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IoT Based Falling Detection System

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Abstract: This paper presents a fall detection system for elderly individuals using a smart sensor that can detect changes in body position and notify caregivers when a fall has occurred. The system is designed to be affordable and addresses the issue of falls being a common cause of medical attention required by the elderly, particularly when living alone. The detection algorithm is designed to differentiate between actual falls and normal daily activities (known as Activities of Daily Living or ADLs) in order to reduce false alerts and improve the accuracy of the system. This paper aims to provide a practical solution to combat the issue of falls among the elderly population and to help caregivers provide better care for the elderly.

Keywords: Fall Detection System, Accelerometer (MPU6050), ESP8266

1. Introduction

The older generation has made significant contributions to the development of technology and society, and it is important for the current generation in Malaysia to care for and appreciate them. One major issue affecting the elderly is the risk of falling, which can lead to injuries or death. According to the World Health Organization, falls are a leading cause of injury among older adults worldwide [1]. Even in the case of non-injured falls, 47 percent of people report being unable to stand up on their own [2]. To address this issue, a fall detection system using Internet of Things (IoT) technology has been introduced. This system can alert caregivers by mobile application if a fall occurs, and can be accessed and controlled remotely [3].

According to studies, if a fall incident is detected and caregivers are notified immediately, the probability of hospitalization is decreased by 26% and fatality is lowered by over 80% [4]. Fall detection system plays a vital role in the daily human life. The author, G. Fortino, suggests that fall detection systems are particularly beneficial for elderly individuals who live alone and have ongoing medical conditions that require monitoring [5]. The purpose of this study is to design a user-friendly fall detection system for elderly people using IoT. The use of IoT technology allows the system to be connected to the internet and be accessed remotely, so the caretakers can monitor the elderly person's activity and detect falls in real-time. Other than that, creating an alert notification system that utilizes a smart sensor to notify caretakers through a mobile application when a fall is detected and evaluate the performance and effectiveness of the system. The system

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aims to detect falls and notify the caretaker immediately to take appropriate action. The use of a smart sensor allows the system to be able to detect falls and send the notification to the caretaker through the mobile application, allowing them to respond quickly in case of an emergency. The evaluation process is essential to ensure that the fall detection system is reliable and efficient in detecting falls and providing caretakers with timely notifications, which can help to improve the safety and security of elderly people.

2. Materials and Methods

2.1 Block Diagram

The block diagram of this system illustrates in Figure 1 the process of how a fall detection system works, specifically using the Node MCU Lua V3 ESP8266. The system begins by utilizing the MPU6050 sensor to detect a fall. Once a fall is detected, the Node MCU Lua V3 ESP8266 sends automatic notifications through the Blynk application on a mobile device. Additionally, an alarm alert is also triggered to notify caregivers. This process is designed to provide quick and efficient fall detection, and notification to caregivers, to ensure timely assistance to the elderly person.

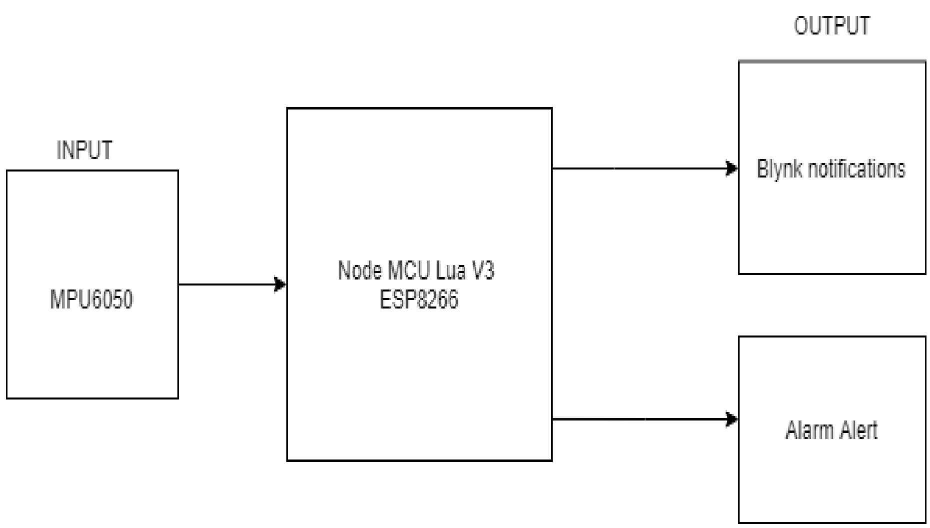

Figure 1: Block Diagram of the System

Figure 1 above shows the block diagram of the fall detection system including the input and output of the whole system.

2.2 Methods

The primary goal of the project that has been presented is to notify the caretakers whenever an older person suffers from any kind of falls. It is possible that employing this alarm system will assist the user in being always aware and in acting promptly in the event of a fall. ESP8266, MPU6050, the BLYNK application and an alarm will be included into this system throughout its development.

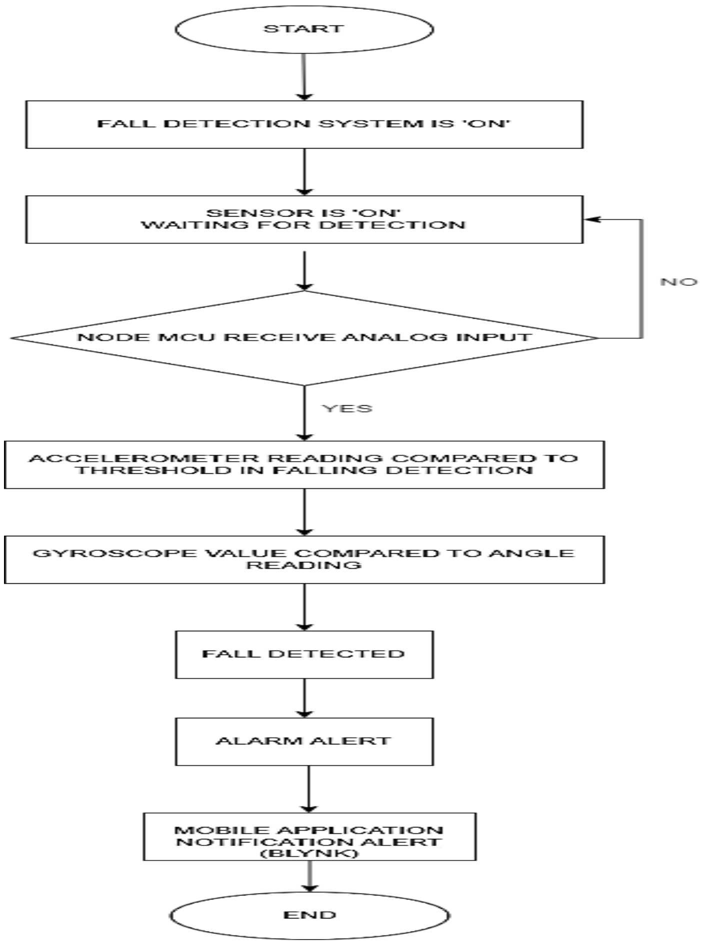

Figure 2: Flowchart of the fall detection system

Figure 2 shows the flowchart of the fall detection system. When the Node MCU ESP8266 microcontroller is turned on, the process of development starts, which includes setting up the MPU6050 sensor and connecting to Wi-Fi. The sensor stays inactive until it detects a fall. If the accelerometer and gyroscope provide the same measurement, the angle reading is considered accurate. When a fall is detected, the sensor sends a warning to the user through the Blynk mobile app and turns the alarm on.

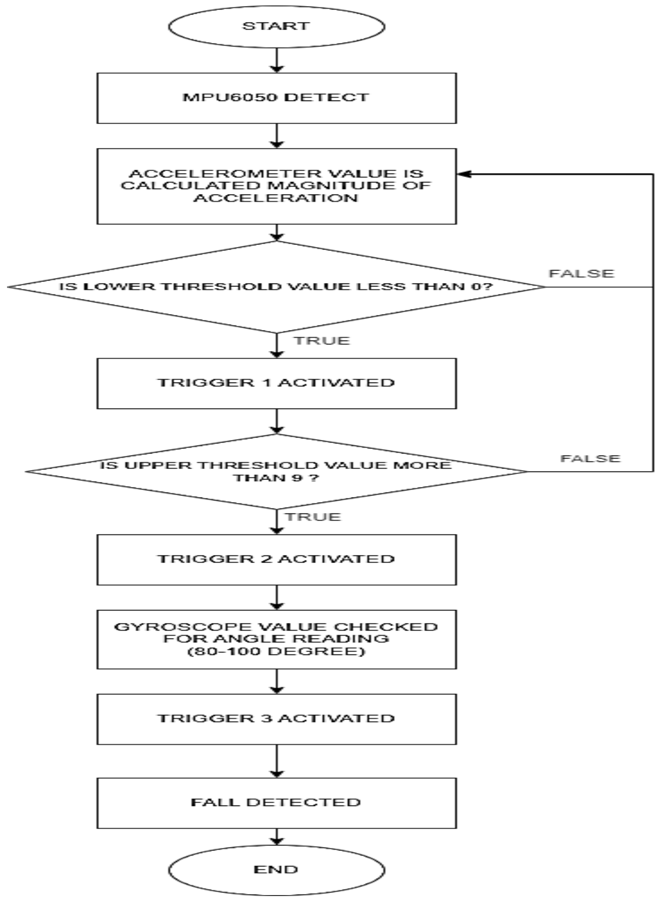

Figure 3: Flowchart of MPU6050

Figure 3 shows the flowchart of the MPU6050. First, MPU6050 will start working, accelerometer value is calculated magnitude of the acceleration. Trigger 1 will activate if lower threshold value = 0, trigger 2 will activate if upper threshold is ≥ 9. Then gyroscope value check for angle reading to activate the trigger 3. If trigger 3 is activated the fall will be detected.

2.3 Project Initialization

To create a functional fall detection system, it is important to properly design and plan the device. One essential component for this is an acrylic container with specific holes for cables, as depicted in the provided Figure 3. These holes are necessary for the USB cable wire and charging cables. The circuit for the fall detection system is placed inside an acrylic container, which will be located inside a chest bag. This circuit includes the Node MCU ESP8266 board, an MPU6050 sensor, a battery, and a buzzer. The acrylic container will be used to house these components and protect them. Figure 4 shows the full circuit inside the acrylic container. This circuit consists of ESP 8266, MPU6050 sensor, battery and buzzer. Two holes are made to connect charging wire for battery and also for USB cable wire.

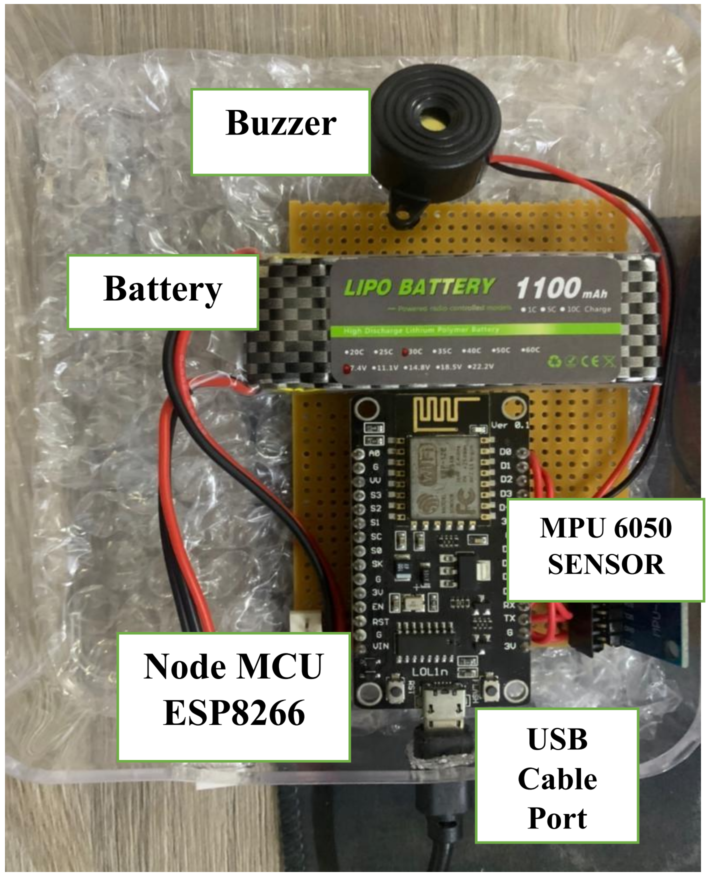

Figure 4: Circuit of the system

Figure 5 shows the acrylic container and chest bag which is easy to wear and safe to use. The acrylic container which is contained in the circuit will be placed inside the chest bags.

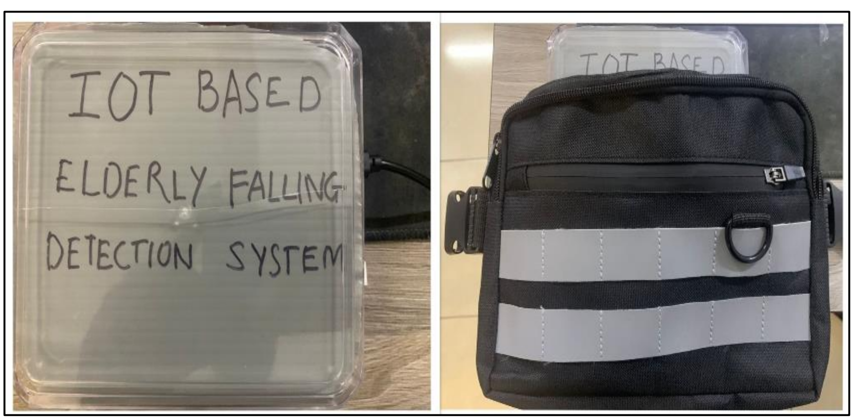

Figure 5: Acrylic container with the chest bag

3. Results and Discussion

The acceleration of various events will be determined by measuring the angles of X, Y, and Z and converting them to m/s^2 units. The results of these measurements will be recorded in a table with 10 samples for each event, which includes 3 types of falling and 5 activities of daily living. The acceleration readings will be displayed on the Blynk app through a terminal widget after subtracting the initial value of 1G (9.8m/s²) due to gravity. The calculations for the acceleration have been programmed into the system and the results can be accessed remotely through the terminal widget. Table 1 shows the range of acceleration values for falls and ADLs, as measured from a set of 10 samples.

Table 1: Tabulation for rage of acceleration and acceleration in G's

TYPE OF EVENTS	EVENTS	ACCELERATION (m/s^2)	RANGE OF ACCELERATION IN G'S
FALLS	FREE FALL FRONT	9.2 – 10.1 m/s^2	0.93 - 1.03G
	FREE FALL BACK	9.4 – 10.3 m/s^2	0.95 - 1.05G
	SIDE FALL	9.5 – 10.8 m/s^2	0.96 – 1.1G
ADL	SITTING IN CHAIR	1.7 – 2.3 m/s^2	0.17 - 0.23G
	WALKING	1.3 – 2.0 m/s^2	0.13 – 0.2G
	STAIRS	3.3 – 4.4 m/s^2	0.33 – 0.45G
	SLOW JOG	3.8 - 5.3 m/s^2	0.38 – 0.54G
	UPPER BODY MOVE	0.9 – 1.9 m/s^2	0.09 – 0.19G

The data shows a range of acceleration values, not a constant value. The acceleration values in the table have been converted to the unit of G, which is a measure of acceleration caused by the Earth's gravity, approximately 9.8 m/s^2 or 1G. The MPU6050 sensor will function in the 2G range since 1.1G is considered the highest acceleration that can be recorded within the G range. The sensor will initially read 9.8 m/s^2 due to gravity but the range must be adjusted to 2G to achieve a better sensitivity output. The fall events have a higher range of acceleration compare to the other 5 ADL events.

Figure 6 shows the scatter graph for the overall acceleration data of 8 types of events. Free fall front, free fall back, side fall have high acceleration data compared to the other five activities.

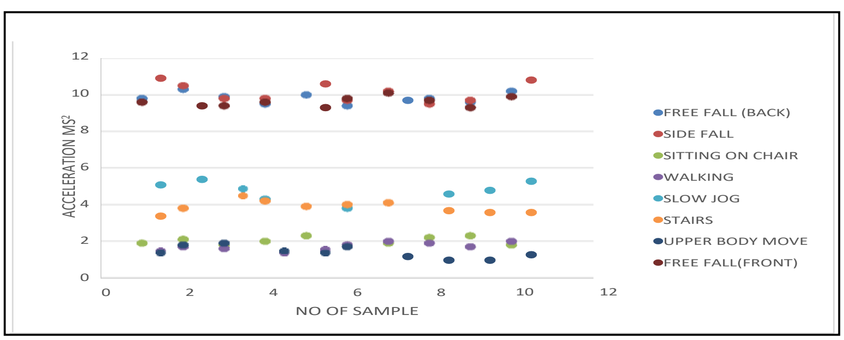

Figure 6: Scatter graph for overall acceleration data

In another experiment involved a moderate weight BMI volunteer who carried out 3 falls and 5 ADLs and data were collected for 30 sets of each activity. The dataset was categorized into TP, FP, TN and

FN and the fall detection system triggers an alarm for caretaker to take immediate action in response to the fall.

Table 2: The data collection for Falls and ADL's

TYPES OF EVENTS	EVENTS	NUMBER OF SAMPLES	TRUE POSITIVE	TRUE NEGATIVE	FALSE POSITIVE	FALSE NEGATIVE
FALLS	FREE FALL FRONT	30	25	-	-	5
	FREE FALL BACK	30	22	-	-	8
	SIDE FALLS	30	27	-	-	3
ADLs	SITTING	30	-	25	5	-
	WAKING	30	-	25	5	-
	STAIRS	30	-	26	4	-
	SLOW JOG	30	-	24	6	-
	UPPER BODY MOVE	30	-	28	2	--
	TOTAL	240	74	128	22	16

Table 2 presents the data collected for both falls and activities of daily living events. A total of 240 sets of data were obtained, with 90 sets for falls and 150 sets for activities of daily living. The performance of the system will be evaluated using the formula provided, based on the data collected, to determine precision, sensitivity, specificity and accuracy. The findings indicate that many of the events had good results, with a low number of false positive or false negative outcomes. However, there were also a significant number of events that had more than 5 negative outcomes, which negatively affected the precision, sensitivity, specificity, and accuracy of the system. The large number of unsuccessful attempts is likely due to problems with the MPU 6050 sensor, which may have had high variability in its data output and may have experienced drifting issues with the gyroscope when the body changed orientation.

In this system, precision and sensitivity are crucial for accurately detecting falls in the elderly. The precision of the system is 77.08%, while the sensitivity for detecting falls is 82.22%. The specificity of the system is 85.33%, and the overall accuracy of the system is 84.17%.

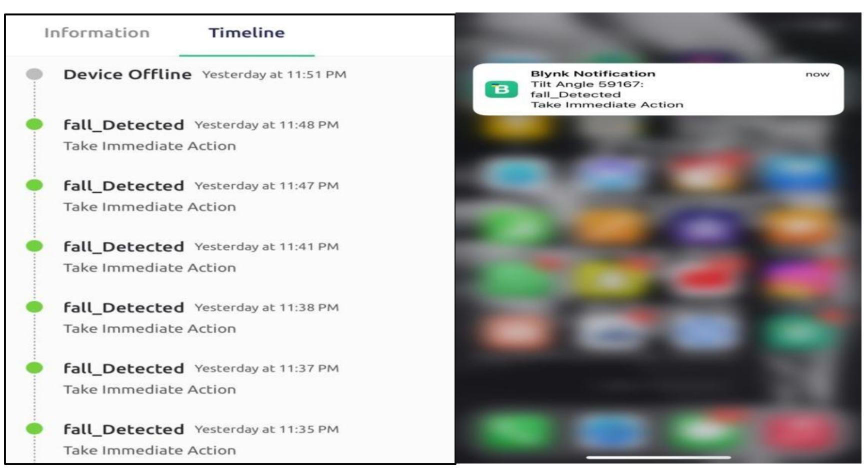

Figure 7: Notifications in mobile phone after fall occurred

Figure 7 shows the notification in mobile phone and Blynk app after fall occurred. Caretakers will receive notifications and alarm will activate whenever fall occurs. When a fall is detected, the sensor will send a notification to the caretaker's Blynk mobile application and activate an alarm to inform them to take prompt action in response to the fall of the elderly person.

4. Conclusion

The IOT Based Elderly Falling Detection System was chosen for the project because it is a practical and affordable solution. The system utilizes a harness with an MPU 6050 sensor to detect falls and everyday activities. The first two objectives of the project, which were to design a user-friendly fall detection system for elderly people using IoT and create an alert notification system with a smart sensor that can notify caretakers, have been achieved. The fall detection system, which uses the smart sensor is able to detect falls and send notifications to caregivers through the Blynk mobile application, and also activate an alarm for those nearby to assist in case of a fall. The third objective of evaluating the performance and effectiveness of the fall detection system has also been accomplished. The system's precision was 77.08%, sensitivity was 82.22%, specificity was 85.33% and overall system accuracy was 84.17%. The system's performance may be affected by factors such as sensor drift and data stabilization.

Acknowledgement

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