions primarily impact the brain, leading to progressive memory loss and increasing difficulty with everyday tasks. As these diseases advance, patients not only struggle with remembering recent events or recognizing familiar faces but also experience a decline in physical coordination and balance. This decline makes them particularly susceptible to falls, which are a leading cause of injury among the elderly [1].

Falls are a major concern for individuals with Alzheimer's and dementia because the consequences can be severe. When a patient fall, the risk of sustaining serious injuries, such as fractures, broken bones, or head trauma, is high. These injuries often require hospitalization and can lead to prolonged periods of immobility, further, the impact of falls goes beyond physical injuries. The experience of falling and the associated trauma can worsen the cognitive symptoms of dementia. Fear of falling again can lead to reduced physical activity, which in turn can accelerate cognitive decline due to decreased stimulation and physical health. This creates a vicious cycle where the risk of falling increases as patients become more sedentary and less engaged in daily activities [2].

The number of people living with dementia is growing rapidly. The World Health Organization (WHO) estimates that by 2050, there could be 152 million people with dementia worldwide. This increasing number highlights the urgent need for effective ways to monitor and care for these patients [2]. One promising solution is the use of Internet of Things (IoT) technology. IoT refers to a network of devices that can communicate with each other and share data. With IoT, we can create systems that constantly monitor patients in real-time. For example, wearable devices like smartwatches can track a patient's movements and detect falls. Sensors in the home can monitor the environment and daily activities [3].

1.1 Problem Statement

The increased risk of falls is a major concern for individuals with physical impairments, dementia, and Alzheimer's disease. Falls can result in severe injuries, worsening cognitive decline and increasing the burden on caregivers and medical personnel. Ensuring continuous patient safety and real-time monitoring remains a challenge, especially when patients are left unattended [4].

Current monitoring and fall detection systems often lack real-time capabilities and efficient data analysis, making it difficult to track patient well-being effectively [5]. However, advancements in IoT technology have significantly improved the accuracy and reliability of monitoring systems. Studies show that using real-time monitoring and early fall detection can reduce the severity of injuries and improve response times [6].

IoT-based systems can quickly alert caregivers and medical professionals if a fall or unusual activity is detected, enabling faster responses and potentially preventing serious injuries. This technology also provides caregivers with reassurance, knowing they will be notified immediately if an emergency occurs [6]. By integrating IoT technology with platforms like Blynk Apps, seamless data collection and analysis can empower healthcare providers to enhance the quality of care for Alzheimer's and dementia patients [7][8].

This study focuses on developing a real-time monitoring and fall detection system using wearable sensors such as gyroscopes and accelerometers, along with GPS tracking via Blynk Apps. The proposed system aims to enhance patient safety, promote independent living, and reduce the burden on caregivers, representing a significant step forward in improving care for individuals with neurodegenerative diseases [1].

This research endeavors to achieve the following objectives:

a) To develop a real-time monitoring system that tracks the location and movement patterns of Alzheimer’s/Dementia patients using IoT technology.
b) To implement a fall detection mechanism utilizing MPU6050 accelerometer and gyroscope sensors to accurately identify and differentiate fall incidents from daily activities.
c) To evaluate the system with IoT-based platforms, specifically the Blynk application, for real-time data visualization and instant fall alerts to caregivers.
d) To evaluate the system’s accuracy and reliability in detecting falls and providing timely alerts, ensuring effective intervention and improved patient safety.

2. Methodology

This section describes the methodology used in designing and implementing an IoT-based system for monitoring and detecting Alzheimer’s/Dementia patients. The system consists of a smart wearable device that tracks movement and location in real time, ensuring continuous monitoring for patient safety.

The system is designed using a combination of sensors, a microcontroller, and wireless communication to process and transmit patient data. The MPU6050 sensor detects movement and fall occurrences, while the GPS NEO 6M module provides real-time location tracking. The ESP8266 microcontroller acts as the central unit, transmitting collected data to the Blynk application via Wi-Fi. This setup enables caregivers to monitor the patient’s status remotely and receive alerts in case of emergencies.

2.1 Overview of the System

The system architecture integrates multiple components to enable real-time monitoring. The MPU6050 detects movement and fall incidents by measuring acceleration and angular velocity on the x, y, and z axes. The GPS NEO 6M module continuously tracks the patient’s location by obtaining latitude and longitude coordinates. All collected data is processed and transmitted through the ESP8266 microcontroller, which connects to Wi-Fi and sends the information to the Blynk application. The Blynk app serves as the interface for caregivers, providing real-time visualization of the patient’s movement and location. If a fall is detected, the system automatically sends an alert notification along with the patient’s location to ensure prompt assistance. The block diagram Fig. 1 illustrates how these components interact to provide a functional monitoring system.

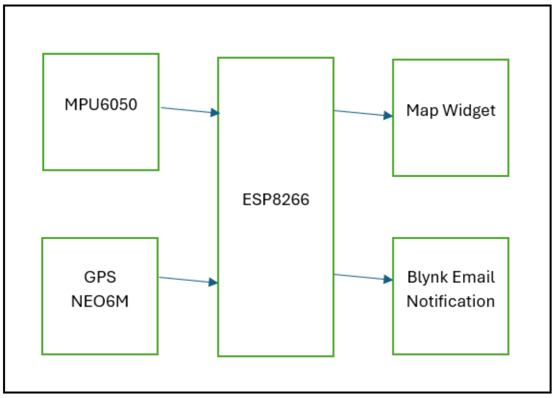


Fig. 1 *Block Diagram of the proposed system*

As shown in Fig. 2, the following components are used to build the system.

a) **Microcontroller**: Functions as connectivity to enable internet access for cloud storage. It is responsible for handling communication between sensors and the Blynk application.

b) **MPU6050**: Captures motion data, measuring acceleration and angular velocity across three axes (x, y, and z). This allows the system to detect sudden falls or unusual movement patterns.

c) **GPS NEO 6M:** Continuously tracks the patient's real-time location by retrieving latitude and longitude coordinates. GPS data is crucial for locating a patient in case of emergencies.

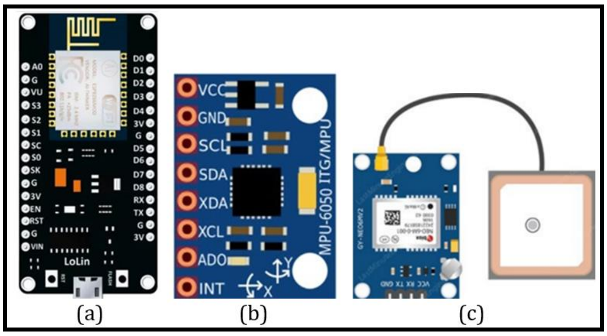


Fig. 2 *Component (a) Microcontroller; (b) MPU6050; (c) GPS NEO 6M*

2.2 Circuit Design

The system's circuit design ensures effective communication between the sensors and microcontroller. As shown in Fig. 3, the wiring configuration is as follows:

1. **MPU6050 Sensor**: Connected to the ESP8266's **D1 (SCL)** and **D2 (SDA)** pins to enable I2C communication.
2. **GPS NEO 6M Module:** Connected to the ESP8266's **D6 (TX)** and **D7 (RX)** pins for serial communication.
3. **Power Connections:** Both the MPU6050 and GPS NEO 6M modules are powered using the **3.3V** pin on the ESP8266, while their ground pins are connected to the **ESP8266 GND**.

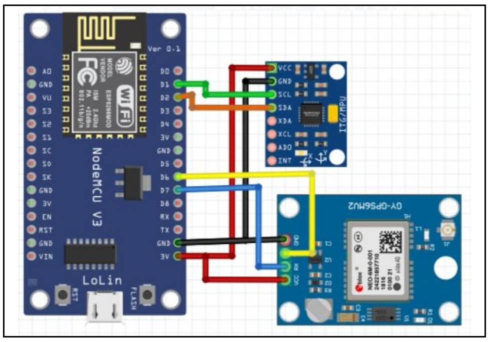
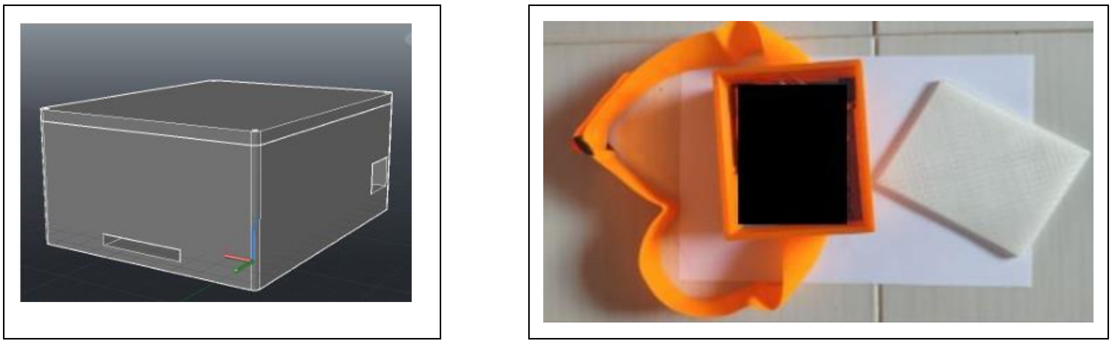


Fig. 3 *Circuit Design*

2.3 3D Printing Case

To house the hardware securely, a 3D-printed case is designed as shown in Fig. 4. The case is custom-built to fit all components while ensuring durability and portability.



(a) **(b)**

Fig. 4 *(a) 3D design (b) Prototype design*

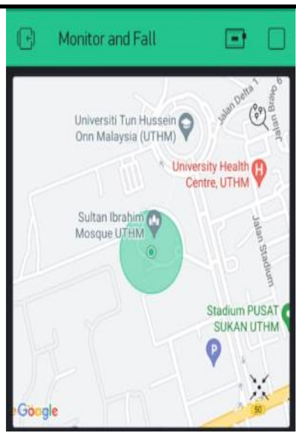
3. Result

In this section, the researcher focusses on the MPU6050 sensor result and several activity statuses like no movement, walking, jogging, running and falling.

3.1 Activity Status: No movement

Table 1 illustrates the outcomes of the no-movement condition in the Blynk application for real-time monitoring and fall detection of Alzheimer's patients. The map's position coordinates are exact latitude and longitude: (1.85, 103.08). The accelerometer results reveal insignificant movement, with acceleration x at -0.22 and acceleration z at 9.57, signifying a steady upright position. Gyroscope readings close to 0 indicate the absence of rotational motion. The graph indicates stability and confirms that the location is stationary. The maps' location indicates the activity is done nearby Sultan Ibrahim Mosque UTHM.

Table 1 *Result of no movement*

Status activity	Data Value	Map Location
		

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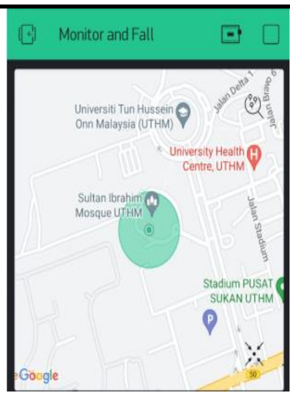
3.2 Activity Status: Walking

Table 2 shows the outcomes of walking activity in the Blynk application for real-time monitoring and fall detection of Alzheimer's patients. The accelerometer readings show the motion consistent with walking, with the acceleration values of 3.11, -1.71 and 9.26 along the x, y, and z axes, respectively. The gyroscope reading also shows consistent angular motion with values -0.07, -0.12 and -0.05 along the x, y, and z axes. The graphs show a clear visualization in acceleration and angular velocity of walking activity. Next, the maps coordinate from the GPS module are latitude 1.85 and longitude 103.08, These coordinates represent the location near Sultan Ibrahim Mosque UTHM.

Table 2 *Result of walking*

Status activity	Data Value	Map Location
		

3.3 Activity Status: Jogging

Table 3 illustrates the result of jogging activity in the Blynk application for real time monitoring and fall detection. The accelerometer reading shows active movement consistent with values 6.13, -0.55 and 8.29 along x, y, and z axes, respectively. The gyroscope also shows the value -0.01, -0.14 and 0.06 along the x, y, and z axes. This gyroscope shows an angular motion occurring. The graphs of acceleration and gyroscope show an active movement during the jogging activity. This location is near the Sultan Ibrahim Mosque, UTHM from the GPS and map's location show the coordinate latitude and longitude are (1.85,103.08).

3.4 Activity Status: Running

Table 4 illustrates the results of the running activity in the Blynk application for real-time monitoring and fall detection of Alzheimer's patients. The location is confirmed that, this location is near the Sultan Ibrahim Mosque, UTHM. This is because the GPS and map's location show the latitude and longitude (1.85,103.08) indicate that this running activity occurs here. The accelerometer reading is 5.99, 0.1 and 7.91 along the x, y, and z axes indicating that are high motion for running. The gyroscope readings are -0.18, -0.15 and -0.1 along the x, y, and z axes also show the angular movement have occurred during the running activity. The graph of acceleration and gyroscopes shows a high movement occur compared to other activity like walking and jogging.

Table 3 *Result of jogging*

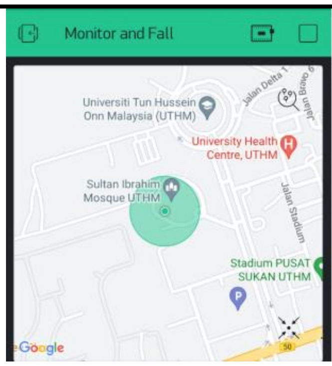
<table>
<tr><th>Status activity</th><th>Data Value</th><th>Map Location</th></tr>
<tr><td></td><td>
</td><td>
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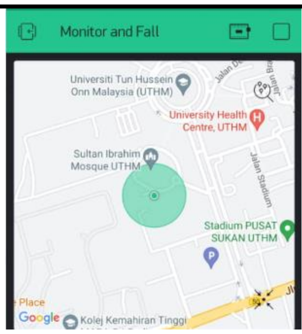
Table 4 *Result of running*

<table>
<tr><th>Status activity</th><th>Data Value</th><th>Map Location</th></tr>
<tr><td></td><td>
</td><td>
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3.5 Activity Status: Falling

Table 5 illustrates the result of fall in the Blynk application for real-time monitoring and fall detection of Alzheimer's patients. The accelerometer readings are -0.12, 0.6 and 9.53 along the x, y, and z axes. This accelerometer shows movement acceleration. Next, the gyroscope reading is -0.12, -0.04 and -0.04 along the x, y, and z axes. This gyroscope also shows an angular movement that has occurred. The graphs of acceleration and gyroscopes show an inconsistent movement, which is we can see the peak-to-peak of each line of the graph for acceleration and gyroscopes are high and change during the fall event this means that a high movement and rotation angular happen during the fall event.

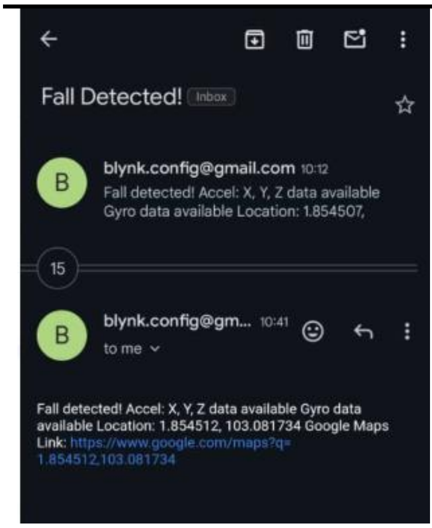
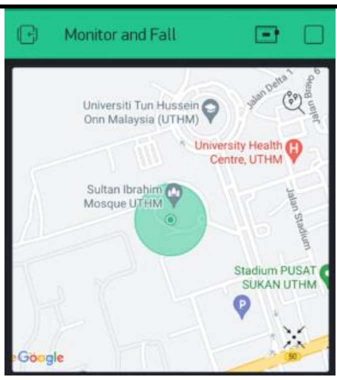
Table 6 shows an alert notification in the email and maps location in Blynk application for real-time monitoring and fall detection of Alzheimer's patients. From the project from the project when it detected a fall, then a notification will be sent to the caregiver for immediate help. As we can see the message show "Fall detected" and the GPS are logging the coordinate when it detects the location of the fall. The maps visualize that the location is near Sultan Ibrahim Mosque UTHM. The latitude and longitude from the email are shown

(1.854512,103.081734). From this result, the caregiver and family member can give immediate help to the patient when the fall is detected.

Table 5 *Result of falling*

Status activity	Data Value
	

Table 6 *Result of maps and email notification*

Notification	Map's location
	

4. Conclusion

The fall detection and monitoring system developed in this project successfully demonstrated its ability to integrate hardware and software components into a functional prototype. By combining sensors, microcontrollers, and IoT platforms, the system reliably detected falls, distinguished between Activities of Daily Living (ADLs) and emergencies, and provided caregivers with real-time alerts and location tracking. These capabilities highlight the system's potential to enhance safety and monitoring for Alzheimer's patients.

The key findings include the system's ability to accurately identify various types of activity and fall, such as do nothing, walking, jogging, and running, from that activity we can analyze it from the various of graph acceleration and movement of the user, so the caregiver can monitor it condition easily, this is because the integrate IoT platform nowadays make it easy and better for future for monitoring real-rime rather than manual monitoring or old method.

Lastly, the integration of GPS modules enabled precise real-time location tracking, ensuring patient safety by allowing caregivers to respond quickly in emergencies. Additionally, the use of IoT platforms like Blynk apps facilitated real-time data visualization and alerting, proving the system's compatibility with modern IoT technologies and enhancing its practicality in caregiving scenarios.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contributions to the paper as follows: ***study conception and design:*** *Aiman Syazmin Shamsudin, Zuhairiah Zainal Abidin;* ***data collection:*** *Aiman Syazmin Shamsudin****; analysis and interpretation of results:*** *Aiman Syazmin Shamsudin, Zuhairiah Zainal Abidin:* ***draft manuscript preparation:*** *Aiman Syazmin Shamsudin, Zuhairiah Zainal Abidin. All authors reviewed the results and approved the final version of the manuscript.*

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