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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electronics and Computer Technology and Engineering

DEVELOPMENT OF TRACK AND ALERT SYSTEM FOR MEMORY IMPAIRED PERSON BASED ON IOT

TEE MING LOONG

Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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DEVELOPMENT OF TRACK AND ALERT SYSTEM FOR MEMORY IMPAIRED PERSON BASED ON IOT

TEE MING LOONG

A project report submitted
in partial fulfillment of the requirements for the degree of
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DEDICATION

To my beloved mother, Chen Siew Kuen, and father, Tee Kok Seng,
My kind and helpful supervisor, Madam Gloria Raymond Tanny and my lecturers.
You all's belief in my abilities and steadfast encouragement have fuelled my determination.
You all helped me overcame challenges.
This accomplishment is a testament to the inspiration drawn you all's wisdom.
Thank you.

ABSTRACT

Dementia presents significant challenges for the elderly, often resulting in memory impairment and an increased risk of falls. To address these issues, this project introduces a simple tracking device designed specifically for dementia patients. The device incorporates a GPS tracking system and geo-fencing technology to alert caregivers via the Blynk platform when the wearer wanders away from designated areas. Additionally, a fall detection mechanism utilizing an MPU6500 accelerometer and gyroscope module is integrated to detect falls and promptly notify caregivers. Alerts generated by both systems provide real-time information on the wearer's situation, location, and timestamp, enabling caregivers to respond swiftly. Through rigorous testing, the device demonstrates high efficiency, accuracy, and specificity, meeting the criteria for practical use in real-world scenarios.

ABSTRAK

Demensia membawa cabaran besar kepada golongan warga emas, sering menyebabkan kehilangan ingatan dan peningkatan risiko jatuh. Bagi menangani masalah ini, projek ini memperkenalkan sebuah peranti pemantauan mudah yang direka khas untuk pesakit demensia. Peranti ini menggabungkan sistem pemantauan GPS dan teknologi geo-fencing untuk memberi amaran kepada penjaga melalui platform Blynk apabila pemakai berjalan jauh dari kawasan yang ditetapkan. Selain itu, mekanisme pengesanan jatuh yang menggunakan modul akselerometer dan giroskop MPU6500 turut disertakan untuk mengesan jatuh dan memberi amaran dengan segera kepada penjaga. Amaran yang dihasilkan oleh kedua-dua sistem memberi maklumat secara waktu sebenar tentang situasi, lokasi, dan tarikh masa pemakai, membolehkan penjaga bertindak dengan pantas. Melalui ujian yang teliti, peranti ini menunjukkan kecekapan, ketepatan, dan spesifisiti yang tinggi, memenuhi kriteria untuk digunakan dalam situasi dunia nyata.

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My deepest gratitude goes to my parents, whose unwavering support and sacrifices have been the bedrock of my academic journey. Their encouragement, and belief in my abilities have been a constant source of dedication and perseverance. This achievement is a testament to their enduring love and commitment.

An honourable mention is extended to my friend, Huang Cerise, whose motivation and assistance were pivotal throughout the project. Cerise's guidance in report writing and poster making significantly enriched the quality of this work. I am truly thankful for the unwavering support and collaborative spirit that defined our journey together.

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CHAPTER 1

INTRODUCTION

1.1 Background

According to the World Health Organization (WHO), approximately 50 million people worldwide are currently living with dementia, and this number is expected to triple by 2050 [2]. Dementia is a progressive condition that affects memory, thinking, and behaviour, as well as an individual's ability to live independently.

Memory loss, including dementia, is a significant risk factor for wandering in older adults. According to studies, up to 60% of people with dementia will wander at some point during their illness, and those who wander are more likely to fall, be injured, or become lost [1].

Furthermore, carers of people with dementia frequently experience high levels of stress, anxiety, and burnout. According to an Alzheimer's Association survey of family carers of people with dementia, more than 40% reported high levels of emotional stress, and more than 25% reported symptoms of depression [1].

To address these issues, the proposed project will design and build a track and alert device that will use IoT technology to monitor the location of memory-impaired elders and alert carers if they are in danger or have wandered off. The device will include an emergency button that the user can press if they require assistance or have become disoriented.

Overall, the project has the potential to increase the safety and quality of life of memory-impaired elders and their carers while reducing the burden on healthcare systems and emergency services. The device can help prevent accidents and reduce the need for emergency interventions by using IoT technology to monitor the location and movements of individuals with memory impairment.

1.2 Problem Statement

The goal of this project is to create a tracking system with geo-fencing and a fall detection system that is tailored to the requirements of memory-impaired people. For both patients and carers, memory impairment, such as dementia or Alzheimer's disease, presents considerable obstacles, particularly when it comes to guaranteeing their security. The lack of capabilities in current tracking technologies that would be required to meet the special needs of people with memory impairments could result in hazards and restrictions in the monitoring and care of these people.

The lack of a complete tracking solution that integrates geo-fencing and fall detection capabilities inside an Internet of Things (IoT) framework is the main issue that this project aims to solve. The inability to precisely track and locate memory-impaired people due to the lack of an integrated system that makes use of these functionalities leaves them open to potentially dangerous situations like wandering off, getting lost, or falling without help.

The project will investigate the use of Internet of Things (IoT) technologies, such as cloud connectivity and wireless communication protocols, to enable smooth data transfer, monitoring, and management of the tracking device. By utilising these developments, the system will allow carers to remotely track the whereabouts of people with memory impairments and receive alerts when specified boundaries are crossed or falls are discovered.

The project's successful completion will allay the worries and difficulties carers encounter in keeping an eye on people with memory impairments by giving them access to a dependable and effective tracking system. The ultimate goal of this project is to improve the safety, security, and quality of life for people with memory impairments while enabling them to maintain their independence and receive the necessary care and support.

1.3 Project Objective

The main aim of this project is to propose a systematic and effective tracking device with geo-fencing and fall detecting system. Specifically, the objectives are as follows:

a) To study the operation of tracking system and fall detection system.

b) To design and develop a tracker with geo-fencing and fall detection function.

c) To evaluate the reliability and efficiency of the device without severely disturbing the everyday life of memory-impaired people.

1.4 Scope of Project

The scope of this project are as follows:

a) The device uses ESP8266 microcontroller included with GPS and Gyroscope/Accelerometer modules.

b) Blynk will be used as the notifying software of the device when it detected falls and out of bound.

c) The device accuracy will not be easily affected by ADL (Activities of Daily Life).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This part of report will cover the project's literature review session. In this part, materials such as conference paper, articles, and book that related to the project as reference. This is a comprehensive and systematic review of existing literature of the project, purposed to learn the current knowledge, providing a foundation and fundamental knowledge for further research.

2.2 Understanding Memory Impairment in the Literature

Memory impairment concern many people, especially when they grow older. Increasing age will increase the likelihood of having memory loss. [3] While the causes of having memory-impairment are many, most of the medical researchers are researching on how to prevent or decrease the probability of memory-impairment specifically caused by Alzheimer's disease. However, there is also other reason of causing memory-impairment such as Mild Cognitive Impairment (MCI).

Mild Cognitive Impairment (MCI) is a more severe type of memory loss. Although they can live independently while having MCI, they do shows similar level of memory impairment compared to the people who got mild Alzheimer's disease [4].

2.3 Internet of Things (IoT)

IoT is one of the "Industry 4.0" enabling technologies. Its purpose is to connect humans with machines and intelligent technologies. The Internet of Things (IoT) is a massive interconnected network of computer devices (for example, sensors) that exchange large volumes of data at high speeds [5]. Although the Internet of Things is all about synchronising things (devices) across the Internet. This concept is possible with a little help from humans. The tri-sectional relationship between the three features of IoT is depicted in Figure 2.1. [6].

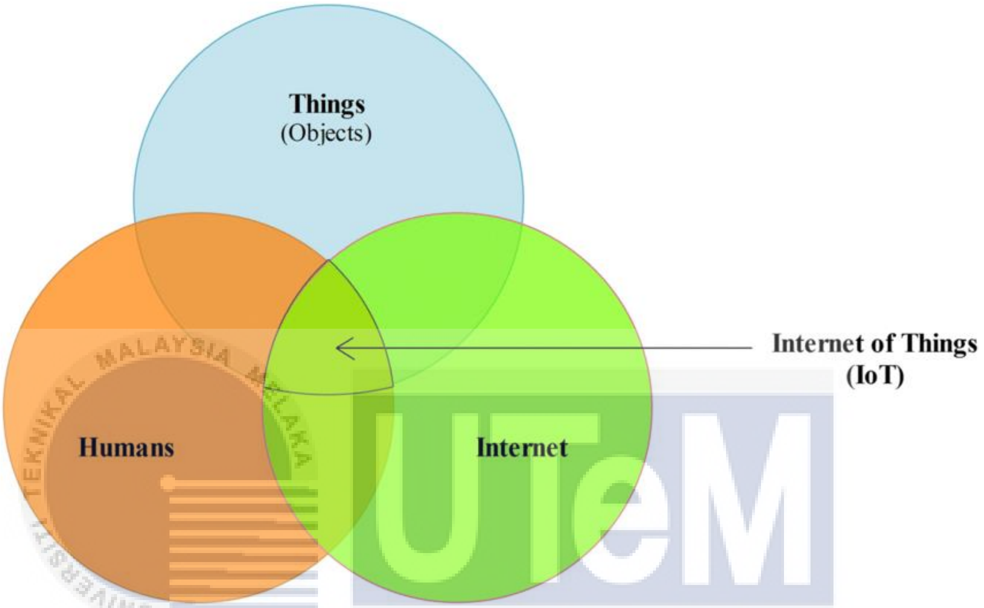


Figure 2.1: Tri-sectional relationship among the three aspects of IoT [6]

2.4 Application of IoT

Recent advances in sensor development, lightweight communication protocols, open source server programmes, web development tools, and IoT dashboards are being used to solve a variety of social challenges [7].

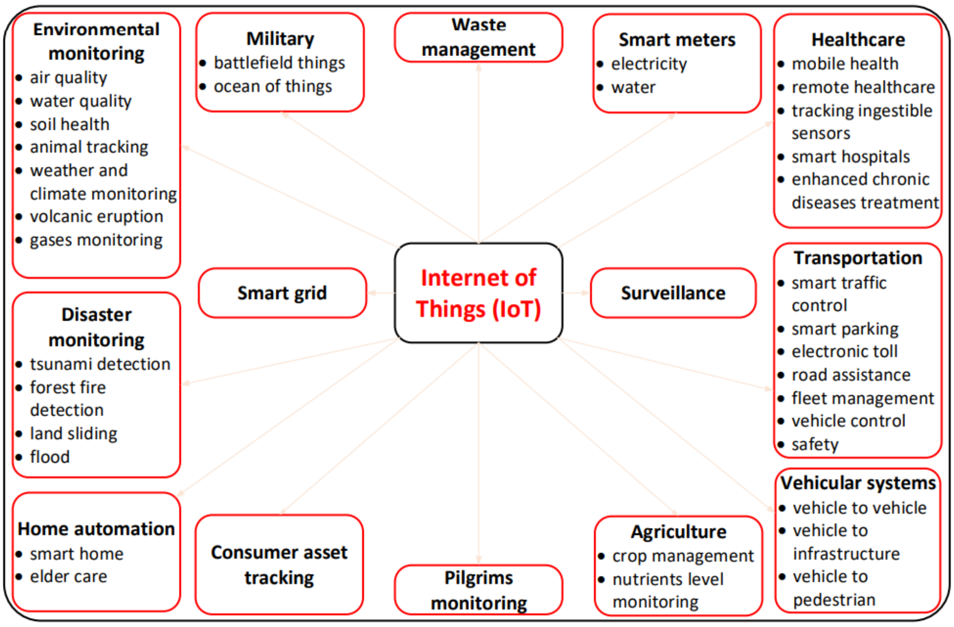


Figure 2.2:: Applications of IoT [7]

2.4.1 IoT in Medical Field

The Internet of Medical Things (IoMT), often known as the Internet of Things, is a systematic application mode that connects healthcare services to the IT system via multiple computer networks. Medical equipment have built-in Wi-Fi systems that enable machine-to-machine communication based on the IoMT concept [6].

Elderly individuals at risk of falling can greatly benefit from remote health monitoring systems that track their movements via various devices such as accelerometers [10] or Kinect cameras [13]. Other patients such as those facing heart disease, neurological illness ,and diabetes can also monitor their condition using wearable technology like respiration rate monitors [10], wireless body sensors [14], pulsometers [17] an autonomous nervous system based textile [18] just to mention a few. Once acquired the crucial signals are then processed, amplified and filtrated before being delivered over networks for safekeeping on remote servers that can later on be analyzed by medical experts who go over patients’ history logs through graphical user interfaces. [19]

2.4.2 IoT in Medical Field: Past Research

This part briefly lists the past researches done particularly for IoT in Medical Field.

Istepanian et al. highlighted the potential advantages of using M-IoT in non-invasive glucose level sensing, and the study provided a feasible m-IoT architecture based on diabetes management. The observations from the framework were provided to mobile devices for information updates [21].

Doukas et al. advocated using created data for future reference and usage by uploading it to a cloud server. For data management, the study proposed a platform based on cloud computing [22].

Sung et al. investigated the feasibility of synchronising real-time remote identification via WSN in the healthcare domain utilising the Android platform. The paper [23] proposed the Particle Swarm Optimisation (PSO) approach.

Amendola et al. proposed using RFID-based applications for body-centric systems to collect data on human behaviour in accordance with power and sanitary laws [24].

Fan et al. asserted that IoT-based smart rehabilitation systems were superior strategies for mitigating issues connected with ageing populations and a shortage of health personnel. The study also presented an Automating Design Methodology (ADM) for IoT smart rehabilitation systems [25].

Xu et al. emphasised the rapid growth of IoT and the ability to connect numerous smart products over the Internet. The study also suggested potential IoT uses in dense information industrial sectors for healthcare services [26].

Yang et al. presented the iHome Health-IoT system, an intelligent home-based platform with an open platform based on an intelligent medicine box (iMedBox) [27].

Hassanalieragh et al. proposed networked sensors that may be worn or incorporated. The framework of these gadgets was capable of gathering rich information indicating an individual's physical and mental wellbeing [28].

2.4.3 Accessibility of Medical IoT Device to Caregivers

Wearable technology, in conjunction with a smartphone, enables healthcare personnel to remotely monitor and treat elderly patients in real time [29]. Through a web browser, physicians can gain access to elderly people's health data and provide feedback. The smartphone may also be programmed to identify emergency scenarios such as falls and irregular heart rates and transmit notifications to carers and medical facilities [29].

2.5 GPS Tracking Device

A GPS tracking device is a gadget that allow users to keep track and monitor the real-time location of the device. GPS trackers communicate with a network of satellites to identify their whereabouts. The tracker employs trilateration, which determines latitude, longitude, elevation, and time by comparing the positions of three or more satellites in the Global Navigation Satellite System (GNSS) network. [30]

2.5.1 Design and Implementation of Real-Time GPS Tracking System

[11] had done researched and designed a reliable and accurate real time tracking system by using Global Positioning System (GPS) and Global System for Mobile Communication (GSM) services. The system provides for the localisation of a portable tracked unit and the transmission of its location to the tracking centre.

The GPS tracking system comprises of a portable tracked device attached to a person, and the tracking centre will monitor the location of the portable device. The mobile tracked device receives its GPS coordinates and delivers them as SMS to the tracking centre, which can be as simple as a personal computer. The design of mobile tracked device is showed in Figure 2.3.

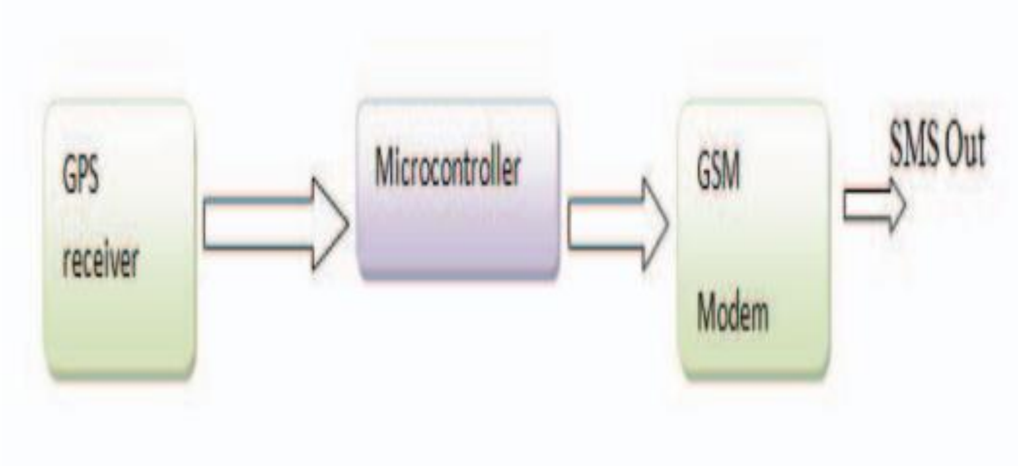


Figure 2.3: The Mobile Tracked Device Design [11]

The GPS receiver gets location coordinates from satellites in NMEA format, which carries a lot of information, with a resolution of five readings/second [31]. The microprocessor evaluates the location information according to the method contained in it, extracting the longitude and latitude, and then commands the GSM modem through serial communication to transmit SMS containing the mobile tracking device's longitude and latitude. Figures 2.4 and Figure 2.5 show the microcontroller algorithms for filtering the NMEA message and delivering the coordinates.

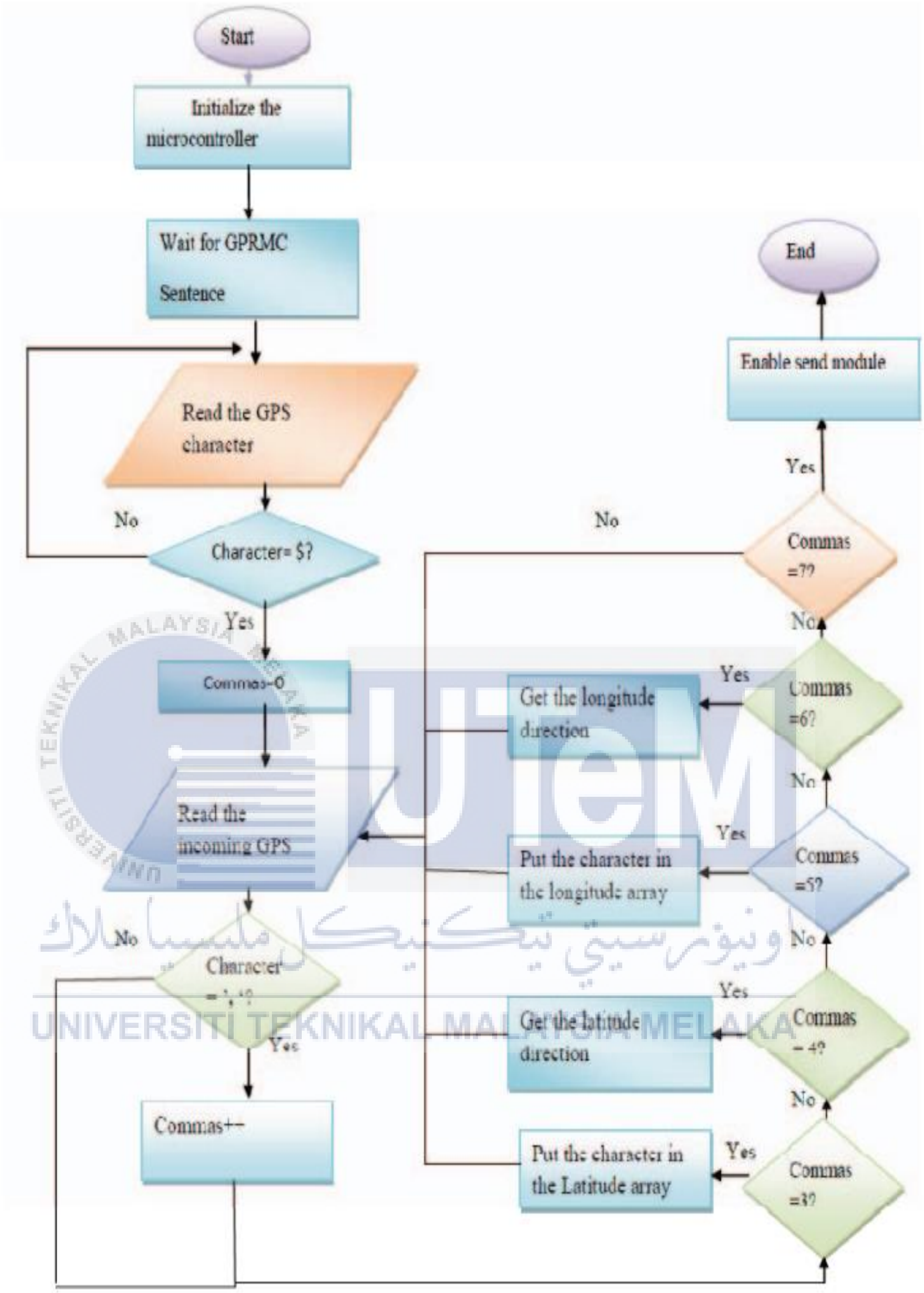


Figure 2.4:The National Marine Electronics Association (NMEA) sentence filtering algorithm flowchart [11]

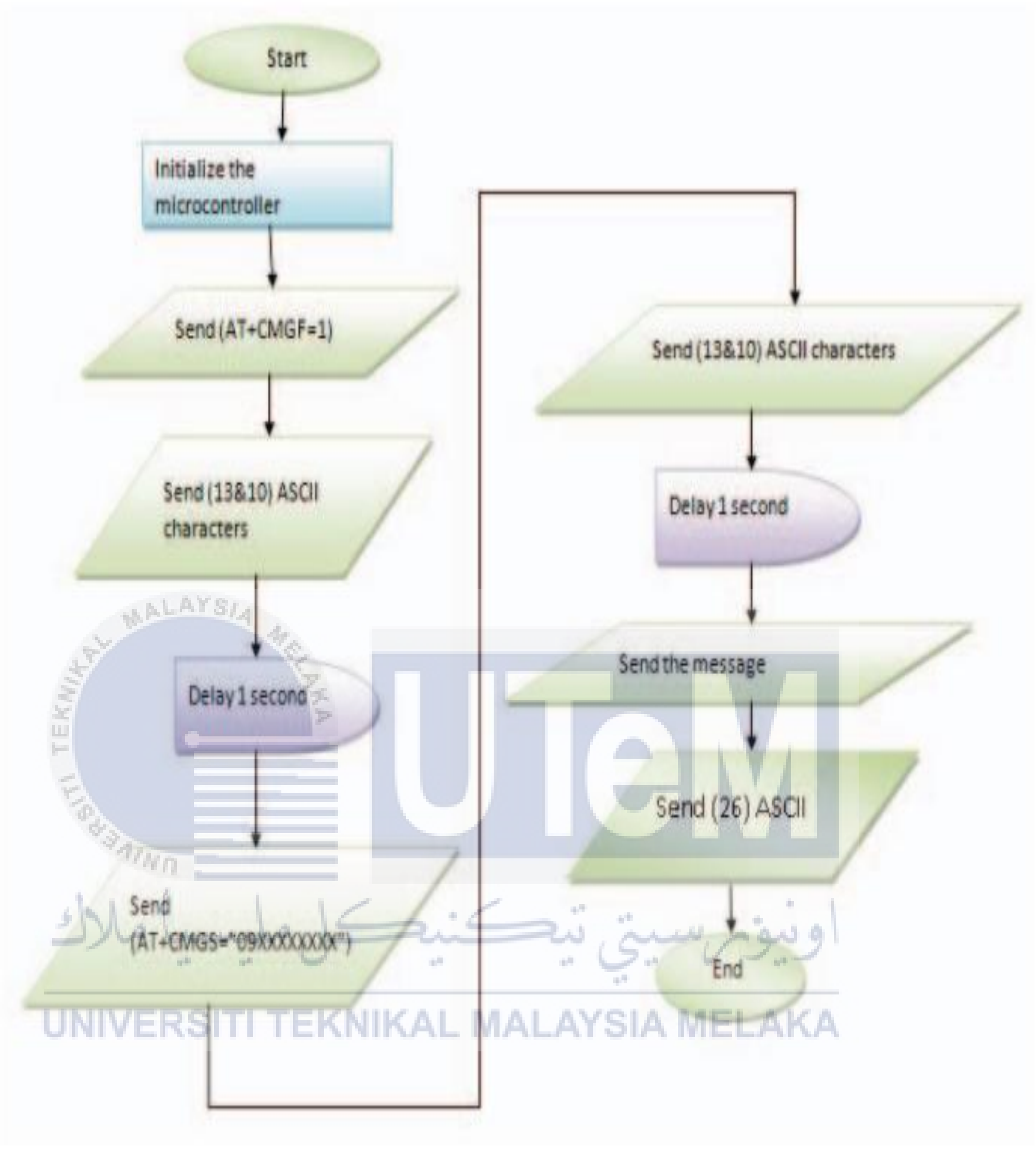


Figure 2.5: SMS algorithm flowchart [11]

The performance of the device is reliable with a system accuracy from 1 to 2.5 meters. Its system total delay is approximately 10 second which is moderate and can be further improved. Overall, the performance of the GPS tracker device is reliable for individual use.

2.5.2 Tracking Device in Dementia Care

A research and design on tracking device purposely for dementia care. They have researched the complexities of caregiving for persons with dementia in institution and home [32]. Dementia patients are like regular people in that they can walk and go places. Although most patients will have a favoured route to wander off and can be guided back by carers in a specific method, it requires a thorough understanding for each patient. The standard procedure for carers at institutions to locate a missing patient is as follows [32]:

1. The caregivers look inside the building.
2. The caregivers call the patient’s relative.
3. The caregivers look outside the building.
4. The caregivers report to the police.

Therefore, it is a very tedious and exhausting way for the caregivers to take care their patient.

When dementia occurs, pre-existing roles can have a different effect on the care concept. In their research, they found one situation where the father was suffering from dementia and his daughter and wife were to care for him. However, the father has always had a strong role and taken command of the family, and he continued to manage the family when he had dementia, causing the female carers to cope with the patient. Wan et al. argue that proposing a universal technical assistance system that works in all situations is indeed difficult [32].

A prototype for the tracking device was developed and tested it in three different settings: a dementia care centre in the countryside, a hospital in the city, and a family. They discovered that carers in rural areas have problems with technology because they have little to no knowledge of technology gadgets, whereas the problem they encountered in city hospitals is that the tracker has an insufficient battery, which dies out before the patient starts wandering off, forcing the nurses to find them manually. The tracker works flawlessly for family members; the patient's wife used it both at home and at work. However, the patient's wife chose not to activate the fencing function and lowered the frequency of the tracker's location reports in order to be less intrusive and allow her husband more privacy [32].

In conclusion, the proposed device had some favourable effects on the experiences of dementia patients and their carers. However, there are still problems that affect the device's performance, such as autonomous issues, environmental considerations, patient and caretaker behaviours, privacy and safety.

2.6 Fall Detecting System

The device in this research not only used a tracking system but also a fall detect system. This subtopic will go through previous studies for fall detection.

A past research [12] has done about making a fall detection systems by combining simple threshold method and Hidden Markov Model (HMM) algorithm.

2.6.1 Fall Detecting Algorithm

The flow diagram for the fall-detection system is shown in Figure 2. The subject's sensor handset sends real-time 3-axis accelerations to the server through a network, and the five types of fall-feature parameters are derived from the sample data in the learning and assessing ranges. [12]

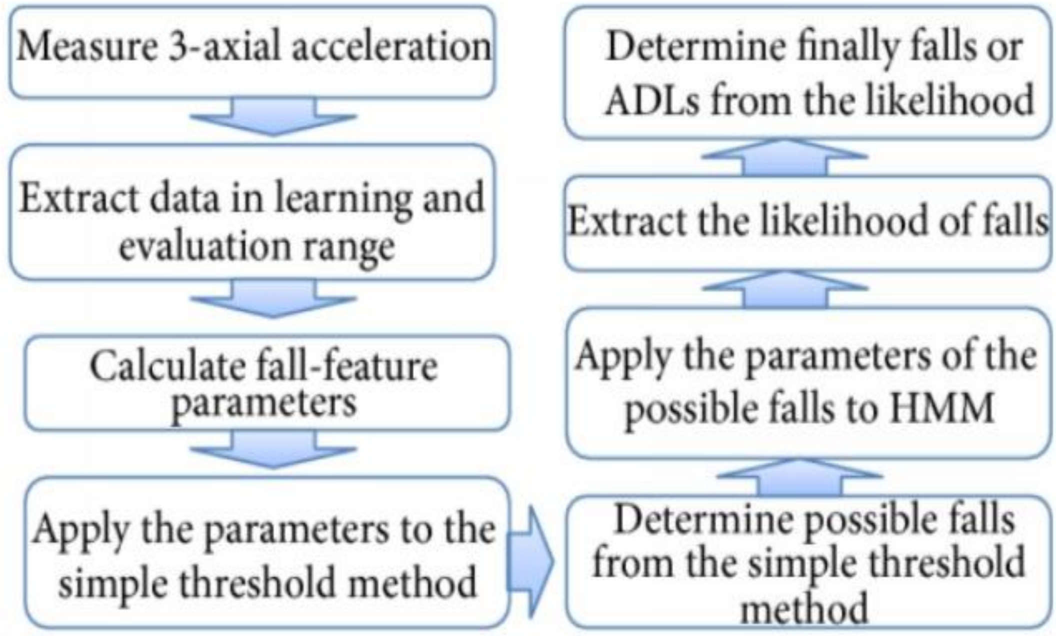
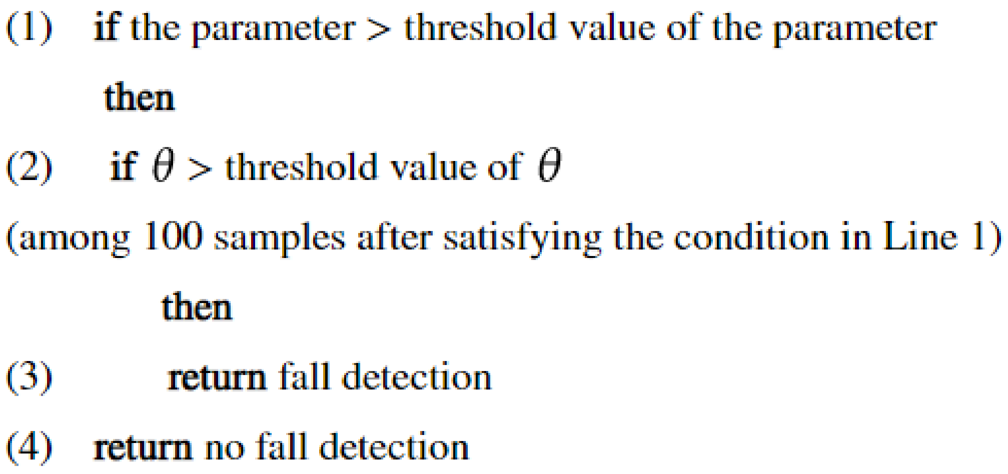


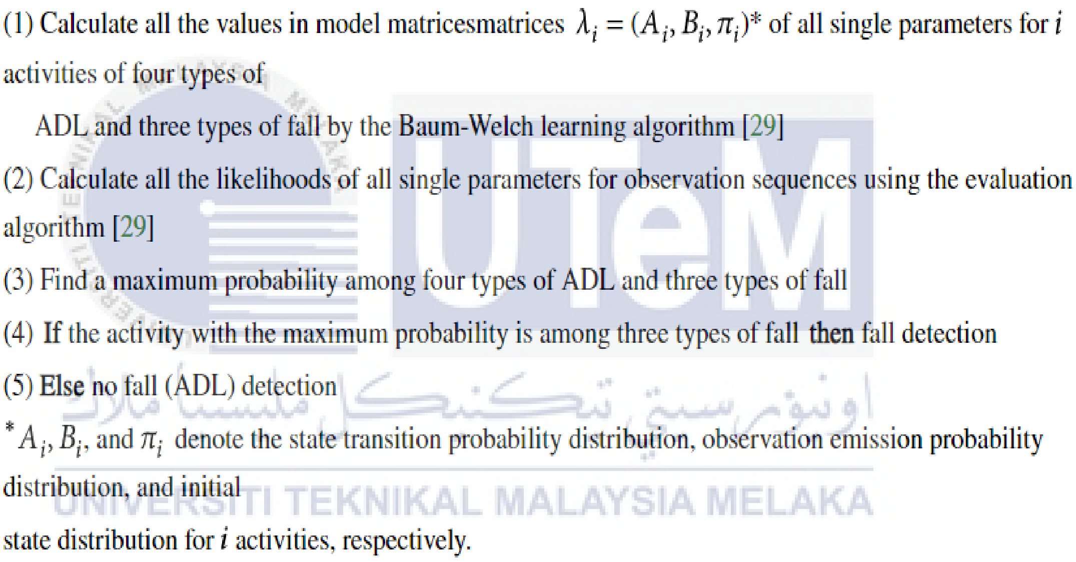
Figure 2.6: Flow diagram for fall detection system [12]

The five parameters are utilised in the simple threshold method to detect whether any of the parameters have exceeded a certain threshold level within a given time frame. If any parameters surpass the threshold level, a fall event is proposed; each parameter is analysed by the HMM algorithm and the system determines the potential of three types of falls: single-level falls, swing falls, and falls to a lower level. If the algorithm detects a high likelihood of any of these three falls, the alert will sound. Otherwise, the device will interpret it as normal activity. Figure 2.7 and figure 2.8 shows the simple threshold method and HMM algorithm used in the fall detecting system.



```
(1)  if the parameter > threshold value of the parameter
       then
(2)    if $\theta$ > threshold value of $\theta$
(among 100 samples after satisfying the condition in Line 1)
         then
(3)        return fall detection
(4)  return no fall detection
```

Figure 2.7: Simple threshold method used in the fall detecting system [12]



(1) Calculate all the values in model matricesmatrices $\lambda_i = (A_i, B_i, \pi_i)$* of all single parameters for i activities of four types of

ADL and three types of fall by the Baum-Welch learning algorithm [29]

(2) Calculate all the likelihoods of all single parameters for observation sequences using the evaluation algorithm [29]

(3) Find a maximum probability among four types of ADL and three types of fall

(4) If the activity with the maximum probability is among three types of fall **then** fall detection

(5) **Else** no fall (ADL) detection

* A_i, B_i, and π_i denote the state transition probability distribution, observation emission probability distribution, and initial

state distribution for i activities, respectively.

Figure 2.8:HMM algorithm used in the fall detecting system [12]

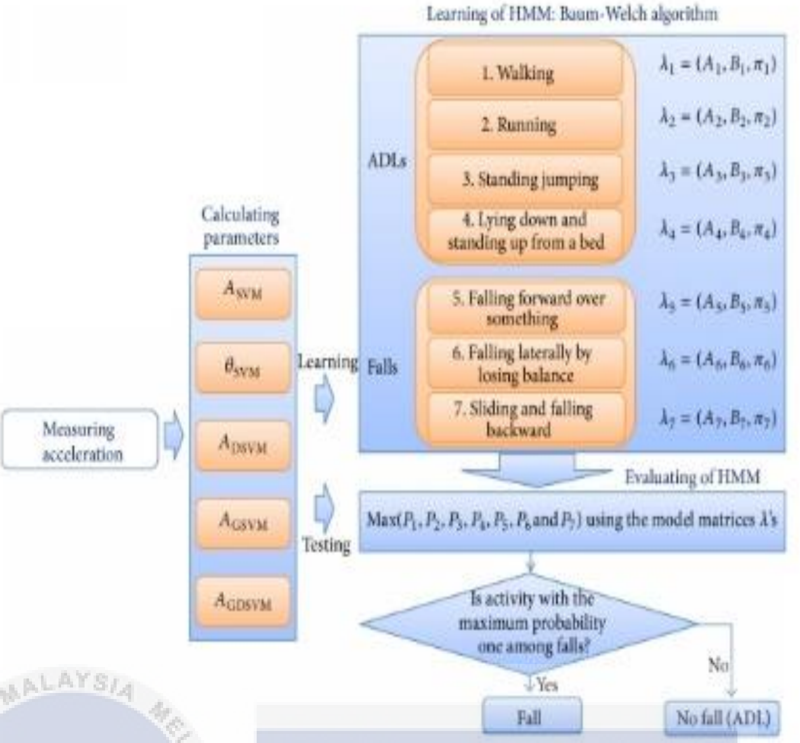


Figure 2.9:Flow diagram of fall detecting system with HMM algorithm [12]

In summary, Lim et al.'s research shows that the device that implemented both simple threshold method and HMM algorithm (accuracy around 99%) is more accurate compared to device that only implemented simple threshold method (accuracy lower than 99%). The addition of HMM algorithm have decreased the probability of having false positive.

2.6.2 Smart Walking Stick with Fall Detector

A research [20] has done where the researchers has created a smart walking stick that implemented with fall detecting system. In their research, the walking stick is able to send an immediate notification to the user's caregivers when the stick detect a fall. The device is composed by a walking stick, GPS module and GSM module.

While the research proposed a very good idea to detect fall of a certain person, the report does not fully described how its fall detector work. The report mainly described the feature implemented on the walking stick such as LED light and lightweight material.

In summary, the advantages and limitation can still be estimated without a detail report. By looking at the feature, the walking stick is expected to be easy to carry and able to light up the way as the user using the walking stick. The walking stick is probably implemented with simple fall detector in the market. However, this invention could produces false positives. For example, the walking stick may assume the user fell down and send notification to the caregivers eventhough the real scenario is the walking stick fell down instead of the user.

2.6.3 Machine Learning Based Fall Detector with a Sensorized Tips

In 2021, a fall detector with sensorized tips was developed, according to a previous study [33]. The research focuses on elderly and disabled people who use an assistive walking aid (ADW), like a cane. Instead of making the user wear the gadget, the research had a sensorized tip on the ADW.

Based on data gathered from a Sensorized Tip attached to an Assistive Device for Walking (ADW), the fall detector approach [33] was developed. Two modules are connected in series to make up the suggested technique. While the second module (User &ADW Fall Detector) uses the fall data to determine if the user fell with the ADW or simply the ADW fell, the first module (ADW Fall Detector) is focused on detecting the fall of the ADW. The purpose of the latter module is to prevent false positives brought on by ADW unintentional falls. The specifics are displayed in figure 2.11.

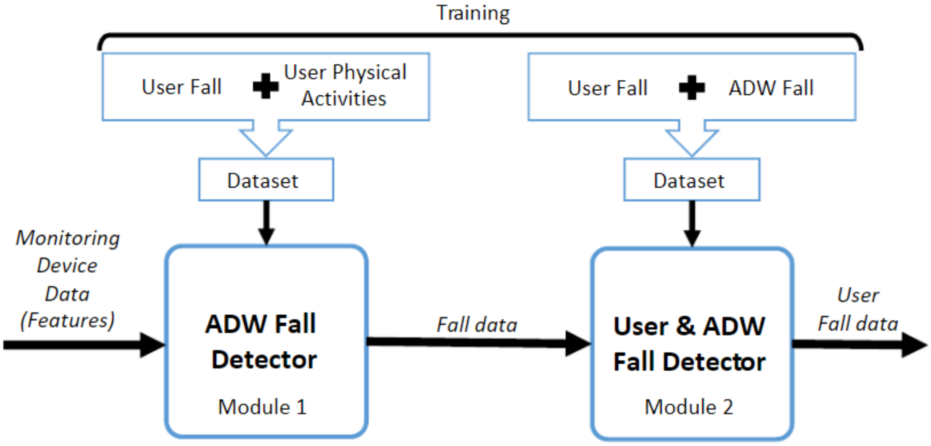


Figure 2.10: Double-module methodology [33]

In conclusion, the gadget [33] developed can attach to ADWs like crutches and canes. The gadget has the ability to recognise false positives in which only the ADW falls but not the user. The research also tests its product in a variety of real-world scenarios, including falls forward, backwards, and while slipping.

2.7 Journal Comparison Table

Table 2.1: Journal Comparison Table

Title	Author	Field	Advantages	Disadvantages
Design and implementation of an accurate real time GPS tracking system. [11]	Abdallah Dafallah, H. A	GPS tracking system	-High accuracy of 1-2.5 meters	-High delay of 10 second

Addressing the subtleties in Dementia Care [32]	Wan, L. Et al.	GPS tracking system in dementia care	-Reliable for family situation	-Not reliable in Rural area because worker lack of technology knowledge. -Low power capacity, the device shut down before patient start wandering away.
Fall-detection algorithm using 3-axis acceleration: Combination with simple threshold and hidden Markov model [12]	Lim, D. Et al.	Fall detecting system using HMM algorithm with simple threshold method	-Combining simple threshold method with HMM algorithm produce sensitive sensor.	-Sensitivity is low and false positive chance is higher if HMM algorithm is not implemented together.
Machine learning based fall detector	Brull Mesanza, A. et al	Implementing fall detecting system to ADW	-Fall detecting device can be attached to	-Smart learning system can be

with a sensorized tip [33]		such as crutches and cane.	ADW instead of wearing. -Able to detect false positive which the ADW fell down and not the user	difficult to code. -Many test need to be done to improve accuracy and prevent false positive.
Smart Walking Stick with Fall Detector. [20]	Nalawade et al.	Walking stick that can notify caregivers when fall detected	-Able to notify immediately after the stick detected fall. -Easy to carry.	-High chances of producing false positive. -Not as reliable as wearable device.

2.8 Summary

In conclusion, the past research has showed that the tracking system and fall detection system is very useful to help caregivers monitoring patients with ease. Moreover, the patient are able to carry out their everyday works without disturbed by the device, as it is easy to carry or wear. For future work, the device can be improve by combining both tracking system and fall detection into one compact device so the caregivers will get to know first when any problem or emergency have been faced by the patients

CHAPTER 3

METHODOLOGY

3.1 Introduction

This section describes the methodology used to create the track and alert system. Following that, this section will discuss the component that will be utilised in the project to build the device. Because the gadget has yet to be manufactured, this section is presently only an estimate. The project is organised into five sections which are planning, design, implementation, testing, and evaluation.

3.2 Overall Concept of Tracking Device

Before delving into the stages, the overall concept of the project should be revised. This gadget should be capable of the following functions:

1. Tracking: Send the user's current location to caregivers.
2. Geo-fencing: Send an alert to caregivers if the user wander too far away from a certain coordinate.
3. Fall detection: When the device detect a fall, it will alert and send the location data to the caregivers.

3.3 Five Stages of Project Development Life Cycle

3.3.1 Planning Stage

In the initial planning stage of the project, a strategic approach was adopted to ensure efficient execution within the defined time frame and budget. A Gantt Chart was instrumental in visualizing and organizing tasks, preventing potential bottlenecks as the project neared its deadline. Regular consultations with the supervisor were conducted to validate the project's relevance and explore opportunities for improvement. This collaborative approach aimed to align the project with expectations and gather valuable insights from the supervisor's expertise. Utilizing a Gantt Chart facilitated ongoing progress tracking, enabling the team to stay on course and make informed adjustments as needed.

Additionally, comprehensive research was conducted by referring to previous studies and projects. This step was crucial for gaining a comprehensive understanding of the project's overarching concept, including the utilization of components, anticipated results, and the systematic construction of the system. By leveraging insights from existing work, the project team could build on proven methodologies and incorporate best practices, ultimately contributing to the project's success.

3.3.2 Design Stage

In the design stage of the tracker with geofence and fall detection system, a meticulous approach was undertaken to integrate key components, ensuring the functionality and reliability of the device. The chosen microcontroller, the ESP8266, proved instrumental due to its built-in WiFi capabilities, ideal for communication in the geofencing system. Additionally, its 3.3V output and compatibility with various modules, including the MPU6500, provided a stable platform for the implementation of the fall detection system. The MPU6500, with its accelerometer and gyroscope functionalities, played a central role in detecting falls by analyzing XYZ values and magnitudes. The incorporation of I2C communication facilitated seamless connectivity between the MPU6500 and ESP8266, contributing to an efficient and cohesive system.

The geo-fencing system was meticulously designed to monitor wearer movements. The system relies on GPS data and a predefined central coordinate to determine whether the wearer exceeds a set threshold distance, triggering notifications through the Blynk app when necessary. The fall detection system, divided into multiple triggers, enhances reliability by discerning between fall scenarios and routine activities. Triggers 1 and 2 focus on sudden accelerations, Trigger 3 validates falling orientation, and Trigger Fall confirms a fall when no further angleChange is detected. This multi-trigger approach minimizes false positives and false negatives, ensuring accurate fall detection.

The overall design emphasizes a synergistic integration of components, harnessing the capabilities of the ESP8266, MPU6500, and GPS module. Through careful consideration of thresholds, trigger conditions, and communication protocols, the tracker with geofence and fall detection system emerges as a robust solution for real-time monitoring and notification in scenarios where user safety is paramount.

3.3.3 Implementing Stage

During the implementation stage of the tracker with geofence and fall detection system, a systematic approach was taken to bring the design concepts to life. The ESP8266 microcontroller, with its built-in WiFi functionality, was successfully integrated to establish communication within the geofencing system. The 3.3V power output of the ESP8266 proved to be well-suited for powering various components, including the MPU6500 module. The MPU6500, responsible for fall detection, seamlessly communicated with the ESP8266 through I2C, enabling the exchange of XYZ values crucial for analyzing accelerometer and gyroscope magnitudes.

The geofencing system was implemented by configuring a central coordinate and setting a maximum radius threshold. Utilizing GPS data, the system continuously monitored the wearer's location, triggering Blynk notifications when the wearer exceeded the predefined distance. The fall detection system, characterized by multiple triggers, was meticulously programmed to analyze XYZ values and magnitudes from the MPU6500. The thresholds for Trigger 1, Trigger 2, Trigger 3, and Trigger Fall were set based on careful consideration of fall scenarios and everyday movements. The implementation prioritized the avoidance of false positives and false negatives, ensuring the reliability of fall detection.

Overall, the implementation stage successfully brought together the selected components and programming logic to create a functional tracker with a robust geofence and fall detection system. The careful integration of hardware and software components ensures the device's effectiveness in real-time monitoring and notification, contributing to user safety and well-being.

3.3.4 Testing Stage

In the testing stage, rigorous evaluations were conducted to validate the performance and reliability of the tracker with geofence and fall detection system. The geofencing system underwent extensive testing, checking its ability to accurately determine the wearer's location and trigger notifications when exceeding the predefined distance threshold. Test scenarios included intentional movements beyond the geofence, simulating real-world situations.

For the fall detection system, a systematic approach was taken to verify each trigger's responsiveness. Test scenarios ranged from controlled falls to routine activities to ensure the system's ability to distinguish between genuine falls and normal movements. The thresholds for Trigger 1, Trigger 2, Trigger 3, and Trigger Fall were fine-tuned during testing to achieve optimal sensitivity and specificity, minimizing the risk of false alarms.

Comprehensive real-world testing involving diverse scenarios was instrumental in refining the system's algorithms and parameters. The iterative testing process allowed for adjustments, ensuring the tracker's accuracy in detecting falls and maintaining geofence integrity. The testing stage was crucial in identifying and addressing any potential issues, ultimately leading to the creation of a robust and reliable tracker with a seamlessly integrated geofence and fall detection system.

3.3.5 Evaluate Stage

In the evaluation stage, the tracker with geofence and fall detection system underwent a thorough assessment to gauge its overall performance, reliability, and adherence to the project objectives. The geofencing system was scrutinized for its accuracy in delineating boundaries, effectively triggering notifications upon breaching the set distance thresholds. Real-world testing scenarios helped evaluate its responsiveness and ability to adapt to dynamic environmental conditions.

The fall detection system, characterized by multiple triggers, was evaluated based on its ability to discern between genuine falls and routine activities. The sensitivity and specificity of each trigger were analyzed to ensure optimal performance. The evaluation process considered diverse situations, from deliberate falls to daily movements, to validate the system's robustness in different contexts.

Throughout the evaluation, user feedback and system logs were instrumental in identifying any potential shortcomings or areas for improvement. The tracker's ability to provide timely and accurate notifications, coupled with its reliability in fall detection, were key metrics in the assessment process. The system's effectiveness in enhancing user safety and well-being was a paramount consideration.

In conclusion, the evaluation stage provided valuable insights into the tracker's performance, enabling refinements and adjustments for enhanced functionality. The iterative nature of the evaluation process contributed to the development of a highly capable tracker with a geofence and fall detection system that aligns with project goals and user expectations.

3.3.6 Methodology

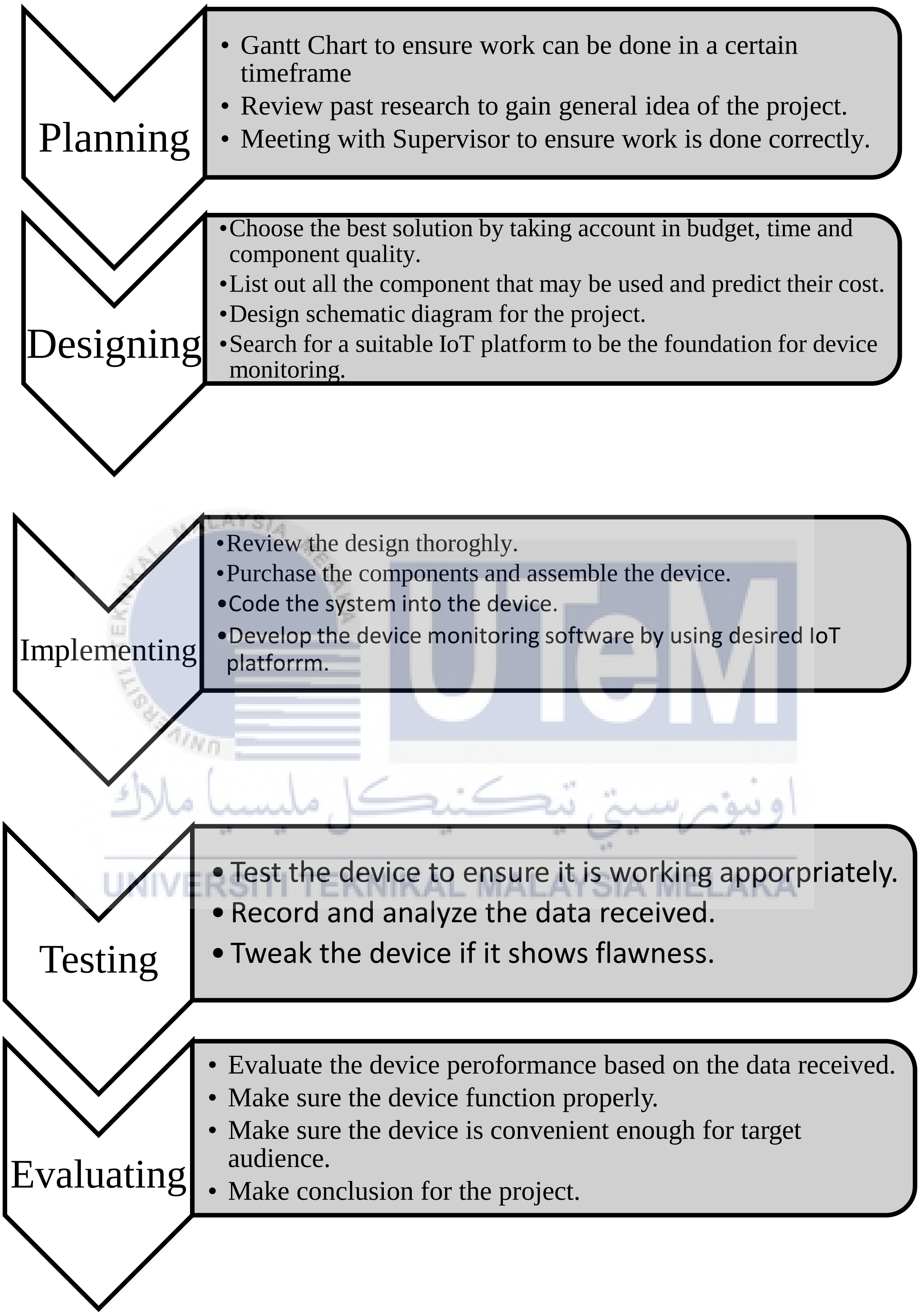


Figure 3.1: The simplified stages of methodology

3.4 Geo-fencing System

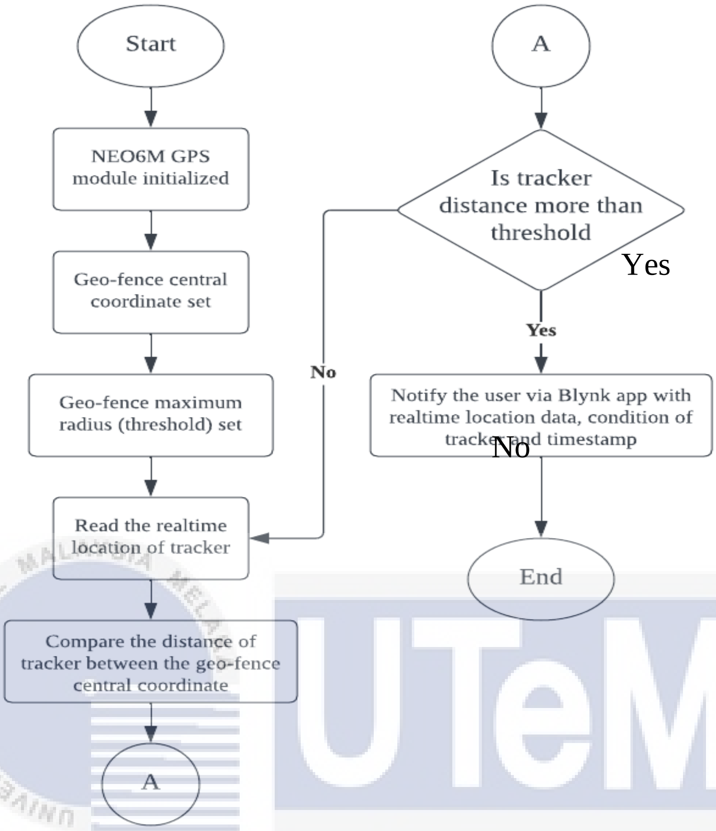


Figure 3.2: Flowchart of Geo-fencing system

Referring to Figure 3.2, which illustrates the flowchart of the geo-fencing system, the functionality aligns with the depicted process in this project. Initially, a central coordinate is established as the focal point of the geofence, followed by the setting of a maximum radius as the threshold. Subsequently, the GPS module reads the data from the tracker, analyzing the distance between the tracker's location and the central coordinate of the geofence.

The system then compares this distance with the pre-set threshold. If the distance surpasses the threshold limit, the ESP8266 triggers a notification to the Blynk user via the app, indicating that the tracker is "out of bounds." The notification includes real-time location data of the tracker and a timestamp. On the other hand, if the tracker remains inside the geofence, the GPS module continues to monitor the location and distance until an "out of bounds" condition is detected. This comprehensive process ensures that the geo-fencing system functions effectively in notifying the user whenever the tracker ventures outside the defined boundaries.

3.5 Fall Detection

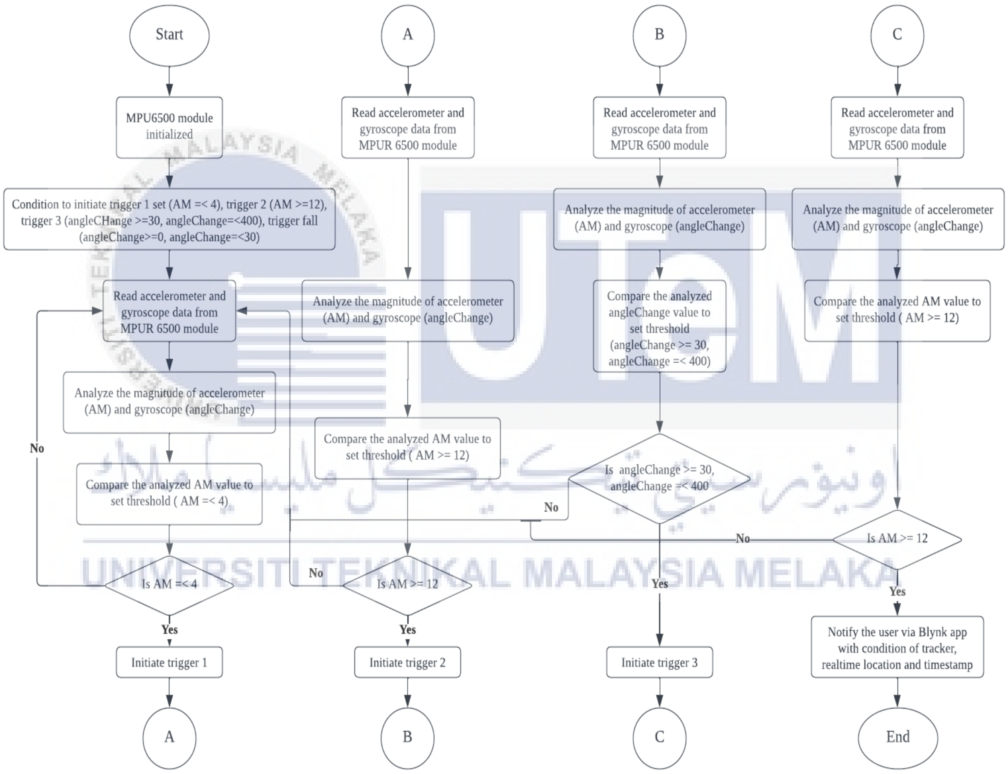


Figure 3.3: Flowchart of fall detection system

Referring to Figure 3.3, outlining the fall detection system flowchart, the system in this project operates in accordance with the depicted process. The fall detection system is strategically divided into four triggers, each designed to address specific conditions and minimize the likelihood of false positives and false negatives, thereby enhancing reliability. These triggers are outlined as follows:

1. **Trigger 1:** Activated when Accelerometer Magnitude (AM) is less than or equal to 4.

2. **Trigger 2:** Activated when AM is greater than or equal to 12.

3. **Trigger 3:** Activated when Gyroscope Angle Change (angleChange) is between 30 and 400.

4. **Trigger Fall:** Activated when angleChange is between 0 and 30.

The MPU6500 reads XYZ value data from the tracker, transmitting it to the ESP8266, which then analyzes the magnitude of both accelerometer (AM) and gyroscope (angleChange). The initiation of triggers depends on the analyzed magnitudes, ensuring that multiple criteria are met before confirming a fall detection. The multi-trigger approach is implemented to discern between actual falls and various Activities of Daily Living (ADL), thus enhancing the system's reliability.

Triggers 1 and 2 assess sudden accelerations, Trigger 3 validates the falling orientation within a specific range, and Trigger Fall ensures that there is no further angleChange after Trigger 3, indicating that the wearer is lying on a surface. This comprehensive methodology aims to accurately detect falls while minimizing false alarms due to routine activities or movements.

3.6 List of Components and Materials

3.6.1 GPS Module

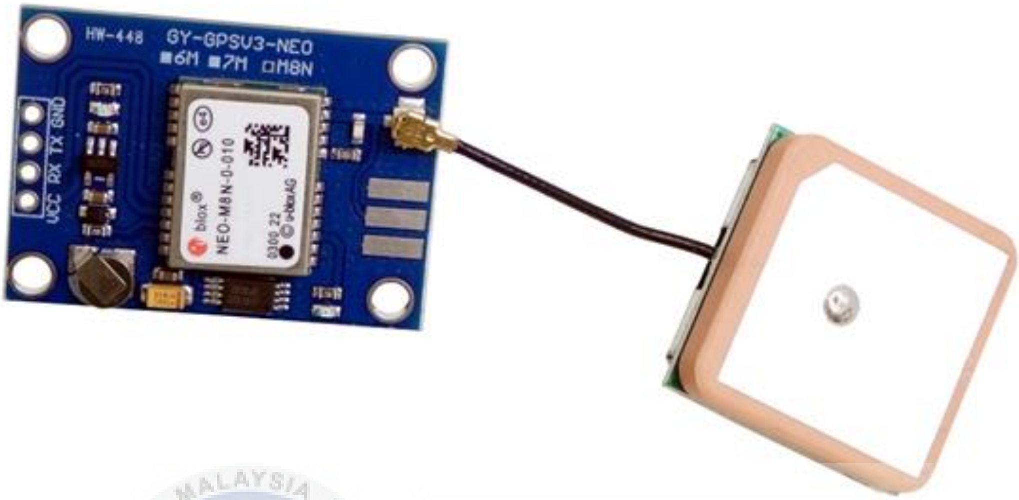


Figure 3.4: NEO-6M GPS Module

The NEO-6M GPS module is a component used in the project to provide precise positioning and tracking. It functions as a GPS receiver, giving real-time geographic coordinates and related data.

The NEO-6M GPS module's main function is to collect signals from several satellites and produce exact geographical positioning data. It is important in sending precise location information, which enables location-based functionality in the project. Within our application, the NEO-6M GPS module serves as a critical sensor for tracking, navigation, and geographic analysis.

A high-sensitivity GPS receiver chipset is incorporated into the NEO-6M GPS module's design, guaranteeing reliable signal gathering and processing capabilities. It is excellent for embedded applications and simple to integrate thanks to its small form factor and integrated antennas. Serial communication protocols are used by the module and the main microcontroller to enable seamless data exchange and control.

Through serial communication, the project's microcontroller and NEO-6M GPS module communicate with one another. It gets electricity and connects to the microcontroller using specific pins, guaranteeing dependable connectivity and management. The microcontroller can use the module's continual updates of latitude, longitude, altitude, and time to make intelligent decisions about where things are.

3.6.2 Microcontroller

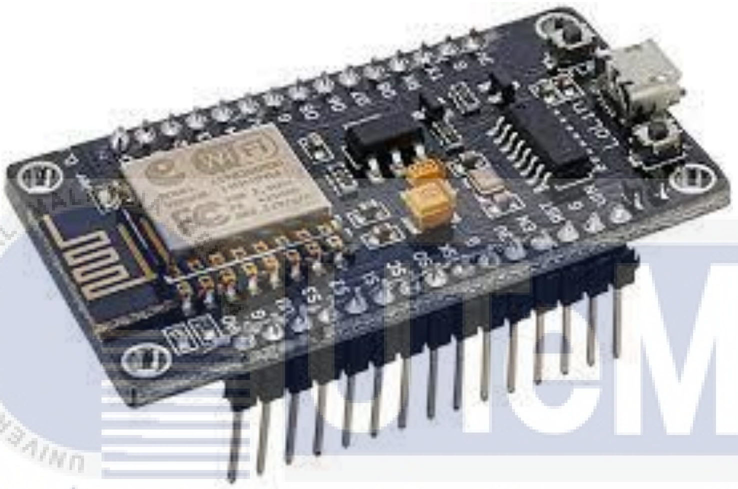


Figure 3.5: ESP8266 Microcontroller

The ESP8266 microcontroller is renowned for its versatile features that make it well-suited for a variety of applications. One of its key attributes is the built-in WiFi functionality, allowing seamless integration with networks and facilitating communication with other devices over the internet. This makes the ESP8266 an ideal choice for projects requiring wireless connectivity.

Additionally, the ESP8266 supports software serial, providing the flexibility to establish multiple serial communication channels without the need for additional hardware. This is particularly advantageous when interfacing with various modules that require serial communication.

The microcontroller's 3.3V output is noteworthy, striking a balance between providing sufficient power for connected components and preventing potential damage due to excessive voltage. This makes it compatible with a wide range of modules commonly used in electronic projects.

Equipped with an I2C (Inter-Integrated Circuit) port, the ESP8266 facilitates communication with I2C-compatible devices, enabling the connection of sensors, displays, and other peripherals that utilize this communication protocol.

Furthermore, the ESP8266 boasts a compact and small form factor, making it suitable for projects with space constraints. Its combination of WiFi capabilities, support for software serial, 3.3V output, I2C port, and compact size makes the ESP8266 a versatile microcontroller widely employed in various IoT and electronic applications.Gyroscope and Accelerometer Module

Figure 3.6: MPU6500 Gyroscope and Accelerometer module

The MPU6500 module is a sensor module that combines both accelerometer and gyroscope functionalities, making it particularly valuable in applications like fall detection systems. The accelerometer component measures acceleration forces in multiple axes, providing data on the module's movement and orientation. The gyroscope, on the other hand, measures the rate of rotation, offering insights into angular velocity and changes in orientation.

In the context of a fall detection system, the MPU6500's accelerometer data is crucial for detecting sudden changes in acceleration, which can indicate a fall. The gyroscope data aids in understanding the rotational aspects of the fall, enhancing the system's ability to recognize distinct fall patterns.

The MPU6500 communicates with the ESP8266 microcontroller via I2C (Inter-Integrated Circuit), a widely used communication protocol. This I2C connection enables efficient and reliable data exchange between the MPU6500 and the ESP8266, facilitating seamless integration into the overall fall detection system.

Basic characteristics of the MPU6500 include its compact size, low power consumption, and ability to operate in various environmental conditions. Additionally, its high sensitivity and precision contribute to its effectiveness in capturing subtle movements and changes in orientation, making it a key component in fall detection and motion-sensing applications.

3.6.3 Power Supply

Figure 3.7: Power bank

A portable device that stores electrical energy in an internal battery and may subsequently release that energy to charge other devices is known as a power bank. It usually includes circuitry that handles the charging and discharging processes, guaranteeing effective power transfer and preventing connected devices from overcharging or power surges. Power banks are charged by plugging them into a power source, such as a wall outlet or a USB connection, and their output ports can power a variety of devices, including smartphones, tablets, and microcontrollers such as the Arduino UNO. The image above is just for illustration purpose only. Actual product may vary due to product enhancement.

3.7 Budget Required for Components

Components	Prices
NEO-6M GPS Module	RM25
ESP8266 Microcontroller	RM20
MPU6500 Gyroscope and Accelerometer Module	RM12
Power Bank	-

Table 3.1: Budget for Project

Table 3.2 provides the approximate budget of the project component. The entire money required is approximately RM57, which is within the range of the university's budget of RM200. The price for the power bank is not listed because the components do not contribute to the gadget's construction; they are just required to turn on the device in order for it to function properly.

3.8 Block Diagram

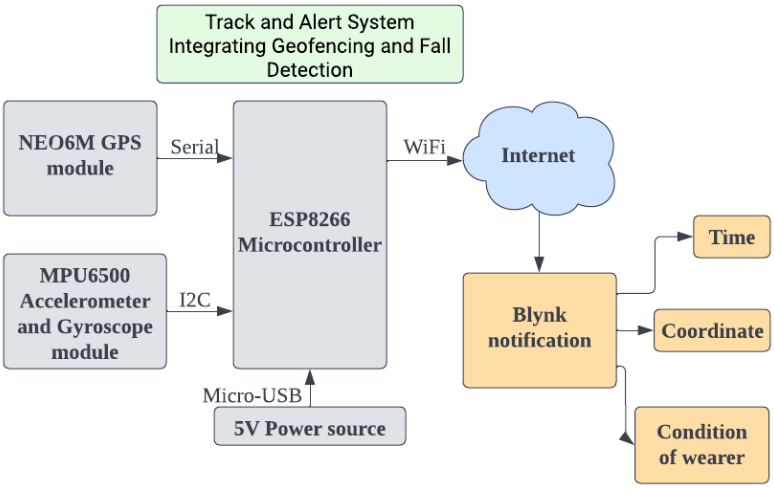


Figure 3.8: Block Diagram for Tracking Device

3.9 Summary

In summary, the device has implemented a GPS tracking system, a geofencing system and a fall detection system. To facilitate the successful implementation of these systems, several components and a microcontroller were utilized in the project. The chosen microcontroller for this project is the ESP8266, complemented by key components including the NEO-6M GPS module, responsible for collecting location and timestamp data from the wearer and transmitting it to the microcontroller. Additionally, the MPU6050 is employed to gather gyroscope and accelerometer data, enabling the detection of falls by the wearer.

The ESP8266 was selected as the microcontroller due to its built-in WiFi module and a power output of 3.3V. This power output is deemed optimal, striking a balance between being neither excessive nor inadequate for powering the other components of the device.

CHAPTER 4

RESULT

This chapter encompasses the presentation and analysis of results obtained from the development of the tracking and alert system. The results are categorized into three main components: the geofencing system, fall detection system, and the notification system. Each of these aspects will be expounded upon in separate subchapters to facilitate a comprehensive understanding of the findings.

4.1 Fall Detection System

The fall detection system constitutes a pivotal subsystem within the device. In this subsystem, the MPU6050 is tasked with detecting the magnitude of accelerometer and gyroscope data, subsequently transmitting this information to the ESP8266 microcontroller. The microcontroller, in turn, employs a specific algorithm to discern whether a fall has occurred. Upon detecting a fall, the device triggers a notification sent to the caregiver's phone through the Blynk app. This notification provides details indicating that the wearer has experienced a fall, accompanied by pertinent information such as the location and timestamp of the incident.

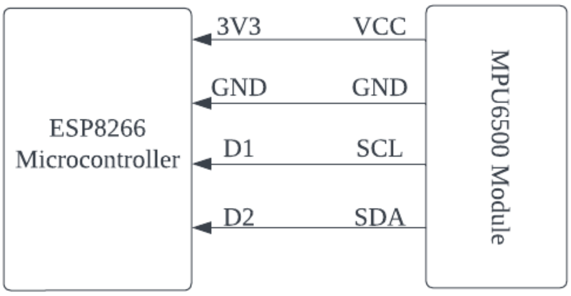


Figure 4.1: Block diagram for fall detector

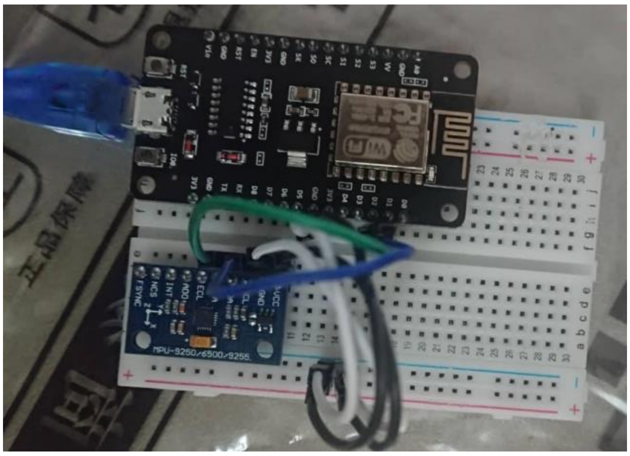


Figure 4.2: Circuit configuration of fall detector.

4.1.1 Accelerometer and Gyroscope Data

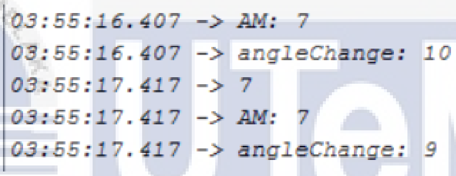
The fall detection system operates by scrutinizing the X, Y, and Z values of the accelerometer and gyroscope within the MPU6500 module. These readings are subsequently transmitted to the ESP8266, which undertakes the computation of the magnitude of both accelerometer and gyroscope data. A predefined threshold is set, and if the calculated magnitude surpasses this threshold, the system interprets it as indicative of a fall. Consequently, the fall detection mechanism is triggered.

4.1.1.1 Static Data

The X,Y,Z data and magnitudes are captured while the MPU6500 module is in a static condition, positioned in various orientations such as standing upfront, lying laterally, and lying in the supine/prone position. By collecting data in these different stances, we can discern which values are unsuitable for setting as the threshold to mitigate the occurrence of false positives. This comprehensive approach allows for a more accurate determination of threshold values that effectively distinguish between normal movements and potential fall events.

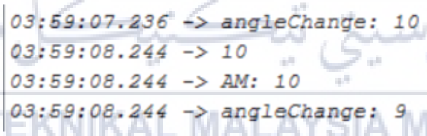
Table 4.1: MPU6500 data in static condition.

Orientations	Accelerometer Magnitude	Gyroscope Magnitude
Standing	10	9 to 10
Lying (Supine)	7	9 to 10
Lying (Lateral Left)	11	9 to 10
Lying (Lateral Right)	9	9 to 10
Lying (Prone)	12	9 to 10



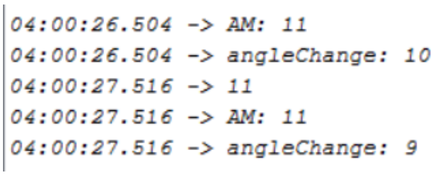
```
03:55:16.407 -> AM: 7
03:55:16.407 -> angleChange: 10
03:55:17.417 -> 7
03:55:17.417 -> AM: 7
03:55:17.417 -> angleChange: 9
```

Figure 4.3: Accelerometer and Gyroscope magnitude data in supine position



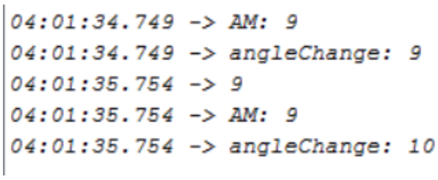
```
03:59:07.236 -> angleChange: 10
03:59:08.244 -> 10
03:59:08.244 -> AM: 10
03:59:08.244 -> angleChange: 9
```

Figure 4.4: Accelerometer and Gyroscope magnitude data in standing position



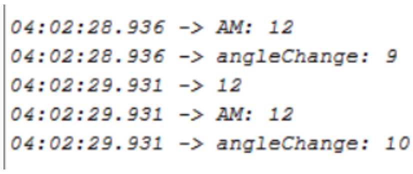
```
04:00:26.504 -> AM: 11
04:00:26.504 -> angleChange: 10
04:00:27.516 -> 11
04:00:27.516 -> AM: 11
04:00:27.516 -> angleChange: 9
```

Figure 4.5: Accelerometer and Gyroscope magnitude data in lateral left position



```
04:01:34.749 -> AM: 9
04:01:34.749 -> angleChange: 9
04:01:35.754 -> 9
04:01:35.754 -> AM: 9
04:01:35.754 -> angleChange: 10
```

Figure 4.6: Accelerometer and Gyroscope magnitude data in lateral right position



```
04:02:28.936 -> AM: 12
04:02:28.936 -> angleChange: 9
04:02:29.931 -> 12
04:02:29.931 -> AM: 12
04:02:29.931 -> angleChange: 10
```

Figure 4.7: Accelerometer and Gyroscope magnitude data in prone position

Upon scrutinizing the results presented in the table, it is advisable to establish the threshold for triggering the first stage as AM (Accelerometer Magnitude) ≤ 4. Additionally, the initiation of trigger 2 should be set at AM ≥ 13. This decision is informed by the observation that the AM value during static conditions typically falls within the range of 9 to 12. By avoiding this range, the triggers are less susceptible to being activated by minor movements, enhancing the system's overall robustness.

4.1.1.2 Fall Data

In collecting fall data, the magnitude data is acquired from the MPU6500 module during instances when a person experiences a fall. The fall postures are categorized into four positions: forward, backward, leftward, and rightward falls. Additionally, recordings are made for falls where the person descends in a diving head-first motion and falls straight with legs down. This comprehensive dataset is instrumental in minimizing the probability of false negatives, ensuring that the fall detection system remains sensitive to various fall scenarios and does not overlook any potential fall incidents.

Table 4.2: MPU6500 data in fall condition.

Fall Orientations	Accelerometer Magnitude	Gyroscope Magnitude
Fall Foward	12	79
Fall Backward	14	49
Fall Leftward	9	302
Fall Rightward	14	253

Random Fall (Diving)	6	105
Random Fall (Straight)	7	99

Blynk Notification

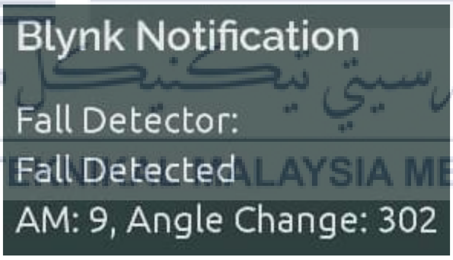
Fall Detector:
Fall Detected
AM: 12, Angle Change: 79

Figure 4.8: AM and angleChange reading from Blynk (Fall Forward)

Blynk Notification

Fall Detector:
Fall Detected
AM: 14, Angle Change: 49

Figure 4.9: AM and angleChange reading from Blynk (Fall Backward)



Blynk Notification

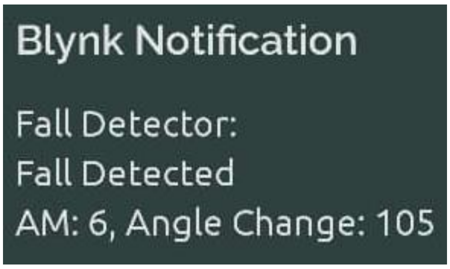
Fall Detector:
Fall Detected
AM: 9, Angle Change: 302

Figure 4.10: AM and angleChange reading from Blynk (Fall Leftward)

Blynk Notification

Fall Detector:
Fall Detected
AM: 14, Angle Change: 253

Figure 4.11: AM and angleChange reading from Blynk (Fall Rightward)


Blynk Notification

Fall Detector:
Fall Detected
AM: 6, Angle Change: 105

Figure 4.12: AM and angleChange reading from Blynk (Fall Diving)


Blynk Notification

Fall Detector:
Fall Detected
AM: 7, Angle Change: 99

Figure 4.13: AM and angleChange reading from Blynk (Fall Straight)

The table and figure above depict the magnitudes recorded during falls in various positions. Through a thorough analysis of this data, we have derived appropriate threshold values. The results obtained in this phase are integral in initiating the third stage of the trigger mechanism. In this stage, the trigger is activated when the magnitude falls within a specified threshold range (angleChange ≥ 30, angleChange ≤ 400). This ensures that trigger 3 is not activated by either overly significant or minimal motion. Notably, the accelerometer magnitude plays a minor role in triggering stage 3, primarily serving to initiate trigger 2 when it surpasses the set threshold (currently established at 12).

4.1.2 Reliablity

In this section, we aim to assess the reliability of the fall detection system by analyzing key metrics, including accuracy, precision, sensitivity, and specificity. The table below presents the results obtained from testing the fall detection system. The testing protocol involves inducing 20 intentional falls and performing various Activities of Daily

Living (ADL) such as walking, sleeping jumping and jogging, recording instances of true and false positives, as well as true and false negatives. This comprehensive evaluation will provide insights into the system's performance under different scenarios.

Table 4.3: Number of reaction got from fall detector.

Scenario	Total Instance	True Positive	False Positive	True Negative	False Negative
Fall down	30	27	0	0	3
ADL	20	0	1	19	0
Total	50	27	1	19	3

Table 4.4: Reliability of fall detector.

Analysis	Value (%)
Accuracy	92.00
Precision	96.43
Sensitivity	90.00
Specificity	95.00

The fall detection system achieved a commendable level of performance, with an accuracy of 92.00%, precision of 96.43%, sensitivity of 90.00%, and specificity of 95.00%. These results indicate the system's ability to accurately identify fall and non-fall scenarios. The high precision highlights a low rate of false positives, enhancing user confidence in the system's alerts, while the sensitivity underscores the system's effectiveness in capturing the majority of actual falls. The strong overall accuracy affirms the reliability of the system in diverse scenarios.

4.1.3 Summary

In conclusion, the fall detection system meticulously analyzes X, Y, and Z values from the MPU6500 module, computing magnitudes and employing three-stage triggers based on accelerometer and gyroscope data. Thorough static condition testing aids in setting appropriate thresholds, with triggers carefully designed to minimize false positives. The extensive dataset collected during falls in various positions ensures sensitivity to diverse scenarios. The reliability assessment, encompassing 20 intentional falls and Activities of Daily Living (ADL), reveals commendable performance with 92.00% accuracy, 96.43% precision, 90.00% sensitivity, and 95.00% specificity. These results affirm the system's robustness, effectively distinguishing between normal movements and potential falls, thus demonstrating its reliability across diverse scenarios.

4.2 Geo-fencing System

The Geo-fencing system serves the purpose of monitoring whether an individual surpasses a specified distance. In this implementation, a radius algorithm is employed, where specific coordinates are designated. A threshold distance is set. When the person traverses beyond the threshold, the geo-fence system triggers a notification through the Blynk application, alerting the user that the wearer has ventured outside the designated boundary. The notification includes details such as the coordinates and timestamp of the event.

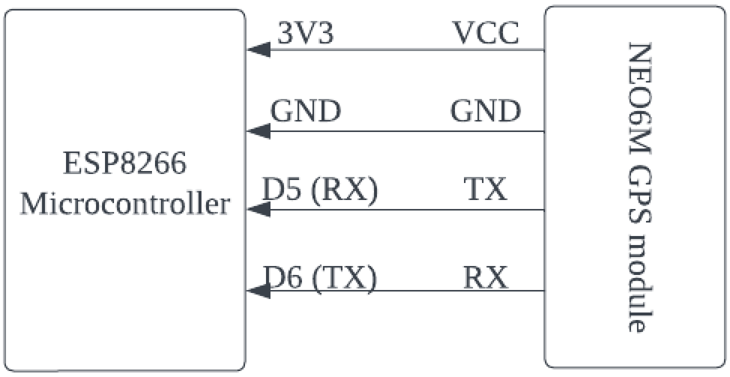


Figure 4.14: Block diagram of Geofencer

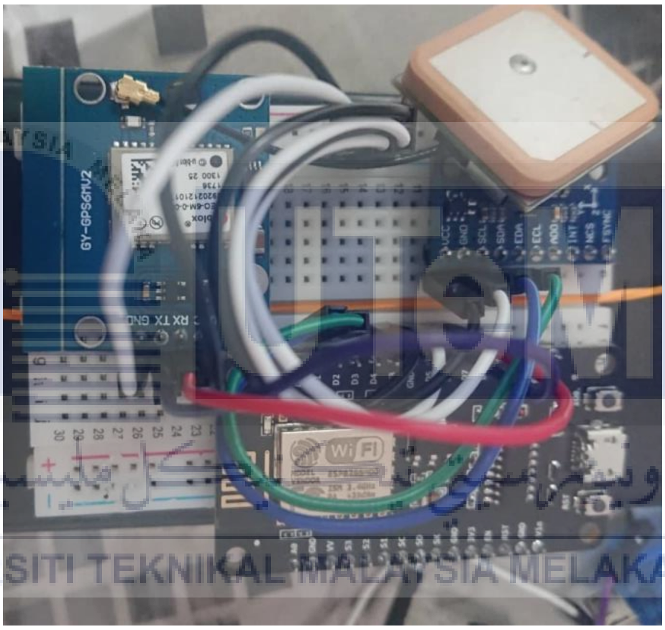
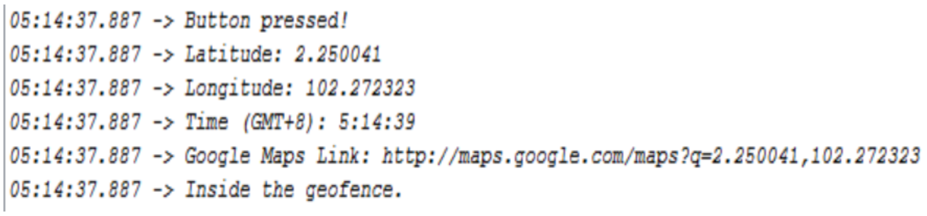


Figure 4.15: Circuit configuration of Geofencer

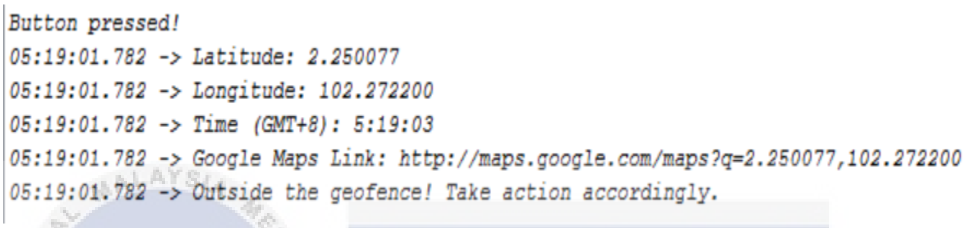
4.2.1 Geofencer data

The geofencing system functions by gathering location data and determining if the person has exceeded the predefined distance threshold, set at 100 meters in this scenario. This determination is made by comparing the current location's distance with the coordinates (latitude=2.250118, longitude=102.272297). Additionally, the user has the capability to press the button widget on Blynk app to retrieve the wearer's location. The serial monitor provides real-time information, indicating whether the person is out of bounds or within the designated area. It also displays the latitude and longitude values, a link to the Google Maps website, and the timestamp of the event.



```
05:14:37.887 -> Button pressed!
05:14:37.887 -> Latitude: 2.250041
05:14:37.887 -> Longitude: 102.272323
05:14:37.887 -> Time (GMT+8): 5:14:39
05:14:37.887 -> Google Maps Link: http://maps.google.com/maps?q=2.250041,102.272323
05:14:37.887 -> Inside the geofence.
```

Figure 4.16: Reply from geo-fencing system (Inside Geofence)



```
Button pressed!
05:19:01.782 -> Latitude: 2.250077
05:19:01.782 -> Longitude: 102.272200
05:19:01.782 -> Time (GMT+8): 5:19:03
05:19:01.782 -> Google Maps Link: http://maps.google.com/maps?q=2.250077,102.272200
05:19:01.782 -> Outside the geofence! Take action accordingly.
```

Figure 4.17: Reply from geo-fencing system (Outside Geofence)

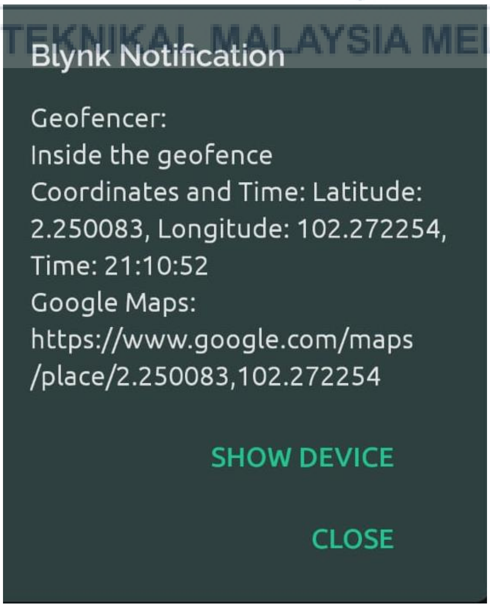
The results presented above illustrate the responses obtained from the geofencing system. Figure 4.16 showcases the response when a person is within the designated geo-fence, providing details such as the latitude (2.250041), longitude (102.272323), timestamp (5:14 am), and a link to Google Maps. In contrast, Figure 4.17 depicts the system's response when a person is out of bounds. In this scenario, the geo-fence coordinates are set to a different location (latitude=2.278282, longitude=102.275221), while the wearer remains in the original position, simulating an out-of-bounds scenario. The serial monitor indicates that the wearer is indeed out of bounds, presenting all relevant information as mentioned earlier.

4.3 Notification System

This section will present the results regarding Blynk notifications triggered when an individual goes out of bounds or experiences a fall. The notification system is designed to alert the Blynk app user in both scenarios – when the wearer is out of bounds or has fallen. Furthermore, the Blynk app user has the capability to track the wearer's position by utilizing the button widget within the Blynk app. This feature enhances the overall functionality of the notification system, providing real-time information and enabling active tracking of the wearer's location.

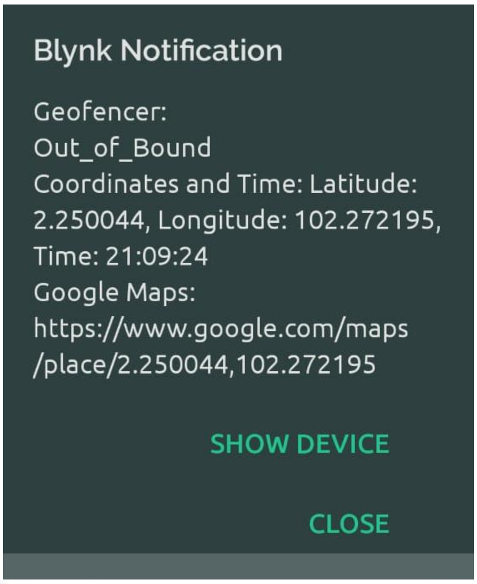
4.3.1 Geofencing System

The geo-fencing system functions as a proactive safety measure, notifying the Blynk app user whenever the tracker goes out of bounds. Additionally, users have the flexibility to manually request the tracker's location by pushing the designated button widget within the Blynk app. In the event of a geo-fence breach, the notification promptly conveys crucial details, including the condition of the tracker, real-time latitude and longitude coordinates, timestamp, and a convenient link to access Google Maps. This multifaceted approach ensures that users receive comprehensive and timely information, empowering them to monitor and respond to the tracker's movements effectively.


Blynk Notification

Geofencer:
Inside the geofence
Coordinates and Time: Latitude: 2.250083, Longitude: 102.272254, Time: 21:10:52
Google Maps:
https://www.google.com/maps/place/2.250083,102.272254

Figure 4.18: Blynk notification from Geofencing system (Inside geofence)


Blynk Notification

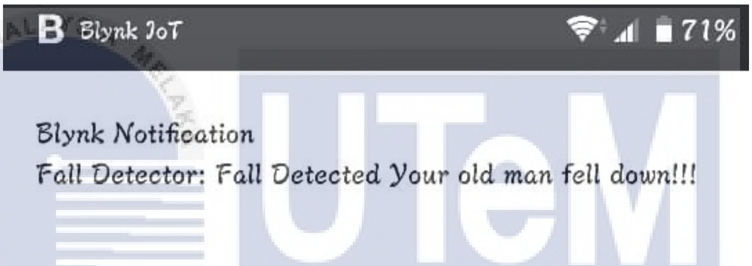
Geofencer:
Out_of_Bound
Coordinates and Time: Latitude: 2.250044, Longitude: 102.272195, Time: 21:09:24
Google Maps: https://www.google.com/maps/place/2.250044,102.272195

Figure 4.19: Blynk notification from Geofencing system (Out of bound)

Referring to Figures 4.18 and 4.19, the notification system consistently provides users with clear and detailed information regarding the tracker's status. The notification explicitly communicates the condition of the tracker, offering insights into its current state. Moreover, real-time coordinates are included, allowing users to precisely determine the tracker's location at the moment of the alert. The timestamp further adds a temporal dimension to the notification, providing users with the exact time of the tracked event. Additionally, the integration of a Google Maps hyperlink enhances user convenience, enabling a seamless transition from the notification to a visual representation of the tracker's location on the map. This transparent and informative notification system ensures that users are well-equipped to make informed decisions promptly.

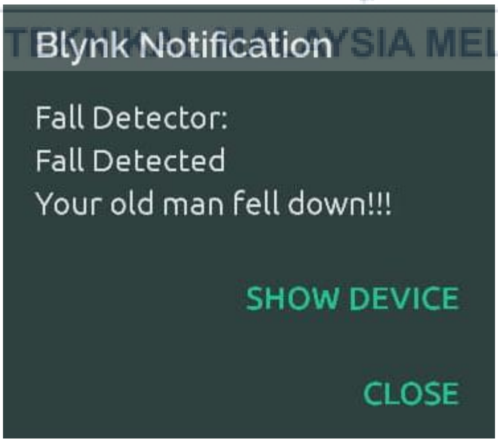
4.3.2 Fall Detection System

The fall detection system is designed to enhance user safety by triggering a notification to the Blynk user when a fall is detected. Upon detecting a fall, the system initiates a notification, promptly informing the user that the tracker has detected a fall event. This immediate alert mechanism is crucial for timely communication of potential emergencies. To further ensure user awareness, the notification is accompanied by a loud beep on the user's phone, facilitating quick and easily perceptible alerts. This multi-modal approach enhances the effectiveness of the fall detection system, providing users with timely and noticeable notifications to address potential safety concerns.



Blynk Notification
Fall Detector: Fall Detected Your old man fell down!!!

Figure 4.20: Blynk notification from fall detecting system



Blynk Notification

Fall Detector:
Fall Detected
Your old man fell down!!!

Figure 4.21: Blynk information from fall detecting system

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, this project successfully implemented a comprehensive tracker equipped with geofencing and fall detection functionalities, catering to the safety and well-being of individuals, particularly those with dementia. The geofencing feature establishes virtual boundaries around a central coordinate, promptly notifying caregivers through the Blynk app if the tracker ventures beyond the predetermined radius. This real-time alert system includes vital information such as the wearer's location and timestamp, facilitating a swift response to potential safety concerns.

The fall detection system, employing a multi-trigger approach, enhances reliability by minimizing false positives and negatives. The integration of accelerometer and gyroscope data ensures a nuanced analysis of wearer movements, differentiating between falls and routine activities. The fall detection mechanism is particularly crucial for families with dementia patients, as it provides an added layer of security by promptly signaling potential falls. Trigger conditions, such as sudden accelerations and specific falling orientations, contribute to the accuracy of fall detection, addressing the unique challenges posed by dementia patients' daily activities.

Overall, this tracker offers families with dementia patients a valuable tool for maintaining the safety and well-being of their loved ones. The geofencing and fall detection features work synergistically to provide a comprehensive solution, allowing caregivers to proactively address situations that may compromise the patient's safety. This project not only showcases technical innovation but also underscores the practical implications of technology in enhancing the quality of life for individuals with specific healthcare needs and their families.

5.2 Potential for Commercialization

The commercialization potential of this innovative tracker, equipped with geo-fencing and fall detection functionalities, is substantial and holds promise for various markets. The demand for technologies addressing the safety and well-being of individuals, especially those with specific healthcare needs, presents lucrative opportunities for commercialization.

In the consumer market, there exists a growing demographic of families and caregivers seeking reliable and user-friendly solutions to enhance the safety of their loved ones, particularly those with conditions such as dementia. The tracker's intuitive design, real-time alerts, and ease of use position it as an appealing product for households looking to provide enhanced care and ensure the security of vulnerable family members.

Moreover, the healthcare industry stands to benefit significantly from the integration of this technology into remote patient monitoring systems. Hospitals, assisted living facilities, and healthcare providers can leverage the tracker's capabilities to enhance patient care, improve response times, and streamline caregiving processes. The potential for partnerships with healthcare institutions and service providers adds another dimension to the commercialization outlook.

Beyond individual and healthcare applications, the tracker's capabilities may find utility in institutional and industrial settings. For instance, in facilities catering to the elderly, such as nursing homes or retirement communities, the tracker could be employed to enhance resident safety and improve emergency response procedures.

In conclusion, the commercialization potential of this versatile tracker extends across consumer, healthcare, and institutional markets. Its innovative features, addressing critical safety concerns, position it as a marketable solution that aligns with the evolving landscape of technology-driven care and remote monitoring. By tapping into these diverse markets, the tracker has the potential to become a widely adopted and indispensable tool for ensuring the well-being of individuals across various sectors.

5.3 Future Works

As technology evolves, there are exciting avenues to enhance the capabilities of the tracker. Future work could focus on refining geo-fencing precision, integrating health monitoring features, customizing alert preferences, exploring smart home integration, and developing wearable form factors. These potential enhancements aim to offer users more accurate, personalized, and versatile solutions for safety, health monitoring, and seamless integration into their daily lives.

5.3.1 Enhancing Geo-fencing Precision

To further refine the geofencing functionality, future work could focus on enhancing the precision of location tracking. This could involve leveraging advanced GPS technologies, integrating additional sensors for improved accuracy, and implementing machine learning algorithms to predict and adjust for potential discrepancies in GPS data. The goal is to create an even more reliable and responsive geofencing system that minimizes false positives and ensures timely notifications.

5.3.2 Integrating Health Monitoring Feature

Expanding the tracker's capabilities to include health monitoring features could be a promising avenue for future development. Incorporating biometric sensors for heart rate monitoring, activity tracking, and even vital sign measurements could provide valuable health insights. This extension would not only enhance the device's utility for individuals with specific health conditions but also position it as a holistic health and safety solution.

5.3.3 Customizable Alert Preferences

To cater to diverse user preferences and scenarios, future iterations of the tracker could include customizable alert preferences. This feature would allow users or caregivers to tailor notification thresholds, choose specific notification methods, and prioritize certain alerts over others. Providing users with the flexibility to personalize their alert settings would enhance the overall user experience and adapt the device to varying caregiving needs.

5.3.4 Exploring Wearable Form Factor

Considering the evolving landscape of wearable technology, future iterations could explore the development of wearable form factors for the tracker. This could involve creating discreet and comfortable wearables that individuals are more likely to adopt willingly. Wearable designs could also facilitate continuous monitoring, providing a more comprehensive dataset for geofencing and fall detection algorithms.

5.3.5 Summary

In summary, these future directions aim to elevate the tracker's capabilities, incorporating advancements in technology, health monitoring, customization, ecosystem integration, and wearable design. By continually innovating and addressing emerging needs, the tracker can evolve into a more sophisticated and indispensable tool for enhancing safety and well-being in various contexts.

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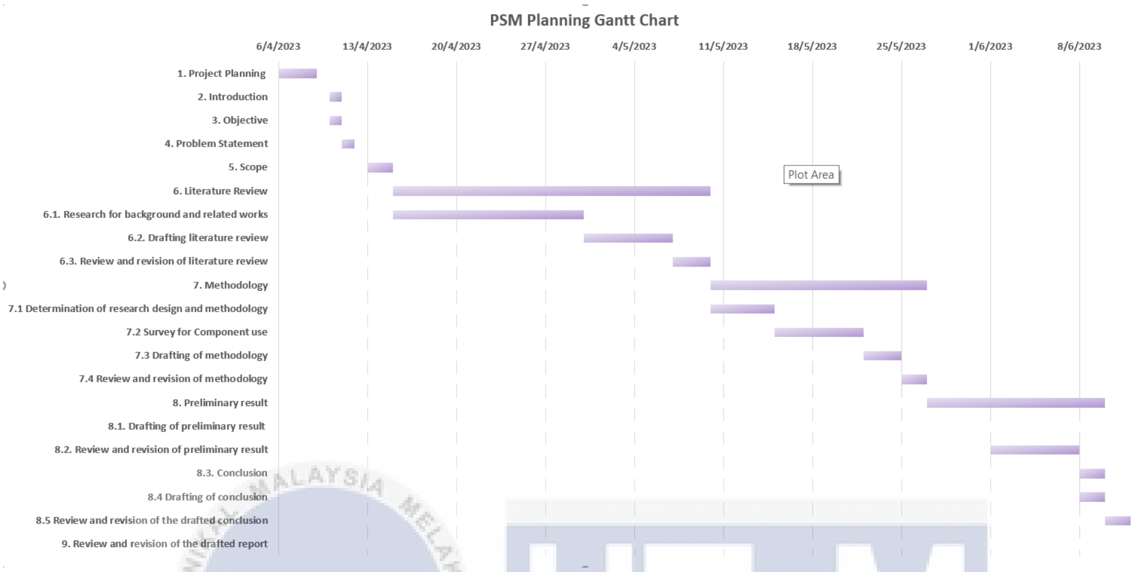
APPENDICES

Appendix A Gantt Chart for PSM 1



Appendix B Program Coding for Geofencing System

```
#define BLYNK_TEMPLATE_ID "TMPL61YK4iJ8e"
#define BLYNK_TEMPLATE_NAME "GeofencerCopy"
#include <SoftwareSerial.h>
#include <TinyGPS++.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>


#define RX_PIN D5  // Define the RX pin for GPS module
#define TX_PIN D6  // Define the TX pin for GPS module
#define GPS_BAUD 9600  // GPS module baud rate


#define BLYNK_AUTH_TOKEN "ztnf7mvPxnjhxPr8F7htUgb1qblLvmue"
#define WIFI_SSID  "HAHA"
#define WIFI_PASS  "BukitBeruang_41"


SoftwareSerial gpsSerial(RX_PIN, TX_PIN);  // Create a SoftwareSerial object for the
GPS module
TinyGPSPlus gps;  // Create a TinyGPS++ object

const double geofenceLatitude = 2.250118;    // Replace with the center latitude of your
geofence
```

```
const double geofenceLongitude = 102.272297;  // Replace with the center longitude of
your geofence
const double geofenceRadius = 100.0;         // Replace with the radius of your geofence in
meters

const int timeZoneOffset = 8; // Adjust this according to your time zone
String userInput;  // Declare userInput globally
String coordinatesAndTime;  // Declare coordinatesAndTime globally

void setup() {
  delay(1000);
  Serial.begin(115200);
  gpsSerial.begin(GPS_BAUD);
  Blynk.begin(BLYNK_AUTH_TOKEN, WIFI_SSID, WIFI_PASS);
}

BLYNK_WRITE(V1) {
  // This function is called when the button state changes
  int buttonState = param.asInt();
  userInput = param.asStr();
  Serial.println("User Input: " + userInput);

  coordinatesAndTime = getCoordinatesAndTime();

  if (buttonState == 1) {
    // Button on V1 is pressed
    handleButtonPress();
  }
}

void loop() {
  Blynk.run();
  readGPSData();

  if (Serial.available() > 0) {
    String command = Serial.readStringUntil('\n');
    command.trim();

    if (command.equalsIgnoreCase("Check")) {
      printLocation();
      checkGeofence();
    }
  }
}

String getCoordinatesAndTime() {
  // Check if the GPS has a valid fix
  if (gps.location.isValid()) {
    String latitude = String(gps.location.lat(), 6);
    String longitude = String(gps.location.lng(), 6);
```

```
    // Get the individual components of GPS time
    int gpsHours = gps.time.hour();
    int gpsMinutes = gps.time.minute();
    int gpsSeconds = gps.time.second();

    // Calculate the local time in seconds since midnight with GMT+8 offset
    unsigned long localTime = (gpsHours + timeZoneOffset) * 3600 + gpsMinutes * 60 +
gpsSeconds;

    // Calculate hours, minutes, and seconds
    int hours = (localTime / 3600) % 24;
    int minutes = (localTime / 60) % 60;
    int seconds = localTime % 60;

    // Format the time in 24-hour format with leading zeros
    String formattedTime = String(hours) + ":" + (minutes < 10 ? "0" : "") + String(minutes)
+ ":" + (seconds < 10 ? "0" : "") + String(seconds);

    Serial.println("Coordinates and Time: " + latitude + ", " + longitude + ", " +
formattedTime);  // Debug print

    coordinatesAndTime = "Latitude: " + latitude + ", Longitude: " + longitude + ", Time: "
+ formattedTime;
  } else {
    Serial.println("GPS data not available");
    coordinatesAndTime = "GPS data not available";
  }

  return coordinatesAndTime;
}



void readGPSData() {
  while (gpsSerial.available() > 0) {
    if (gps.encode(gpsSerial.read())) {
      if (gps.location.isUpdated()) {
        // Optionally, you can print the data to the Serial Monitor continuously
        // Serial.print("Latitude: ");
        // Serial.println(gps.location.lat(), 6);
        // Serial.print("Longitude: ");
        // Serial.println(gps.location.lng(), 6);
      }
    }
  }
}

void printLocation() {
  if (gps.location.isUpdated()) {
```

```
    Serial.print("Latitude: ");
    Serial.println(gps.location.lat(), 6);
    Serial.print("Longitude: ");
    Serial.println(gps.location.lng(), 6);
    printFormattedTime();
  } else {
    Serial.println("GPS data not available");
  }
}

void printFormattedTime() {
  Serial.print("Time (GMT+8): ");
  Serial.print((gps.time.hour() + 8) % 24);  // Ensure the hour is within the 0-23 range
  Serial.print(":");
  if (gps.time.minute() < 10) {
    Serial.print("0");
  }
  Serial.print(gps.time.minute());
  Serial.print(":");
  if (gps.time.second() < 10) {
    Serial.print("0");
  }
  Serial.println(gps.time.second());
}

void checkGeofence() {
  coordinatesAndTime = getCoordinatesAndTime();
  double distance = TinyGPSPlus::distanceBetween(
                    gps.location.lat(),
                    gps.location.lng(),
                    geofenceLatitude,
                    geofenceLongitude);
 String logMessage = ", Coordinate and Time: " + coordinatesAndTime;
 String googleMapsLink = "https://www.google.com/maps/place/" +
String(gps.location.lat(), 6) + "," + String(gps.location.lng(), 6);

  if (distance > geofenceRadius) {
    Serial.println("Outside the geofence! Take action accordingly.");
    // You can add actions here, such as sending an alert or triggering an event

    // Format the log message explicitly

      Blynk.logEvent("out_of_bound", "\nCoordinates and Time: " + coordinatesAndTime +
"\nGoogle Maps: " + googleMapsLink);
      Serial.println("out of bound! \nCoordinates and Time: " + coordinatesAndTime +
"\nGoogle Maps: " + googleMapsLink);
  } else {
    Serial.println("Inside the geofence. \nCoordinates and Time: " + coordinatesAndTime +
"\nGoogle Maps: " + googleMapsLink);
```

```
    Blynk.logEvent("inside_the_geofence", "\nCoordinates and Time: " +
coordinatesAndTime + "\nGoogle Maps: " + googleMapsLink);
  }
}

void handleButtonPress() {
  // This function is called when the button is pressed in the Blynk app
  Serial.println("Button pressed!");

  // Perform actions associated with the button press
  printLocation();
  checkGeofence();
}
```

Appendix C   Program Code for Fall Detection System

```
#define BLYNK_TEMPLATE_ID "TMPL6_ljz2DTD"
#define BLYNK_TEMPLATE_NAME "Fall Detector"
#define BLYNK_AUTH_TOKEN "CIBi40tOjpPTp1UD8s_C5ASU_3OVT-OU"

#include <Wire.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

#define WIFI_SSID  "HAHA"
#define WIFI_PASS  "BukitBeruang_41"

const int MPU_addr = 0x68;  // I2C address of the MPU-6050
int16_t AcX, AcY, AcZ, Tmp, GyX, GyY, GyZ;
float ax = 0, ay = 0, az = 0, gx = 0, gy = 0, gz = 0;

boolean fall = false;
boolean trigger1 = false;
boolean trigger2 = false;
boolean trigger3 = false;

byte trigger1count = 0;
byte trigger2count = 0;
byte trigger3count = 0;
int angleChange = 0;
int lastNotifiedAM = 0;
int lastNotifiedAngleChange = 0;

void setup() {
  delay(3000);
  Serial.begin(115200);
  Blynk.begin(BLYNK_AUTH_TOKEN, WIFI_SSID, WIFI_PASS);

  Wire.begin(D2, D1);  // Use D2 for SDA and D1 for SCL on ESP8266
```

```
  Wire.beginTransmission(MPU_addr);
  Wire.write(0x68);  // PWR_MGMT_1 register
  Wire.write(0);     // set to zero (wakes up the MPU-6050)
  Wire.endTransmission(true);


  pinMode(D5, OUTPUT);  // Use D5 instead of pin 11
  digitalWrite(D5, HIGH);
}

void loop() {

  Blynk.run();
  mpu_read();

  ax = (AcX - 2050) / 16384.00;
  ay = (AcY - 77) / 16384.00;
  az = (AcZ - 1947) / 16384.00;

  gx = (GyX + 270) / 131.07;
  gy = (GyY - 351) / 131.07;
  gz = (GyZ + 136) / 131.07;

  float Raw_AM = pow(pow(ax, 2) + pow(ay, 2) + pow(az, 2), 0.5);
  int AM = Raw_AM * 10;

  Serial.println(AM);
  raw_read();

  if (trigger3 == true) {
    trigger3count++;
    if (trigger3count >= 6) {
      angleChange = pow(pow(gx, 2) + pow(gy, 2) + pow(gz, 2), 0.5);
      Serial.println(angleChange);
      if ((angleChange >= 0) && (angleChange <= 30)) {
        fall = true;
        trigger3 = false;
        trigger3count = 0;
        Serial.println(angleChange);
      } else {
        trigger3 = false;
        trigger3count = 0;
        Serial.println("TRIGGER 3 DEACTIVATED");
      }
    }
  }

  if (fall == true) {
    Serial.println("FALL DETECTED");
```

```
    Blynk.logEvent("fall_detected", "AM: " + String(lastNotifiedAM) + ", Angle Change: "
+ String(lastNotifiedAngleChange));
    digitalWrite(D5, LOW);
    delay(20);
    digitalWrite(D5, HIGH);
    fall = false;
  }

  if (trigger2count >= 6) {
    trigger2 = false;
    trigger2count = 0;
    Serial.println("TRIGGER 2 DECACTIVATED");
  }

  if (trigger1count >= 6) {
    trigger1 = false;
    trigger1count = 0;
    Serial.println("TRIGGER 1 DECACTIVATED");
  }

  if (trigger2 == true) {
    trigger2count++;
    angleChange = pow(pow(gx, 2) + pow(gy, 2) + pow(gz, 2), 0.5);
    Serial.println(angleChange);
    if (angleChange >= 30 && angleChange <= 400) { // Manipulated variable
      trigger3 = true;
      trigger2 = false;
      trigger2count = 0;

      lastNotifiedAM = AM;
      lastNotifiedAngleChange = angleChange;

      Serial.println(angleChange);
      Serial.println("TRIGGER 3 ACTIVATED");
    }
  }

  if (trigger1 == true) {
    trigger1count++;
    if (AM >= 12) { // Manipulated variable
      trigger2 = true;
      Serial.println("TRIGGER 2 ACTIVATED");
      trigger1 = false;
      trigger1count = 0;
    }
  }

  if (AM <= 4 && trigger2 == false) { // Manipulated variable
    trigger1 = true;
    Serial.println("TRIGGER 1 ACTIVATED");
```

```
  }

  delay(100);

}

void mpu_read() {

  Wire.beginTransmission(MPU_addr);
  Wire.write(0x3B);
  Wire.endTransmission(false);
  Wire.requestFrom(MPU_addr, 14, true);
  AcX = Wire.read() << 8 | Wire.read();
  AcY = Wire.read() << 8 | Wire.read();
  AcZ = Wire.read() << 8 | Wire.read();
  Tmp = Wire.read() << 8 | Wire.read();
  GyX = Wire.read() << 8 | Wire.read();
  GyY = Wire.read() << 8 | Wire.read();
  GyZ = Wire.read() << 8 | Wire.read();
}

void raw_read() {

  double Raw_AM = pow(pow(ax, 2) + pow(ay, 2) + pow(az, 2), 0.5);
  int AM = Raw_AM * 10;
  angleChange = pow(pow(gx, 2) + pow(gy, 2) + pow(gz, 2), 0.5);

    // Log accelerometer and gyroscope readings to Serial Monitor
  Serial.print("AM: "); Serial.print(AM); Serial.println("\t");
  Serial.print("angleChange: "); Serial.print(angleChange); Serial.println("\t");

}

// Function to handle the button press on Blynk app
BLYNK_WRITE(V1) {
  int buttonState = param.asInt();
  double Raw_AM = pow(pow(ax, 2) + pow(ay, 2) + pow(az, 2), 0.5);
  int AM = Raw_AM * 10;

  if (buttonState == 1) {
    // Button is pressed, notify AM and angleChange
    Blynk.logEvent("fall_detected", "AM: " + String(AM) + ", Angle Change: " +
String(angleChange));
  }
}

// Callback function to handle the button press
void ButtonPressedCallback() {

  double Raw_AM = pow(pow(ax, 2) + pow(ay, 2) + pow(az, 2), 0.5);
```

```
  int AM = Raw_AM * 10;

  // Notify button press
  Blynk.logEvent("fall_detected", "AM: " + String(AM) + ", Angle Change: " +
String(angleChange));
}
```