Digital Monitoring and Tracking System with IoT Technology for Elderly Patients

Muhammad Fareez Haziq Eddie Wan[1], Zuhairiah Zainal Abidin[2], Aizan Ubin[3], Huda A. Majid[4]
1- Faculty of Electrical and Electronic Engineering, University Tun Hussien Onn Malaysia, Parit Raja, Batu Pahat, 86400, Malaysia.
Email: fareezhaziq97@gmail.com
2- Advanced Telecommunication Research Center (ATRC), Faculty of Electrical and Electronic Engineering, University Tun Hussien Onn Malaysia, Parit Raja, Batu Pahat, 86400, Malaysia.
Email: zuhairia@uthm.edu.my (Corresponding Author)
3- Faculty of Electrical and Electronic Engineering, University Tun Hussien Onn Malaysia, Parit Raja, Batu Pahat, 86400, Malaysia.
Email: aubin@uthm.edu.my
4- Faculty of Technical Engineering, University Tun Hussien Onn Malaysia, Parit Raja, Batu Pahat, 86400, Malaysia.
Email: mhuda@uthm.edu.my

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ABSTRACT:
This study aimed to design a system utilizing an ESP8266 microcontroller, GPS, and MPU6050 sensors to observe and record the movement patterns of elderly patients. A scale prototype was developed by integrating an MPU6050 IMU sensor and a GPS module with an ESP8266 module configured for Wi-Fi communication with a nearby server. Data were collected and evaluated by sensors positioned on test subjects to imitate the movements of elderly patients. Upon successful real-time tracking of the test subject's movements, the data was transmitted to the network using Blynk and email applications for analysis and subsequent display. The collected data yielded valuable insights into the patient's conduct, encompassing frequent walking, pacing, and wandering. The utilization of this device has the potential to improve the safety and well-being of elderly patients and provide valuable data to healthcare professionals and caregivers through its real-time tracking capabilities.

KEYWORDS: Gyro Sensor, GPS, Blynk, Email, Arduino.

1. INTRODUCTION

Technology has become an essential and integral component of modern-day living and influences how we all live and work.[1] For the most part, technology has a positive impact because it helps us manage and control our daily routines[2]. Technology can help in other areas, such as overcoming the numerous challenges faced by health and social care [3]. Ambient Assistive Living (AAL) is creating new living spaces that combine social[4] environments with cutting-edge technology to create products and services that significantly improve the occupant's quality of life [5]. Many areas of research and technology contribute to assistive solutions, and numerous trials are conducted to determine their feasibility [6]. The Internet of Things (IoT) paradigm is the foundation for many AAL technologies [7]. IoT is a framework that allows developers to connect various devices, systems, and technologies to perform specific tasks such as monitoring [8,9]. Smartphones that use electrocardiograms can be used to assess and analyze the heart's condition [10]. Wearable sensor technologies and IoT have enormous potential to improve our way of life by providing monitoring systems that track and manage our routines [11]. Additional features like real-time communication allow the providers to transmit and analyze data while identifying and acting on concerning behavior or symptoms [12].

This study focuses on developing a portable device capable of tracking and monitoring the movement and location of elderly patients. The expected functionality of this device involves detecting movement and location and the subsequent alerting and notification of carers. Furthermore, the caregivers will receive notifications when the elderly individual leaves their current place and condition.

2. SYSTEM DESIGN CONFIGURATION

Fig. 1 shows the proposed system design consisting of a hardware and software implementation part. As for the hardware part, it consists of components such as

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ESP8266-V3, GPS Neo-6m, and MPU6050. Meanwhile, the software used an Arduino IDE and Blynk as an IoT cloud platform.

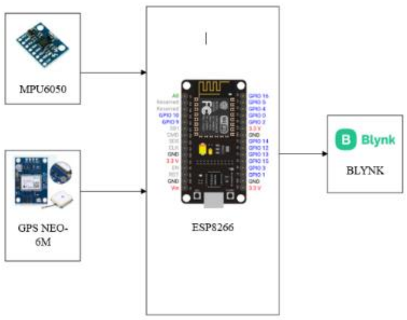


Fig. 1. The workflow of the digital monitoring and tracking system.

The flowchart for the system design is depicted in Fig. 2. Initially, the sensors will retrieve data regarding their location and gyro orientation, transmitting it to the ESP8266 module, provided all sensors are successfully connected to the ESP8266. Fig. 3 depicts a flow chart illustrating the process of Blynk and email notifications. Blynk is a web server, while email is a local cloud storage solution. Once the ESP8266 transmits data collected from sensors, Blynk will retrieve the data via serial communication from the ESP8266 module. Once the data retrieval process is successfully completed, the data sensors will be stored within the Blynk platform. Subsequently, the caregiver will receive a message through either the Blynk application or email.

2.1. IoT System

A data recording system is one of the crucial features offered by Blynk, however, it is only one of many choices. In this project, a data recording system is necessary to achieve the project's goals. The three separate menus that can be accessed at the very top of the Blynk platform are shown in Fig .4 to Fig.6. These figures show the templates, automation, and devices platforms, respectively.

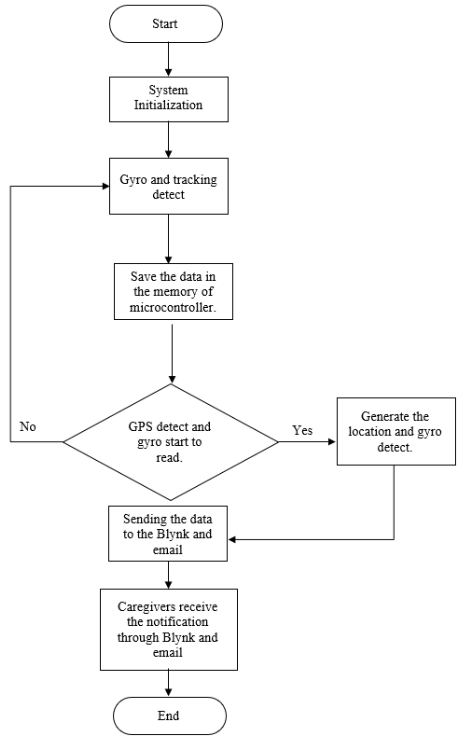


Fig. 2. Flowchart of the monitoring and tracking system.

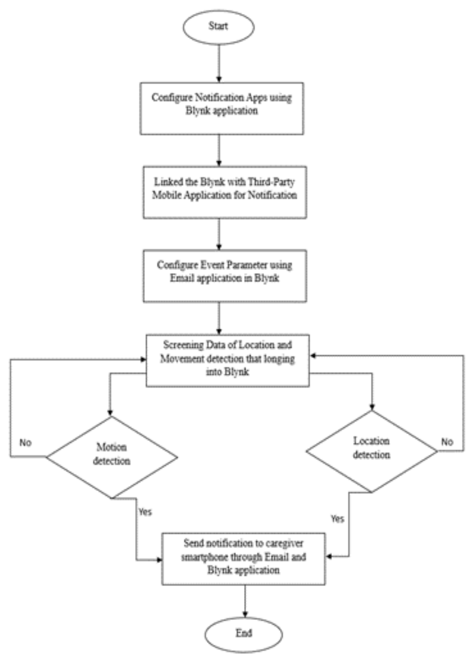


Fig. 3. Flowchart of the notification system.

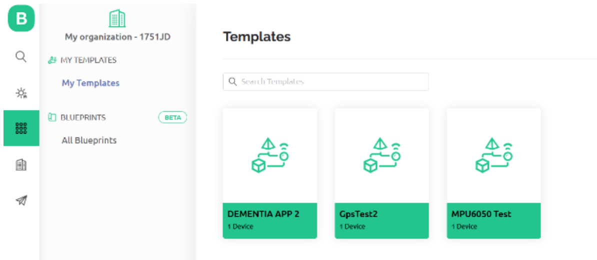


Fig. 4. Templates platform.

Fig. 5. Automation platform.

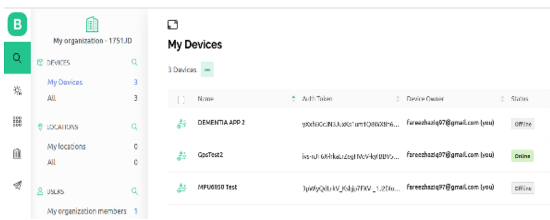


Fig. 6. Device platform.

2.2. Notification Applications

Fig. 7 depicts the various configuration choices accessible within the Blynk program. The utilization of an already established account on the desktop platform is a necessary need for authentication. After successful authentication, the user will receive a unique and identifiable user key. Incorporating the intended devices within the "My automation" segment is imperative to enhance visibility. Following this, it is necessary to develop an application inside the allocated section for applications, enabling notifications to be delivered to the specified device. Every application that is newly developed is allocated a distinct authentication token. The utilization of this token, in combination with the user key, facilitates the establishment of a connection with the Blynk Platform.

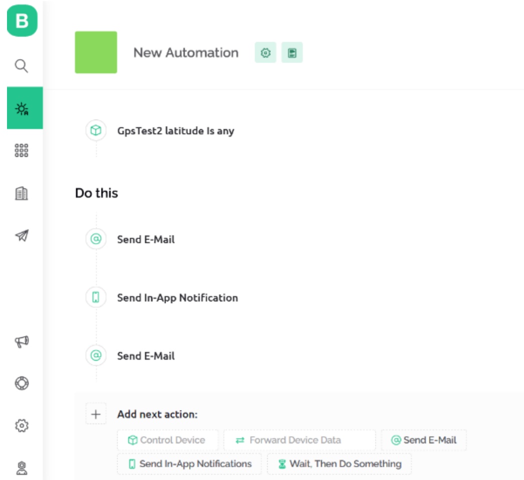


Fig. 7. Blynk Automation Configuration.

3. RESULT AND DISCUSSION

All the sensors installed in the prototype system have been tested. Besides, the real-time monitoring graph obtained from the Blynk dashboard, and the results obtained are discussed in this section.

3.1. Scale Prototype

The monitoring and tracking system module prototype consists of an MPU6050 gyro sensor, a GPS module, and a microcontroller. The data-collecting process includes the integrated utilization of ESP8266-V3 components. The design illustrating the prototype is shown in Fig. 8, while Fig. 9 shows the developed scale prototype with a power bank as its power supply.

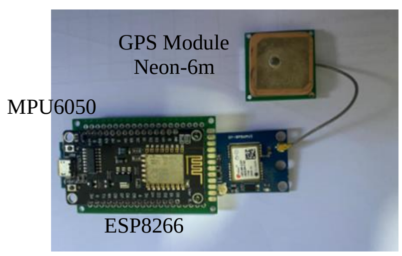


Fig. 8. The scale prototype configuration.

Fig. 9. The complete scale prototype with power supply.

3.2. Gyro Orientation Measurement

The MPU6050 can determine the angular orientation of the gyroscope in three dimensions, specifically along the X, Y, and Z axes, as depicted in Fig. 10. The approach's efficacy was evaluated through experimental investigation comprising three conditions: falling, fast walking, and slow walking, characterized by short strides. The Blynk App's output can be observed in two visual displays, as depicted in Figs. 11 and 12. Fig. 11 illustrates the readings of fall-detection circumstances obtained from the gauge, wherein the parameters of X, Y, and Z angles are varied. Meanwhile, Fig. 12 illustrates the graph depicting the movement detector, emphasizing subtle variations in the corresponding X, Y, and Z angles. The comparison findings of the gyro reading between the three conditions are presented in Table 1. The data analysis reveals that the recorded gyro reading angle is comparatively smaller in slow conditions than in fast and fall conditions. The findings suggest that elderly individuals tend to have a decrease in walking speed and mobility, resulting in a reduced incidence of tilting. Furthermore, there is an elevation in the angle measurement for the placements of all axes when people encounter a sudden fall, especially on the z-angle. Comparison graph of gyro reading angle within three conditions is shown is Fig. 13.

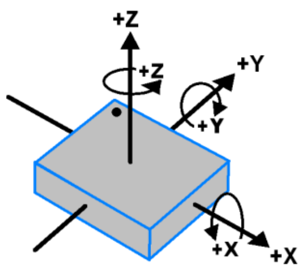


Fig. 10. MPU6050 orientation and rotation.

Fig. 11. Fall detection reading on Blynk App.

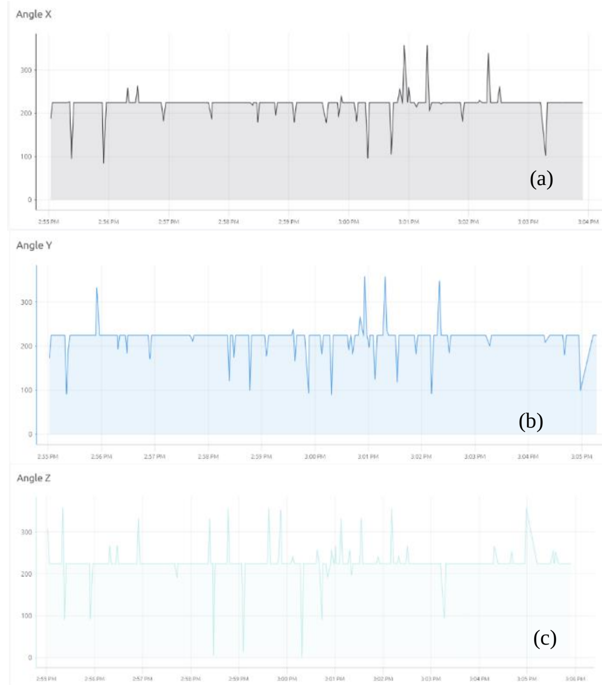


Fig. 12. The graph detector on Blynk App (a) X orientation, (b) Y orientation and (c) Z orientation.

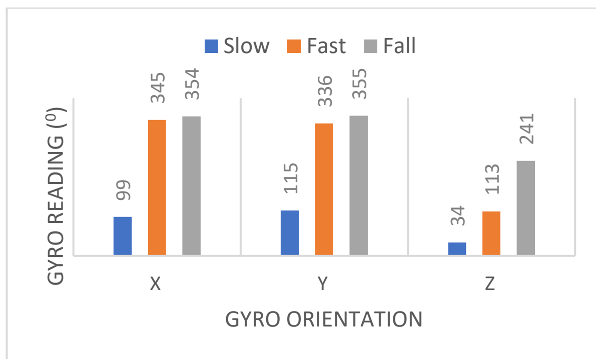
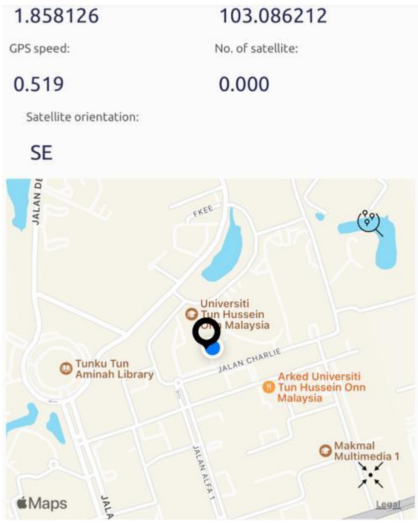


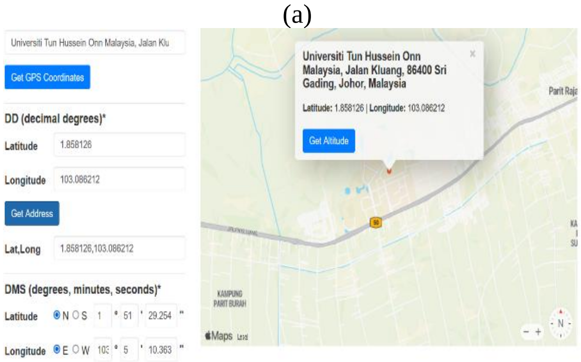
Fig. 13. Comparison graph of gyro reading angle within three conditions.

3.3. GPS Positioning

A comparative analysis was undertaken to validate the precision and accuracy of the GPS data obtained from the GPS module by comparing it with the data from the Google Maps application. Fig. 14 (a) depicts the GPS position acquired from the GPS module. In contrast, Fig. 14 (b) presents the location derived from Google Maps with the input of longitude and latitude data collected from the GPS Module. The accuracy and reliability of the location received from the developed device can be observed.



(a)



(b)

Fig. 14. GPS Location (a) Blynk Apps and (b) Google Maps.

3.5. Notification Alerting

Figs. 15 and 16 illustrate a set of triggered events in which the location of the patient's latitude is achieved by transmitting a notification to Blynk and Email Apps on the caregiver's mobile device, respectively.

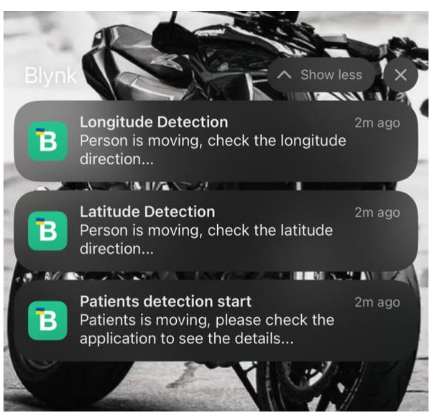


Fig. 15. Notification System in Blynk Application.

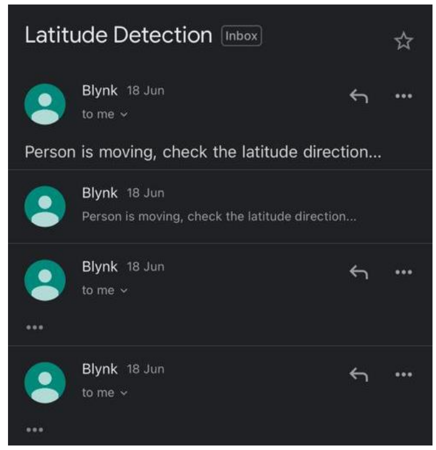


Fig. 16. Notification alert system in an email application.

4. CONCLUSION

Consequently, the monitoring and tracking system module, which integrates the sensors and microcontroller to capture sensor data, retrieve GPS data, and display the specified output on the Blynk application, has evolved as expected. The notification and data recording systems have also been constructed according to specifications. If the event conditions are satisfied, these systems send a push notification to the caregiver's mobile device and store the orientation movement and GPS position data in the cloud. To enhance the system in the future, it is suggested that integration with Starlink, which has been launched in Malaysia, could be considered to establish a GPS-like system. This integration would effectively mitigate any potential disruptions to accurately tracking patients' locations within a building. In addition, a high precision sensor could be implemented to obtain more precise and accurate results.

5. ACKNOWLEDGMENT

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