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Wearable Fall Detection Device

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Abstract: A family member's constant monitoring of the well-being and health of the elderly, particularly those who live alone, is required. This is due to the significant risk of death from falls among the elderly, particularly those who live alone and sick. On the other hand, constant monitoring of the elderly takes time and disrupts the work-life balance of their family members. Wearable Fall Detection Device (WFDD) had been developed to be wear at the wrist like a smart watch and the family members could monitor their elderly movement by using smart phone. WFDD allow caregivers and family members to be notified when an older person's wearable gadget detects a fall. This approach is supposed to make it easier for family members to keep an eye on their senior relatives. Using WFDD, a caregiver can provide equal and constant attention to numerous elderly people at the same time. Meanwhile, due to the elderly will not feel controlled while being observed, this wearable device will not cause any discomfort to them. As a result, WFDD could help the family members to monitor their loves one and notify an alert if falls happen. Hence, the family member able to call an emergency service for help as soon as the fall happen and suppose able to lower the probability of elderly dying due to falls.

Keywords: Fall Detection, BLYNK, WFDD

1. Introduction

According to World Health Organization (WHO) [1], a fall is defined as an event that will result in a person accidentally tripping on the ground or other lower level. It stated that adults older than 65 years have the highest risk of severe complications such as injuries, hip fractures, head trauma, or death due to falls. A study conducted by Yannis [2] analyzed the risk factors for falls in the elderly. The author concluded that the benefits of exercise and home safety should be informed to the elderly to prevent falls. A study conducted in Malaysia from April until May 2017 by Leong Joyce et al. [3], among the elderly patients at General Physician Clinic, Hospital Kuala Lumpur (HKL), stated that respondents aged 80-89 years old had a higher incidence of fall.

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Other researchers agree [4][5] that the early detection of falls can be crucial for the survival of an older, and a system to alert the people nearby and attract help is required in this situation. The uses and benefits of mobile devices and apps for health care professionals have been well discussed and analyzed by Lee Ventola [6]. Previous research [7] has shown that most men with a strong interest in new technology use mobile devices such as smartwatches, smartphones, and tablets to track physical activity to remain healthy.

1.1 Problem Statement

Existing technology uses magnetometers sensor which is extremely sensitive to their surroundings. Hence, to mount a chip-based magnetometer on a board is considering a crucial process. Transformer or relay field effects must be considered. Low voltage and current in a circuit trace can produce a magnetic field, that strong enough to disrupt a semiconductor, but it lacks precision. Besides, the rotation of an accelerometer along its axis of movement cannot be measured. As a result, it detects angular velocity in conjunction with a gyroscope. It is temperature sensitive, only works in a narrow temperature range and costly for navigation and tilt sensing application.

To overcome the drawback of the existing product, the WFDD is proposed using MPU6050 sensor technology that includes a 3-axis accelerometer and 3-axis gyroscope modules. The accelerometer provides information about the angular parameter, such as three-axis data, while the gyroscope determines the orientation. The magnitude of the acceleration will be compared to the threshold value to detect the fall. To monitor velocity, acceleration, direction, displacement, and many other motion-related data, a micro-electro-mechanical system (MEMS) is employed. Because it has a 3-axis accelerometer and a 3-axis gyroscope, the MPU 6050 is the best option. The effect of WFDD on the environment concerns the safety of older people who live alone in their homes. The impact on mental health is when children will better concentrate on their jobs while still caring for them their parents due to getting this live band.

1.2 Project Objective

- To develop the hardware and firmware of the Wearable Fall Detection Device (WFDD)
- To monitor and analyses the WFDD on the condition falling with 5 different subjects.
- To evaluate and study the effectiveness of WFDD in daily life by detecting the personhood movement.

2. Related Studies

Putu Edy et al. designed the event-triggered machine learning (EvenT-ML). The strategy is described in this work as a novel tool for detecting human falls [8]. Extracting features only while the subject is in the active state prevents feature extraction from being performed all of the time. It also improves previous work by addressing ambiguity induced by multiple acceleration peaks, determining the temporal alignment of fall stages more accurately, and extracting features from the fall stages. Because each stage has its characteristics, precise alignment of fall stages increases falls detection.

Next, for the project from Farhanahani et al. is designed to detect falls by using acceleration impulses received from a Shimmer three-axis accelerometer and data collected through Bluetooth by the Shimmer Connect program [9]. First, to define crucial points in time, the experiment was conducted on daily activities and the falling process. Then there is the fall detection algorithm, which uses two parameters to identify falls: a sum-vector of the horizontal plane and a sum-vector of all axes and acceleration.

Then, this study developed by Young et al. for a cluster-analysis-based user-adaptive fall detection technique that combines a heart rate sensor with an accelerometer to lower the risk of falls. First, designers presented the optimal 13-D feature subset utilizing filter and wrapper to develop a lowcomplexity model [10]. However, previous studies have omitted the feature vector creation of heart rate sensors and acceleration. Then researchers confirmed that using a heart rate sensor and a single accelerometer to detect falls is substantially more effective. Finally, comparing the suggested user-adaptive strategy to 12 standard approaches verifies its effectiveness.

Petar Mostarac et al. studies about the entire system is comprised of a set of sensors on the patient, local data collection units implanted in the patient, and data collection, processing, and storage systems for each patient. Furthermore, local receivers capture data from sensors worn by patients and send it to a server, where it is stored. The technology has two functions: real-time patient monitoring and early detection of a fall in order to summon medical aid [11].

This research by Lourdes et al. describes a way for configuring a simple, comfortable, and rapid fall detection and human activity recognition system based on multimodal sensors that may be deployed and accepted [12]. The methodology is based on the setup of specific types of sensors and machine-learning methods and procedures.

The studies by Nur Izdihar et al. about several sensors and algorithms for fall detection are available. The sensor options have various axis variants, including one, two, and three axes. In a natural context, the proper algorithm for a fall detection system must discern the state of a falling person in any circumstance. A sensor, a microcontroller, a power source, a Bluetooth module, and a receiver module make up this system [13].

Research by Gurdir et al. is about advancement in the IoT Fall Detection System will ensure that the fall is recognized and the victim is treated appropriately at the appropriate moment. It was, furthermore, employing the Internet of Things (IoT) technology to link with the fall detection system and get alert notifications via the Cayenne app. The Wemos D1 Mini, MPU 6050 sensor, and Cayenne app are crucial components in developing this project. The accelerometer or gyroscope sensor with six axes integrated is the system's input, and it will detect any change in a person's body posture or motion. At the same time, the Wemos D1 Mini will interface with the Cayenne software to send notifications via IoT to the mobile phone and record relevant information [14].

In summary, NodeMCU ESP 8266 WIFI module technology will be used for this project because it can transmit data over a long distance while maintaining a low power consumption. Additionally, the ESP 8266 is well-suited for this project because it will deploy the MPU 6050 sensor in the wrist hand and will run entirely on battery power. The MPU6050 module is being used because it is tiny in size and consumes little power. It also has a high repetition rate, a good shock tolerance, and a cheap user price point. With an I2C bus and an auxiliary I2C bus interface, the MPU6050 can readily interfere with other sensors such as magnetometers and microcontrollers. This initiative will investigate the subject in order to establish it.

3. Methodology

This section will describe the circuit connections and the software flow diagram for implementing the system. The overview block diagram of WFDD, which is the overall system for monitoring fall detection in elderly people in this project, is shown in Figure 1.

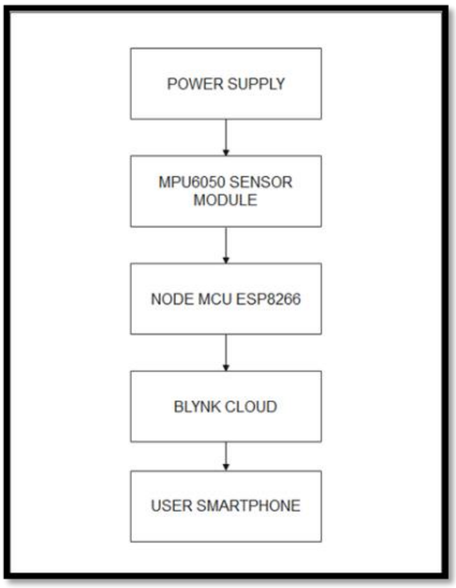

Figure 1: Overview Block Diagram of WFDD

3.1 Flowchart

The project's flowchart is depicted in Figure 2. This will demonstrate the project's progress from inception to completion.

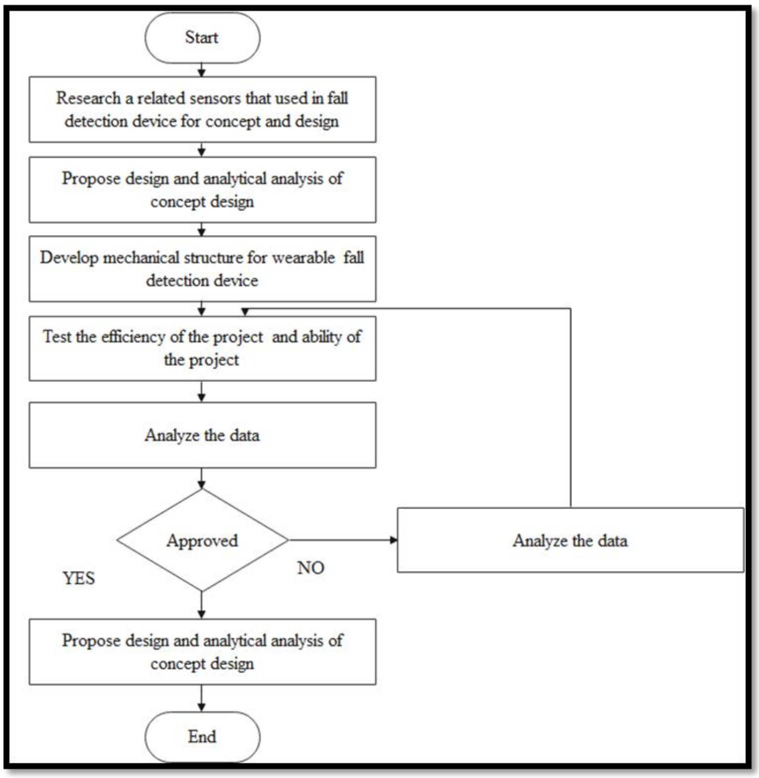

Figure 2: Flowchart of Fall Detection Device Process

Presents a workflow for completing this project before receiving a result. There are a few steps in the process flow that must be completed to complete the project. Firstly, research a related sensor used in fall detection devices for concept and design. This data will prove why this project needs to be developed with analytical analysis in the design concept—after that, developing the wearable fall detection device based on the study done. The production of the wearable fall detection device platform will be equipped with the Arduino, MPU 6050, and the ESP 8266 Wi-Fi module. The Arduino microprocessor will use MPU 6050 sensor as input to collect data from the wearer of a fall detection device. After that, the NodeMCU ESP8266 Wi-Fi module sends a notification through the efficiency test and ability test to make sure the device can work well. The outcome of the tests would be recorded, and if it is not acceptable, the device will need to troubleshoot and upgrade a few enhancements until the project has been completed.

3.2 The value of the sensor

The project's first stage is to determine the value of the sensor. It begins with a simple test code uploaded to the ESP 8266 and then progresses to the MPU 6050 sensor. Two wires are required to connect the NodeMCU and the MPU6050. The MPU6050's SCL and SDA pins are linked to the NodeMCU D1 and D2 pins, respectively, while the MPU6050's VCC and GND pins are attached to the NodeMCU 3.3V and Ground pins. The project's wiring diagram is depicted in Figure 3.

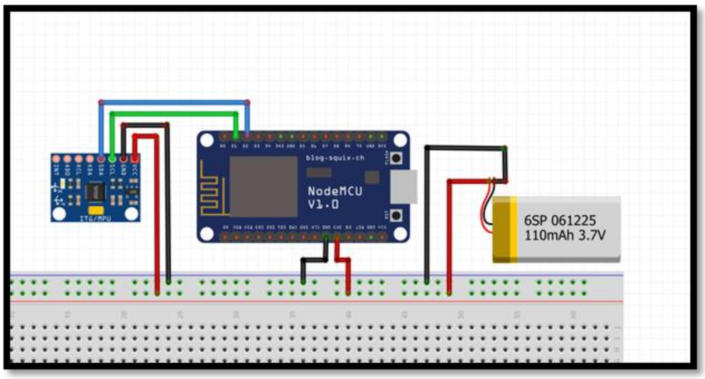

Figure 3: Wiring Diagram of WFDD

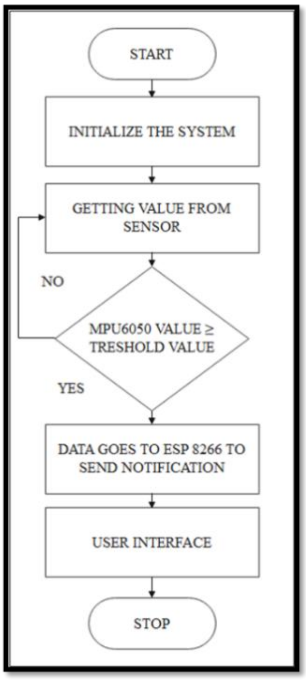

Figure 4: Flowchart of WFDD Process

3.3 The Process of WFDD

A flowchart of the fall detecting device process is shown in Figure 4. The microcontroller Arduino will connect with the sensor, read its value. At the same time, the Blynk software will allow the user to get sensor notifications on the application website in real-time. If the Arduino value exceeds the threshold, the data is sent to the Wi-Fi module, sending the fall notification to the app's website. The website can send the notification to the appropriate user.

4. Results and Discussion

This section contains an evaluation of the project's results and a discussion of the findings. The debate is based on the project's findings. Additionally, the final hardware design is depicted in Figure 5.

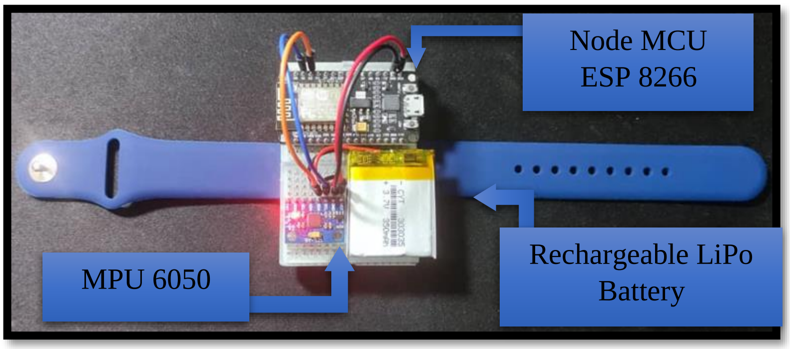

Figure 5: Final Hardware Design of WFDD

4.1 Results

The results may be displayed as tables, figures, charts, or diagrams. The section on results is divided into two sections. The first section of data analysis is to determine the device's functionality for detecting falling activities, and the second section is an experiment to evaluate the WFDD's performance at detecting falling events.

4.1.1 The Value for Sensor WFDD

This section will demonstrate the successful reading of the WFDD for the sensor using the Arduino IDE Serial Monitor, as illustrated in Figure 6.

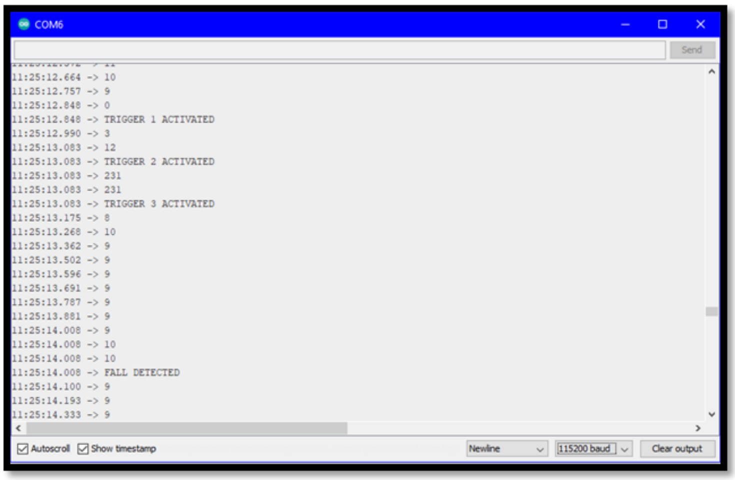

Figure 6: The Value of WFDD On Arduino IDE Serial Monitor

4.1.2 Result of Experiments

The falling events were done with five volunteers of varying ages and genders. These subjects were evaluated in the same falling position and with the same equipment to collect real-time acceleration during the fall. The device recognized and collected data in a stationary position and after falling. For each person, the experiment was repeated three times and the results is recorded in Figure 7. A number of 1 indicates that no fall detection reading was detected, whereas a value of 2 indicates that a fall detection reading was detected.

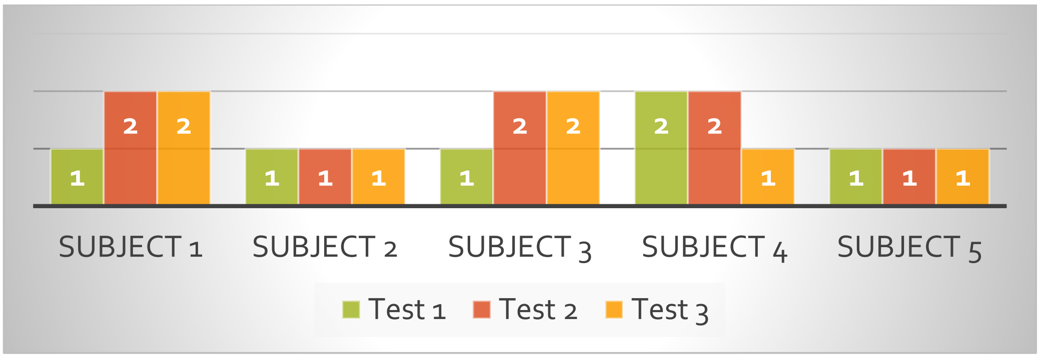

Figure 7: The Result of Experiments

If a fall is detected, the caregiver will be notified via email and the Blynk mobile application. Figure 8 depicts the notification experience for detected falls on Blynk websites, Figure 9 depicts the email notification interface for detected falls, and Figure 10 depicts the notification screen for detected falls in a mobile application.

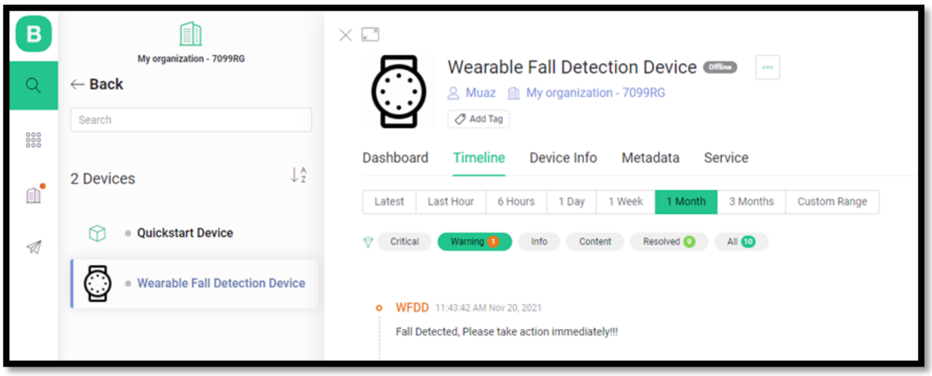

Figure 9: The Interface Notification on Blynk Website

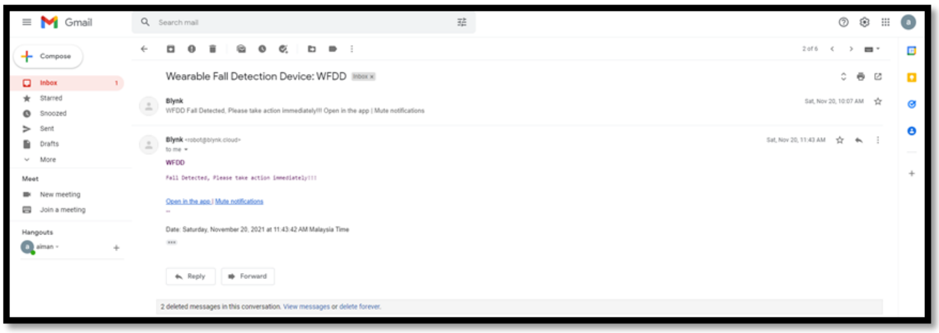

Figure 10: The Notification on Gmail

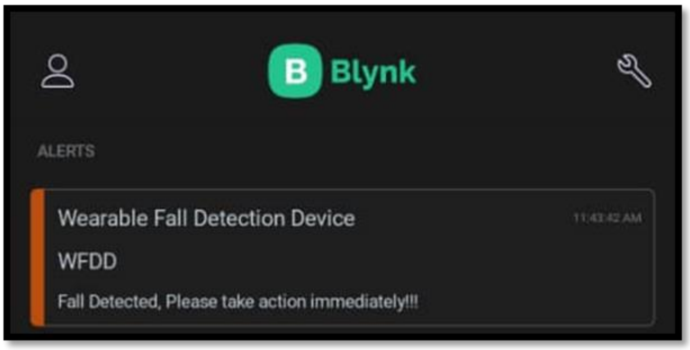

Figure 11: The Notification on Blynk Applications

4.2 Discussions

The Table 1 below shows that a fall could be noticed in the first experiment with subject one due to the plotter's serial readings pointing upwards. This is because subject 1's movement is more energetic and healthier. As a result, the WFDD will be capable of detecting falls. However, the fall occurrence could not be observed in the second experiment with subject two due to the plotter's serial readings pointing downward. This is because subject 2's mobility is slowed down by age and health problems. As a result, the WFDD is incapable of detecting falls. Next, In the third part of the experiment with subject 3, a fall could be observed due to the plotter's serial readings pointing upwards. This is because subject 3's movement is unaffected by age or health issues, making it more active. Thus, the WFDD is capable of detecting falls.

Table 1: The Final Result of Experiments

SUBJECT	FALL DETECTED OR NOT DETECTED
SUBJECT 1	FALL DETECTED
SUBJECT 2	FALL NOT DETECTED
SUBJECT 3	FALL DETECTED
SUBJECT 4	FALL DETECTED
SUBJECT 5	FALL NOT DETECTED

The falling occurrence could be noticed in the following experiment with the fourth subject because the serial readings of the plotter pointing upwards were also pointing upwards. This is because subject 4's movement is still unaffected by age and health factors, which causes subject 4's movement to be more energetic and faster than other subjects. As a result, the WFDD is capable of detecting declining activity. Besides, the fall incident could not be identified in the last trial with subject five because the plotter serial readings were pointing downwards, as they were in the previous experiment with subject 2. As a result of subject 5's relatively sluggish mobility, which may also be influenced by his or her age and health, this is the case. This results in an inability to identify falling activity by the WFDD. The purpose of WFDD is for those who leave alone or having healthy issue as stated in Problem Statement, however WFDD failed to detect the fall occurs for those having healthy issue due to slow motion. Next, what would happen if no follow-up action was taken to save the patient after WFDD provided the notification? This is risky since WFDD can only send messages once to each platform, including the BLYNK website, registered email address, and BLYNK application. This creates risk, resulting in the death of the patient who has fallen. Consequently, to circumvent WFDD's vulnerability, each WFDD user must enable notifications on their phone.

After completing all tests, several conclusions can be drawn, such as that an individual's age and health features play a significant part in the WFDD project. This is because the body will move more swiftly when you are younger and in better health. As a result, WFDD is more accurate in detecting movement. In comparison, when dealing with challenges associated with advanced age or a significant ailment that impairs movement and causes slower body movements, the WFDD is less accurate at detecting any falling activity.

5. Conclusion

In conclusion, WFDD is a device that allows family members and caregivers in old people's homes to electronically watch the elderly for any signs of falling, but not suitable for those having healthy, Since WFDD cannot identify fall activity if the patient's movements are slow during the fall, the patient's delayed mobility may be influenced by the patient's critical health status, including heart disease, stroke, or another type of sickness issue based to result and analysis This device is used by family members and caregivers. This allows family members and caregivers to concentrate on other things rather than spending too much time and effort on the elderly. The fall detection device's main function is to receive real-time data from a wearable fall detection device and to generate a notification to notify family members and caregivers when fall activity is identified among the elderly.

5.1 Recommendation

Some recommendations might be considered to improve this system for future work to raise the project's effectiveness by changing the collecting and monitoring scenario. In addition, the system design provided in this study can be expanded in various ways, including functionality and reliability, as future work. The following are some of the anticipated consequences of this project:

- It is possible to upgrade this wearable device by switching from the ESP 8266 to another IoT's board such as ESP 32 to integrate WFDD because the ESP32 is far more powerful than the ESP8266, featuring a larger number of GPIOs with numerous functions, faster Wi-Fi, and Bluetooth capability.
- WFDD's software and hardware must be upgraded so that it can accurately identify falling behavior even when the user moves slowly.
- Improve the WFDD programmer's coding to enable it to send more alerts in the event of a fall activity; this is critical because it enables users to be notified more precisely.
- Additionally, the alarm sensor can be used as a reminder to take a prescription and a monthly check-up at the hospital to monitor the health system.

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