UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF PORTABLE SMART TRACKING AND FALL DETECTION SYSTEM FOR SENIOR CITIZEN

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By

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DEDICATION

I dedicated this writing to my family, friends and classmates for always supporting me during this time and special thanks for those supporting me on completing this paper

ABSTRACT

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Individuals aged 60 and over are considered senior citizens in Malaysia. The number of senior people is increasing in almost every country, including Malaysia. Senile dementia, often known as Dementia, is one of the ailments experienced. As a result, special precautions must be taken to monitor the location and condition of the elderly when they leave the house in order to keep them safe.

The goal of this project is to create a portable Smart Tracking and Fall Detection system for older folks that is both efficient and accurate. A GPS module, a SW 420 vibration sensor, and a GSM module comprise this system. If the senior falls, the GPS module will identify the position, and the vibration sensor will detect the vibration. The data will be communicated to the family through SMS using the GSM module. According to the results of the prototype test, the prototype correctly recognises the location when family members request it. The study concluded that the average deviation between the device's coordinates and Google maps is

0.75-1 metres, which is still considered acceptable, and the SMS is delivered in 3-5 seconds if the user falls or becomes lost. The battery may still power the system for 50 minutes before shutting down altogether after 68 minutes.

ABSTRAK

PEMBANGUNAN PENGESAN PINTAR MUDAH ALIH DAN SISTEM PENGESAN JATUH UNTUK WARGA EMAS

oleh

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Individu berumur 60 tahun ke atas dianggap warga emas di Malaysia. Jumlah warga emas semakin meningkat di hampir setiap negara termasuk Malaysia. Nyanyuk, sering dikenali sebagai Dementia, adalah salah satu penyakit yang dialami. Sehubungan itu, langkah berjaga-jaga khusus perlu diambil bagi memantau lokasi dan keadaan warga emas apabila keluar rumah bagi memastikan mereka selamat.

Matlamat projek ini adalah untuk mencipta sistem Penjejakan Pintar dan Pengesanan Jatuh mudah alih untuk orang tua yang cekap dan tepat. Modul GPS, sensor getaran SW 420 dan modul GSM merangkumi sistem ini. Jika senior jatuh, modul GPS akan mengenal pasti kedudukan, dan sensor getaran akan mengesan getaran. Data tersebut akan disampaikan kepada keluarga melalui SMS menggunakan modul GSM. Mengikut keputusan ujian prototaip, prototaip mengecam lokasi dengan betul apabila ahli keluarga memintanya. Kajian itu menyimpulkan bahawa sisihan purata antara koordinat peranti dan peta Google ialah 0.75-1

meter, yang masih dianggap boleh diterima, dan SMS dihantar dalam masa 3-5 saat jika pengguna terjatuh atau tersesat. Bateri mungkin masih menghidupkan sistem selama 50 minit sebelum dimatikan sepenuhnya selepas 68 minit.

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"In the name of Allah, the most beneficent and the most merciful"

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LIST OF ABBREVIATIONS

3D	Three-dimensional space
GHz	Gigahertz
MHz	Megahertz
RPL	Routing Protocol for Low Power and Lossy Networks
CoAP	Constrained Application Protocol
REST	Representational state transfer
URI	Universal resource identifier
HTTP	Hypertext transfer protocol
V	Volt
DC	Direct current
VIN	Voltage input
UNO	One
GND	Ground
VCC	Voltage common collector
DO	Drop out
RXD	Receive data
TXD	Transmit data
IDE	Integrated development environment
°	Degree
cm	Centimeter
SMS	Short message service
min	Minutes
A	Ampere
W	Watt
GPS	Global positioning system
GSM	Global system for mobile communications
OS	Operating system
ADLs	Activities of daily living
PC	Personal computer
IRISYS	Infrared integrated systems Ltd
DB	Database
RSSI	Received signal strength indicator
MCI	Manufacturing control instruction
Wi-Fi	Wireless fidelity
RFID	Radio frequency identification
BLE	Bluetooth low energy
IoT	The Internet of Things

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The effects of ageing on cultural, economic, and healthcare elements of life are numerous. According to the medical issue, as individuals age, they become more susceptible to a variety of physical diseases that can be caused by natural factors or sickness. The senior population in developing nations is growing faster than in industrialised countries. The number of adults above the age of 60 was predicted to be about 962 million in 2017. This figure has more than doubled since 1980, when there were around 382 elderly citizens. The number of senior people is expected to double by 2050, reaching over 2.1 billion people worldwide (United Nations, 2017). The reduction of different organ functions as a result of ageing, notably the decline of brain function, is one of the health issues that many elderly Malaysians face throughout time. Memory (often forgetting), thinking and understanding (difficulty focusing the mind), calculating, knowledge, speech, even judgement, as well as personality changes, are all symptoms of dementia. Furthermore, this injury is frequently recognised with changes in emotional control as apathy and preferring being alone as feeling gloomy (Dening et al., 2015). Social behaviour and motivation deteriorate, as does the capacity to do everyday tasks (Donovan et al., 2012).

There are a lot of studies and related works that perform research on Dementia. One of them would be working on a software that will identify and monitor older people fallen in an unsafe environment. SIMBAD is a smart sensor that detects falls in the elderly. They used an infrared Integrated System to detect the fall and trigger a warning signal (Sixsmith et al., 2004).

Following that, as an enhancement to the system, a tracking system was implemented, which can only identify the elderly from a fall. In this system, capacitive proximity was employed as a floor sensor technique to monitor and detect falls. The full capacity is plant on the floor and is used to observe elderly folks living alone in their houses. The proximity capacitive approach is used to design and develop integrated sensors that can determine a person's weight (Arshad et al., 2017). The internet of things (IoT) is being applied as involves integrating of the elderly as technology advances. This system is designed for indoor usage and makes use of Bluetooth Low Energy (BLE) technology (Mighali et al., 2017). Following that, IoT and Big Data were employed to enhance the fall detection system. This technology is utilised inside and communicates with a healthcare practitioner via an IoT Gateway (Yacchirema et al., 2018). The elderly is given special attention in an elderly day care centre. This system uses Bluetooth Low Energy (BLE) technology to identify many persons in a room (Kashimoto et al., 2017). There's also SOULMATE, an outside application that helps the elderly navigate when they're out and about (Neven et al., 2018).

A NOTECASE is use indoor and outdoor for the elderly as a care system devised in research to track and monitor the elderly. RFID, Wi-Fi, as well as the Global Positioning System (GPS) are all employed in this system in combination with the mobile and web-based applications. RFID and GPS tracking are employed, while Wi-Fi is used for communication. This device is clever, yet it is unable to identify falls among the elderly (Wai et al., 2015). Using the Global System for Mobile Communication and GPS, a tracking device for outside monitoring was developed, although it was mainly used to track the elderly (Munir et al., 2012).

1.2 Problem Statement

All previous research has concentrated on identifying the elderly's location or detecting the senior falling for indoor applications. Nevertheless, because many elderly individuals participate in outside activities, they require a device that can remotely monitor them and transmit their condition to their relatives. In consideration of this, the purpose of this research is to create a system that will monitor, track, and recognise a fall scenario if they are falling during their activity and inform their family.

1.3 Objectives

Since this project want to develop a system that can be used to remotely monitor, thus the objectives of this study are:

1. To create a system that can identify older people who have fallen within 5 seconds.
2. To design a system that can report the lost-GPS elderly's position to the listed GSM number
3. To develop a system that can deliver information about elderly who have fallen using a mobile phone SMS alert.

1.4 Limitation of study

When the project had been conducted, a few limitations had been occurring which is researcher's limitation and parts limitation. For researcher's limitation, precaution must be taken during conducting the project to make sure that every part is connected to the correct pin to prevent damage to the microcontroller. Next parts limitation that occurs is the parts provided is limited so work planning must be followed to ensure working progress in the right path. Secondly as malfunction of certain parts when the prototype tested, so wise checking for every part before proceed developing the project.

1.5 Overview of Thesis

Chapter 1 gives an introduction of devices that helps elderly deal with Dementia, which described the background of study for devices that helps elderly deal with Dementia. It also explained about the problem statement, objectives and limitation of study on devices that helps elderly deal with Dementia. Then, Chapter 2 provide a review in related literature reports which is relevant with research and some background information to gain more knowledge about research. Meanwhile in Chapter 3 discuss the preparation method from electronics parts to a Smart Tracking and Fall Detection for Golden Age's Citizen devices. Then the certain parts of the devices will be test which are GPS module NEO UBLOX 6M, Vibration & Motion Sensor SW420, GSM module SIM800L and battery. Next chapter 4 for result and discussion where in this chapter I analyse and discussing the result for every part that had been tested. Lastly, Chapter 5 present the conclusion and suggestions for future works of this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Dementia

Dementia is defined by the World Health Organization (WHO) as a syndrome that develops as a result of a brain disorder that is typically chronic or progressive. Memory, reasoning, understanding, computation, learning, language, and judgement are among the higher cortical processes that are impaired. Changes in emotional control, social behaviour, and motivation are frequently associated with these deficits. Dementia can be caused by a variety of conditions, including Alzheimer's disease and cerebrovascular illness (WHO, 1992). Early-onset (or working-age) dementia is defined as dementia that develops before the age of 65, whereas late-onset dementia is defined as dementia that develops beyond that age. Although the causes of dementia are unknown, the end consequence is invariably structural and chemical alterations in the brain, resulting in neuronal death and brain volume reduction.

Officially, the UK's dementia population is estimated to be around 800,000 persons (Department of Health, 2015). This statistic has sparked debate, with some claiming that it is too high because it is based on estimates on data acquired around 20 years ago. More recent study suggests that the genuine amount is about 670,000 (Matthews et al., 2013), with the decrease from the expected amount due to recent improvements in the population's vascular and general health.

2.2 Detecting and Tracking System

2.2.1 A Smart Remote Elderly Monitoring System based on IoT Technologies

A Smart Remote Older Monitoring System based on IoT Technologies is a sensor architecture that uses IoT technologies to gather location and motility data in order to identify behavior change in elderly persons in an unobtrusive, low-cost, and low-power manner (Mighali et al., 2017). The goal of this project is to create an innovative framework of ICT tools and services that can be used by European cities to improve early detection of risk related to frailty and MCI, as well as provide personalised interventions that can help the elderly population improve their daily lives and promote positive behaviour changes. (L. Mainetti et al., 2015)

The system is made up of two sub-system a positioning sub-system that identifies indoor user position and a motility sub-system that detects body motion on a continuous basis. To determine the user's current location, the positioning sub-system uses i) a series of BLE beacons placed throughout the home, (ii) the user's smartphone, and (iii) a BLE-enabled wearable device. The motility sub-system, on the other hand, uses the inertial sensors contained in the monitoring system to recognise the user's activity in a non-intrusive manner.

However, this system can only track the user and cannot detect if the user experienced fall. The system also has a limited memory and processing capabilities limit the spectrum of motions and the power consumption should be kept to a minimum to guarantee the battery life is extended and to relieve the user of the responsibility of recharging or replacing the battery on a regular basis.

2.2.2 BLE-Tag-Based Semi-Automatic Daycare Report Generation System

The BLE-Tag-Based Semi-Automatic Daycare Report Generation System keeps track of older persons' movements and activities in daycare centres (Kashimoto et al., 2017). The goal of this approach is to relieve caregivers at daycare centres of some of their responsibilities. Caretakers at daycare centres create a daycare report with the goal of improving the older citizen's quality of life. However, because each caretaker is responsible for numerous senior citizens at the same time, it is difficult for caretakers to keep detailed records of the senior citizen's activities under the current circumstances. There are various elderly monitoring systems available, but the most of them are ineffective because they demand older citizens to utilise specialised equipment such as a smartphone and/or certain programmes that are intrusive and inconvenient for care recipients.

"Area estimation," "Activity identification in BLE tag," and "Daycare report generation" are the three components of the system. (Kashimoto et *al.*, 2017) To estimate the area, a classifier is created that learns the data set, which includes the RSSI value recorded by the beacon scanner and the response data, which reflects the user's current location. An accelerometer is included into a Bluetooth Low Energy tag. The microcontroller within the BLE tag interprets data from an accelerometer and uses machine learning to assess the user's activity. A BLE advertisement packet is used to send the estimated activity to the server. Based on the RSSI of the tag, the server calculates the elderly's current location and stores the location, activity, and timestamp in the database (DB). The server processes the data in the database and creates the day care report at the end of each day. Furthermore, the server programme creates numerous statistics on the elderly in order to monitor their health state, such as the ratio of activity in each location, the quantity of activity over multiple days, and so on.

This system, however, can only monitor the user and cannot determine if the person has fallen. This system can only be utilised in an interior setting, such as a home or office. The time it takes to create information about a user is one day, and the information cannot be monitored in real time.

2.2.3 The use of mobile devices for physical activity tracking in older adults' everyday life

Wearable monitoring devices like smartwatches and other wristband sensors that measure physical activity (e.g., activity trackers) are also encouraging people to measure their physical activity on a regular basis (Dobkin BH, 2013). The so-called quantified self-movement reflects the increased awareness of these issues (Swan M, 2013). The quantified self-movement is a network that brings together wearable technology companies and consumers with the goal of integrating data collection into daily living and better educating people about their routines and health (Appelboom G et al., 2014).

Activity trackers (wristbands with accelerometer technology for monitoring and recording fitness-related behaviour largely focused on counting steps and time periods of physical activity), smartwatches, and other mobile devices used for physical activity tracking (com-puterized wristbands with various functionalities and applications similar to smartphones, which run on their own operating systems) with the goal of measuring physical activity, as well as smartphone or tablet apps with the same goal.

Mobile devices, on the other hand, can only track physical activity and not the user's location. The gadgets are also unable to identify if the user has fallen. The gadgets have been designed for young or middle-aged people (Direito A *et al.*, 2015) or for those who are already physically active (Dallinga JM *et al.*, 2015), but they are not ideal for the elderly. Despite the fact that a growing number of elderly people have begun to use new digital media gadgets.

However, there is still a divide between younger and older people in terms of new media consumption rates, intensity, and the breadth of widely utilised functionalities (Seifert A *et al.*, 2015). However, the concept of using an accelerometer to detect movement may be used to this project to determine whether or not the user is falling.

2.3 Fall detection system

2.3.1 Smart Inactivity Monitor using Array-Based Detectors (SIMBAD)

SIMBAD (Smart Inactivity Monitor with Array-Based Detectors) is a low-cost infrared detector array that works as a fall detector (Sixsmith *et al.*, 2004). The SIMBAD system attempts to improve the elderly's quality of life, provide them a sense of security, and allow them to live independently (Sixsmith *et al.*, 2004). SIMBAD takes into consideration two major aspects of observed behaviour. It begins by analysing target motion in order to discover the typical dynamics of falls. Second, it tracks target inactivity and compares it to a map of acceptable inactivity times in various parts of the field of vision. The combination of fall detection with inactivity monitoring has the potential to reduce false alarms by watching activity after what seems to be a fall. Furthermore, even if the system does not detect a fall, it might still sound the alert. SIMBAD is essentially an activity-monitoring system that can trigger an alert faster quickly if clear evidence of a fall is detected.

SIMBAD is made up of many subsystems, including a fall detector, a subtle-motion detector, an inactivity monitor, and a high-level reasoner (Sixsmith *et al.*, 2004). The fall detector uses a neural network to categorise falls based on vertical-velocity estimations generated from IRISYS sensor data or the tracker. A subtle-motion detector is a signal-based system that detects minor movements in the field of vision of the sensor. The inactivity monitor measures periods of inactivity in the sensor's area of view using data from the tracker and subtle-motion detector. When a goals is no longer visible, it's time to move on, this subsystem keeps an eye on two different sorts of inactivity in the area of the last known position. The high-level reasoner is responsible for monitoring the output of the fall detector, inactivity monitor, and subtle motion detector, as well as generating warning signals as necessary. The system generates two types of alarms: those triggered by inactivity over extended periods of time and those generated by the detection of a fall.

The devices, on the other hand, can only detect if the person is falling and cannot follow their location. The gadgets are also not movable and cannot be transported to other locations; they are only intended for use indoors. The system is untrustworthy since its performance levels indicate that it is still in the prototype stage. More research and development are needed to enhance the fall detector and improve the efficiency of the inactivity monitor.

2.3.2 Capacitive proximity floor sensing system for elderly tracking and fall detection

Capacitive proximity floor sensing system for elderly tracking and fall detection detects the presence and movement of the human body using capacitive proximity sensing technology (Arshad *et al.,* 2017). The designed system deployed in elderly homes by placing a matrix of thin planar electrodes underneath the flooring or on the walls, making the device non-invasive and unobtrusive (Arshad *et al.,* 2017). Mobility and falls are two of the system's parameters. It is expected that the floor sensing system would be able to reduce the need for full-time care for the elderly, resulting in lower health-care costs and a perceived improvement in their quality of life.

The tracking sensors are made up of electrode-based sensors, a central control unit, and a control PC. The electrode, which is typically made of conductive plate, serves as a sensing surface in direct contact with the measurement region. The electrodes in this piece are basic aluminium foils that are put on the floor surface to create a matrix-like array structure. The electrode generates excitation signals and transforms capacitances into voltage signals, which are next conditioned and digitised for data collection by a microcontroller. The purpose of a central control unit is to synchronise all processes and convey data to a control PC. In order to monitor the person's actions, a control PC that receives the measures readings will store the obtained data, rebuild pictures from the integral measurements, and take action depending on the feedback supplied.

Because it allows an electric field to flow through non-conducting substances, capacitive sensing technology is ideal for recognising the human body.

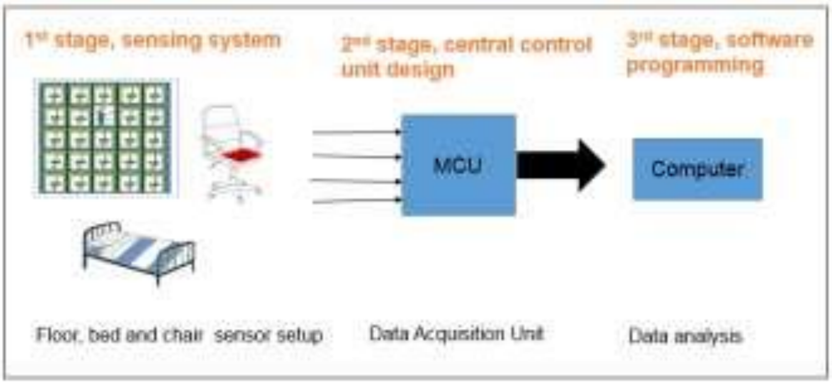

Fig 2. 1 Overview of the elderly's activity monitoring system

The sensing of a body and its proximity to an electrode is possible using capacitive proximity sensors (Arshad *et al.*, 2017). As a result, a moving body causes a change in sensor value. A credible measure of items moving over the electrodes may be achieved if this data combined deviations from an array of sensors. There is no loss of comfort in this manner of monitoring because the device is positioned on the floor surface and may be covered with a carpet.

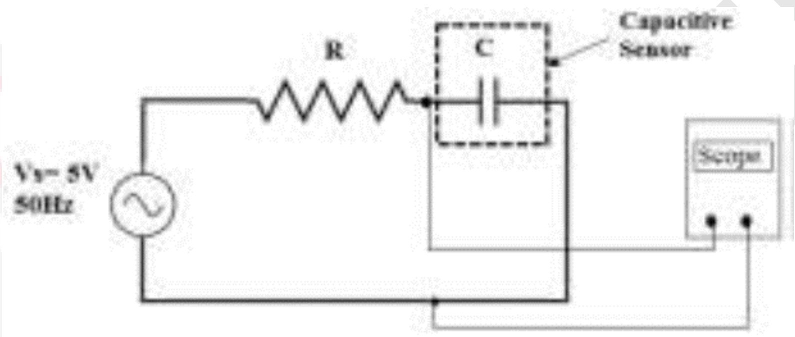

Fig 2. 2 Capacitive sensing measurement principle of a single sensor in two-dimension

However, the system can watch the user's movement and determine if he or she is falling, but it cannot track the user's position. As mentioned, this system may only be operated indoors and must be installed underneath the floor surface beneath the carpet. In this study, the fall detection concept may be used with the GPS tracker.

2.3.3 Fall detection system for elderly people using IoT and Big Data

Low-power wireless sensor networks, smart devices, big data, and cloud computing are all used in the fall detection system. A 3D-axis accelerometer incorporated in a 6LowPAN device wearable is used for this purpose, and it is responsible for gathering data from old people's movements in real-time (Yacchirema *et al.,* 2018). The sensor signals are processed and processed using a decision trees-based Big Data model running on a Smart IoT Gateway to give great efficiency in fall detection. If a fall is detected, an alert is triggered, and the system immediately responds by sending messages to the organisations in charge of elderly care (Yacchirema *et al.,* 2018). Finally, the system offers cloud-based services (Yacchirema et *al.,* 2018). From a medical standpoint, a storage solution is available that allows healthcare professionals to access falls data for additional study. The system, on the other hand, offers a service that uses this information to construct a new machine learning model each time a fall is detected. Experiments have revealed that fall detection has a high success rate in terms of accuracy, precision, and gain.

The device is made up of three modular blocks: NUCLEO-L152RE, one expansion board (X-NUCLEO-IDS01A5) with sub-1GHz RF connectivity working at 868 or 915 MHz, and a ST Microelectronics sensor expansion board (X-NUCLEO-IKS01A1). The NUCLEO-L152RE is powered by an ARM 32-bit Cortex-M3 processor that delivers high-performance digital signal processing while using little power and voltage. Several small ultralow-power sensors make up the sensor board. Only the MEMS motion sensor (LSM6DS0) is selected to collect motion data when an adult fall or performs ADLs. The LSM6DS0 is a three-axis accelerometer with a full-scale acceleration range of 2/4/8 g. The firmware for the wearable devices is based on ‘Contiki,' an open-source operating system (OS) for restricted networks.

We gain complete IoT stack support over 6LowPAN by utilising the Contiki OS, which includes 6lowPAN, RPL (IPv6 Routing Protocol for Low-power and Lossy Networks), and CoAP (through Erbium) supportErbium is a low-power REST engine built in C that allows RESTful access to the wearable device's resources. The REST paradigm, which is built into the constrained application protocol (CoAP), has also been used. CoAP is a lightweight IoT protocol that features resource abstraction, URI usage, RESTful interaction (i.e., methods like GET, POST, PUT, and DELETE to access multiple resources), and customizable header options 14. However, as compared to HTTP, CoAP implementation utilises the least number of resources on restricted devices and networks. As a result, it is appropriate for IoT situations with limited resources. For reading the accelerometer values, the wearable gadget has a CoAP Server integrated in.

The system, on the other hand, may identify if the person is falling but not monitor their whereabouts. As said, this system may be brought to any location because it is a wearable device. However, because it is associated with Big Data, it will be expensive and not everyone will be able to purchase it. However, in this study, the fall detection approach may be combined with a GPS tracker.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss about the electronics parts, method on developing the system and testing procedure. The testing procedure will be discussed about the details flow about the test on certain electronics parts.

3.2 Electronics parts

Electronics parts that used in this project set up are Microcontroller (Arduino Uno), 9V battery (Energizer), vibration & motion sensor (SW420), step-down DC-DC transformer (LM 2596), GPS module (NEO UBLOX 6M), GSM module (SIM800L), breadboard, push buttons, connecting wires and toggle switch were used for this project. All those electronics part available in the lab.

3.3 Project Set Up

3.3.1 9V Power Supply (Energizer)

Power supply functioned to give power to the system. Positive terminal of DC power supply connected to the switch that connected to positive terminal of the breadboard. Next, the negative terminal of DC power supply connected to negative terminal of the breadboard that make a complete circuit.

3.3.2 Microcontroller (Arduino UNO)

Microcontroller is used to control output and receive input of the system. In order to power the microcontroller, it must to be connected to the power supply. The positive terminal that of the power supply connected to the breadboard, connected to the VIN pin on the Arduino UNO microcontroller. The circuit will be not completed when the microcontroller is not connected to the negative terminal of the power supply. Thus, the microcontroller, connected from the negative terminal of the breadboard to the GND pin.

3.3.3 Step-Down DC-DC Transformer (LM 2596)

The function of the step-down transformer is controlling voltage of the system. Step-down transformer connected to the positive terminal of the breadboard and end the circuit by connected to the negative terminal of the breadboard.

3.3.4 Vibration & Motion Sensor (SW420)

The main function of the vibration and motion sensor is to read vibration and motion input. There are 3 pins on this sensor which is VCC, GND and DO. The VCC pin is connected to the positive terminal of the breadboard while the GND pin is connected to negative terminal. Thus, the DO pin is connected to the ‘9’ pin of the microcontroller.

3.3.5 GPS module (NEO UBLOX 6M)

The function of GPS module is to read GPS input. There 3 pins that we used from this module which are VCC, TXD and RXD. VCC pin of this module connected to the positive terminal of the breadboard that connected to the positive terminal of the power supply. TXD 0 pin is connected to the RXD 0 pin on the microcontroller while the RXD pin is connected to the TXD 1 pin.

3.3.6 GSM module (SIM800L)

GSM module is used to deliver output in form of Short Message Service (SMS). There also 3 pins that used on this module which are VCC, TXD and RXD. Positive terminal of the breadboard that connected to positive terminal of power supply is connected to VCC pin. The TXD pin is connected to '7' pin while RXD pin is connected to '8' pin on the microcontroller.

3.3.7 Push Button

The function of push button is to deliver instruction when the button is pushed. There are only positive and negative terminal on push button. The positive terminal of the push button is connected to the positive terminal of the bread board and the negative terminal is connected to the '10' pin of the microcontroller.

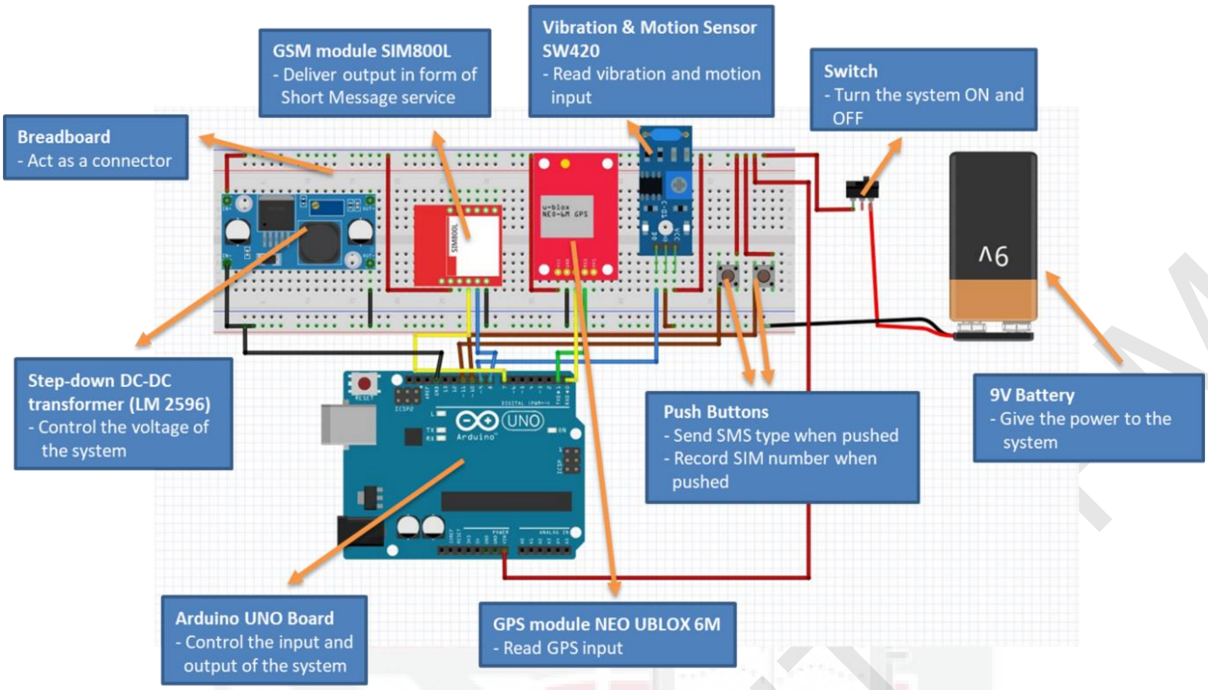

Fig 3. 1 Schematic diagram

3.4 Software

The Arduino IDE is the only software necessary. The Arduino Integrated Development Environment (IDE) includes a text editor for writing code, a message area, a text terminal, a toolbar with buttons for basic operations, and a menu system. It communicates with the Arduino and Genuine hardware by connecting to them and uploading code. The Arduino Integrated Development Environment (IDE) is a cross-platform programme developed in C and C++ functions for Windows, macOS, and Linux. It's used to create and upload programmes to Arduino-compatible boards, as well as other vendor development boards with the support of third-party cores. Figure 3.2 is the flowchart of developed program for the system. Table 3.1 shows the SMS type.

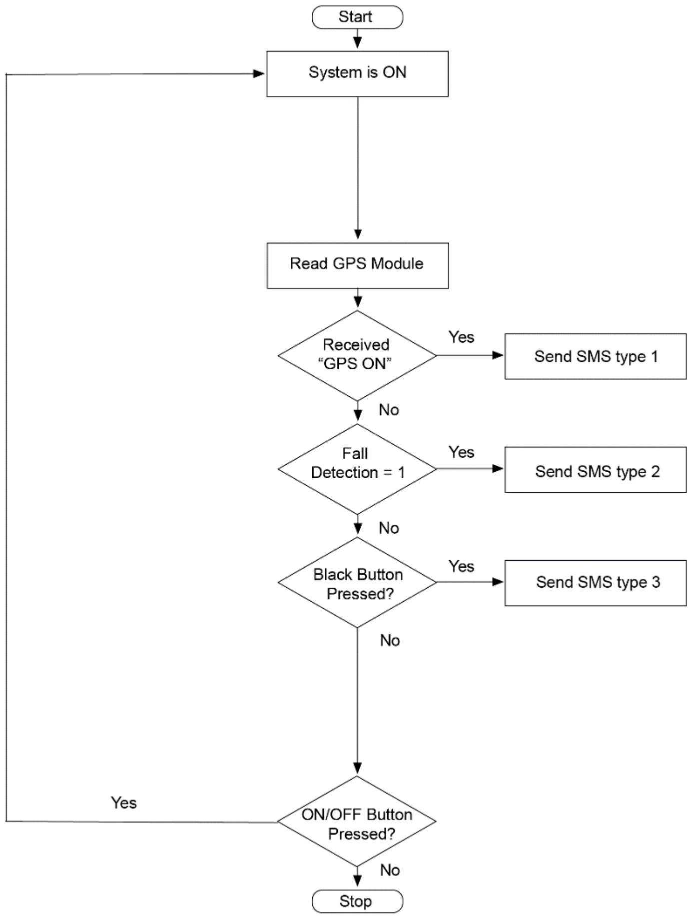

Fig 3. 2 Flowchart of developed program

Table 3. 1 Information of every SMS type

SMS Type	Information
SMS Type 1	GPS Coordinate in google map link form
SMS Type 2	If the elderly experienced falling accident, provide GPS coordinates.
SMS Type 3	Information on whether or not the elderly is already being assisted by someone.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter we will analyse and discussing the GPS Module, Vibration and Motion Sensor, GSM Module and Power Supply that had been tested.

4.2 GPS Module testing

The GPS module was put through its paces to check how effectively it could generate a GPS signal both indoor and outdoor. This scenario also puts the system to the test in order to detect the position of the elderly when they are engaged in activities that cannot be viewed or overseen. The outdoor tests are held in front of the Mawar block, Tun Dr Ismail College, UPM, and the Bukit Ekspo, UPM. Meanwhile, the indoor area is taking place in Rooms 275 and 280 of Tun Dr Ismail College. The testing in the outdoors environment is being done at two different sites. The GPS from the GPS module and Google Maps are being recorded and compared. The results of the testing in the outdoors area are shown in Table 4.2.1. The disparity between Google Maps and the GPS module is around 0.75–1 metre. When seeking for an elderly person within sight, this variation can still be tolerated.

Table 4.2. 1 Outdoor GPS testing result

Location	Google map coordinate	GPS module coordinate	Deviation position (meter)	Average (meter)
In front of the Mawar block, Tun Dr Ismail College, UPM	2.9944829,101.7086795	2.9944829,101.7086795	0	1
	2.9944829,101.7086795	2.9944829,101.7086795	0	
	2.9944829,101.7086795	2.9944829,101.7086795	0	
	2.9944829,101.7086795	2.9944898,101.7086998	4	
	2.9944829,101.7086795	2.9944888,101.7086897	2	
	2.9944829,101.7086795	2.9944829,101.7086795	0	
Bukit Ekspo, UPM	2.9868668,101.7103164	2.9868668,101.7103164	0	0.75
	2.9868668,101.7103164	2.986863, 101.710328	2	
	2.9868668,101.7103164	2.9868668,101.7103164	0	
	2.9868668,101.7103164	2.9868681,101.7103103	1	
	2.9868668,101.7103164	2.9868614,101.7103103	1.5	
	2.9868668,101.7103164	2.9868668,101.7103164	0	

The subsequent testing at the Tun Dr Ismail College's indoor area in Rooms 275 and 280 cannot be configured. It's due to an undiscovered GPS signal within the structure. According to the results of the tests, this system is not suitable for use in an indoor environment. Nonetheless, it may be used in a home complex with similar outdoor characteristics.

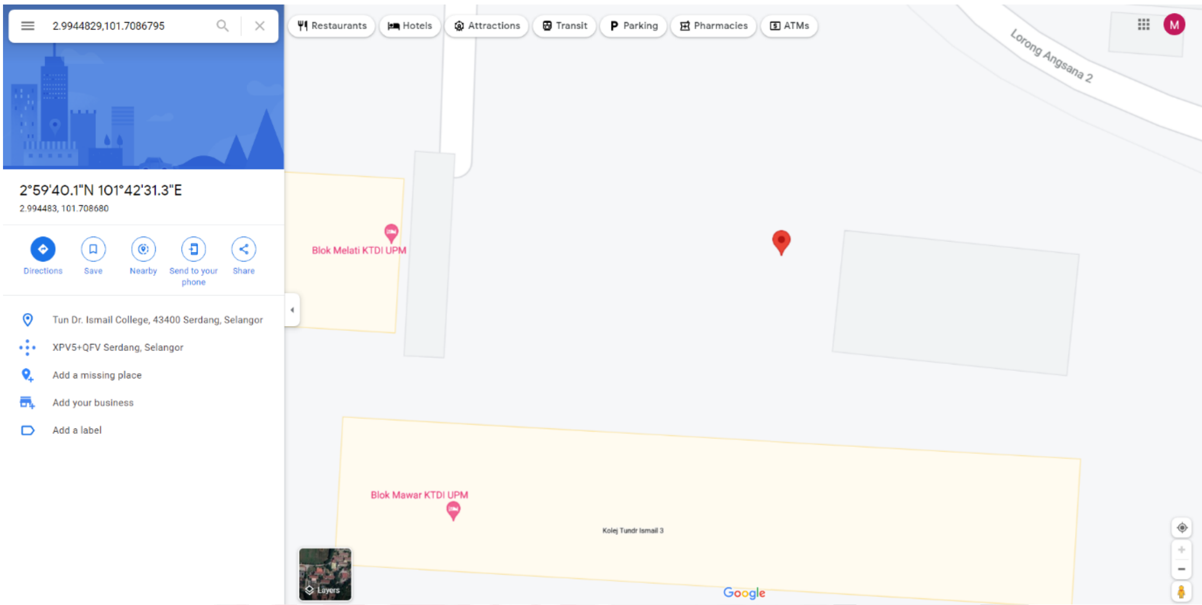

Fig 4.2. 1 In front of the Mawar block, Tun Dr Ismail College, UPM map view

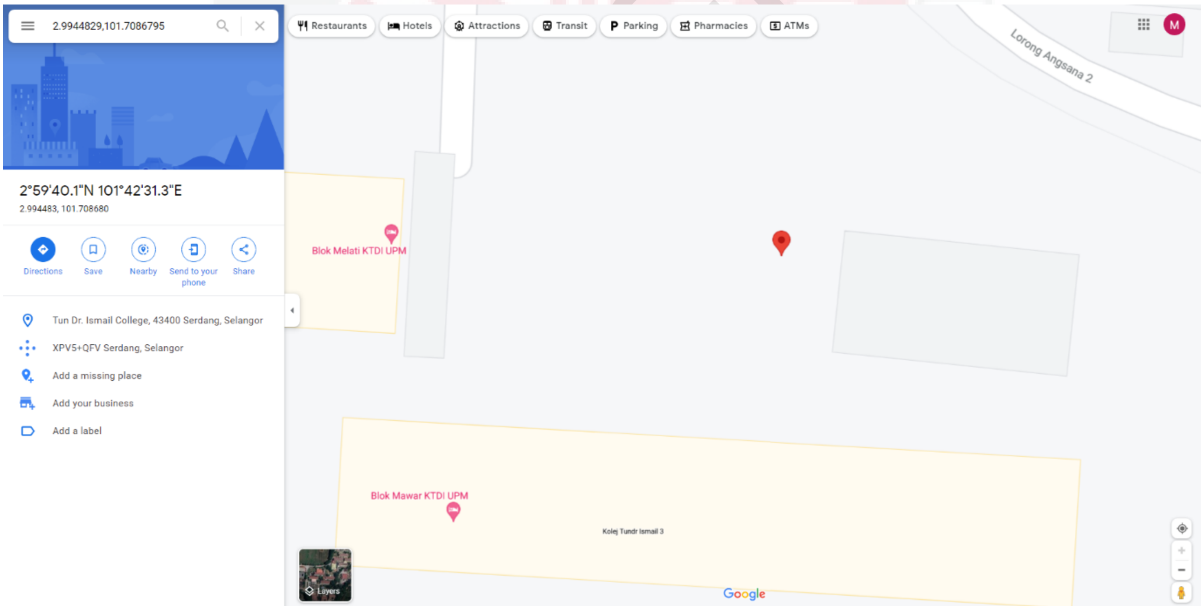

Fig 4.2. 2 Bukit Ekspo, UPM map view

4.3 Vibration and Motion Sensor Testing

The vibration sensor module is being tested to offer an analog vibration value that may be understood as a falling scenario. This scenario also examines how the system can notify the family of an old person's condition, as it is capable of differentiating between a fall and a swing.

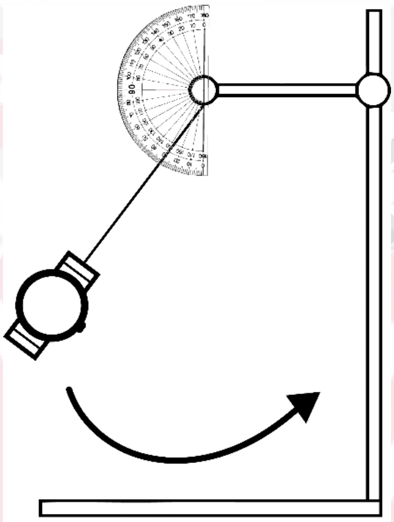

Fig 4.3. 1 Swing Test

Table 4.3. 1 Analog value of vibration sensor for swing test

Swing angle	Analog Value
0°	0
15°	68
30°	183
45°	361
60°	587
75°	694
90°	857

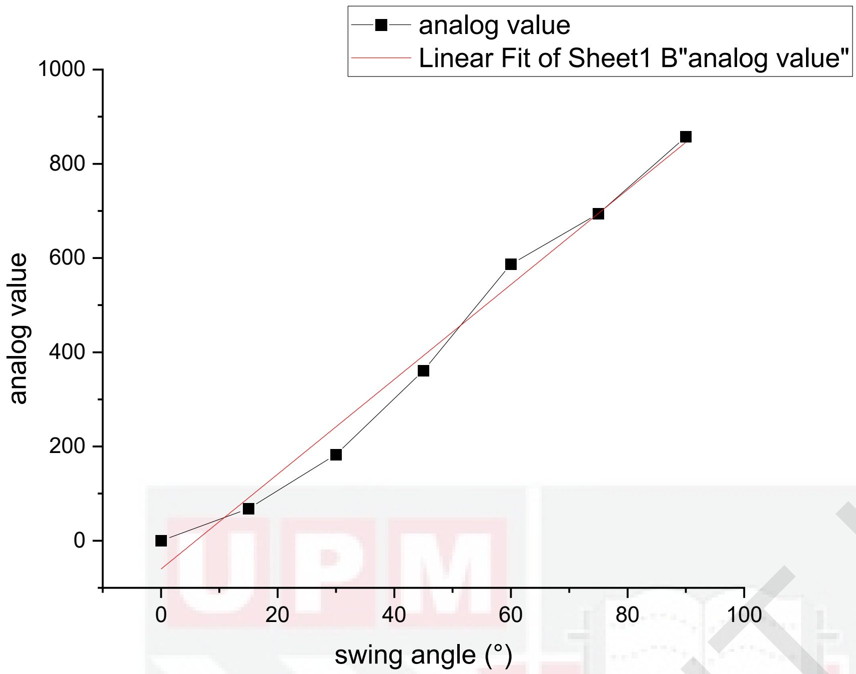

Fig 4.3. 2 The relationship between Swing angle (°) and Analog value

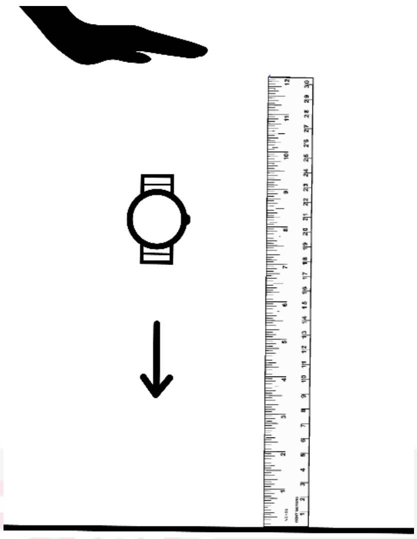

Fig 4.3. 3 Drop Test

Table 4.3. 2 Analog value of vibration sensor for drop test

Height	Analog Value
0 cm	0
10 cm	857
20 cm	1680
30 cm	3197
40 cm	5831
50 cm	7416
60 cm	9539

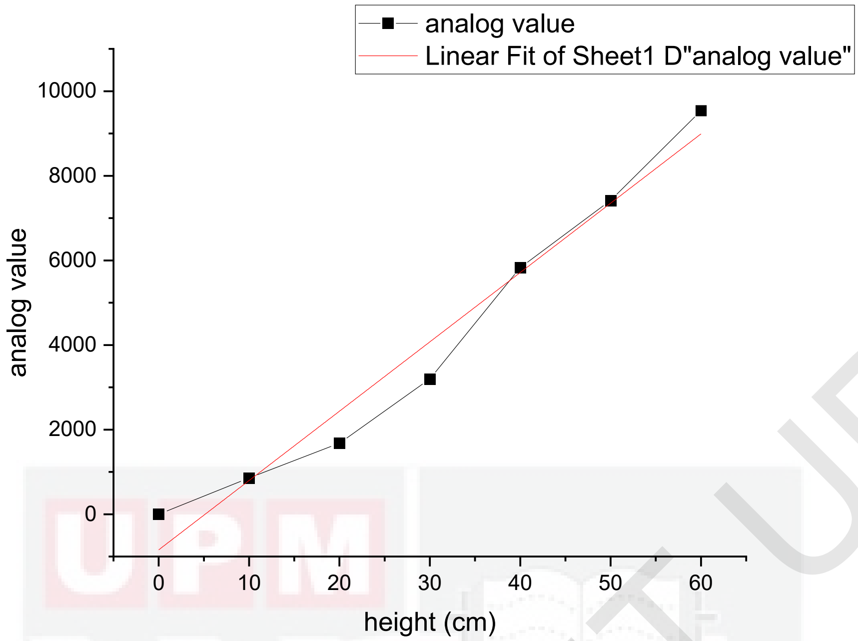

Fig 4.3. 4 The relationship between Height (cm) and Analog value

The testing is done in different ways which are dropping and swinging. The testing started with swing test, the system swung from 15°,30°,45°,60°,75° and 90° angle, the analog value is recorded. Then we proceed with drop test, the system dropped from 10 cm, 20 cm,30 cm,40 cm,50 cm, and 60 cm. The analog value also recorded. From this test we can identify the most suitable threshold value that need to set in the system. The analog value of swing test and drop test is easy to differentiate since they have huge different in value. The analog value that may be interpreted as the fall condition, on the other hand, is much different, and it is set to more than 5000. Once the analog value is set in the programme, the vibration sensor is tested in combination with the GSM module in the next following page. The results of the tests are shown in tables 4.3.1 and 4.3.2.

4.4 GSM Module Testing

The GSM module testing was done to determine how long the system's communication takes to transmit the message to the family. This test is being performed to determine the accuracy of the tracking system when used in combination with the vibration sensor and GPS. The scenario testing progress is shown in figure 4.4.1

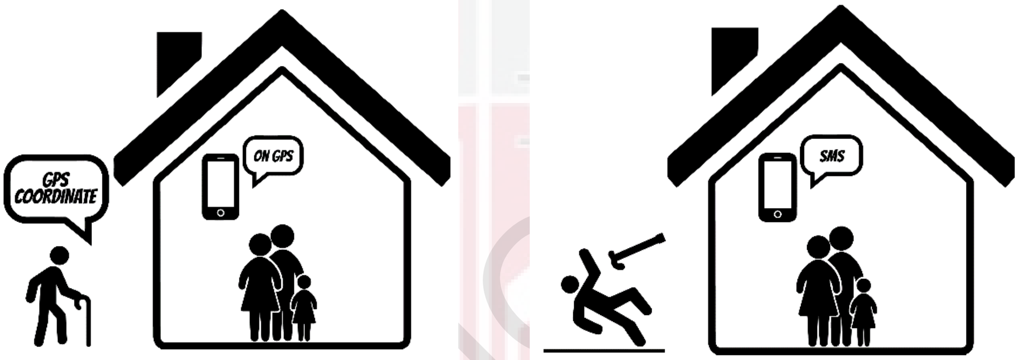

Fig 4.4. 1 (a) Testing Scenario Smart Tracking; (b) Testing Scenario Fall Detection

The first test is evaluating the connection between the GSM module and the GPS module using a smart-tracking device. If family members send "ON GPS" SMS, the device will respond with SMS containing the elderly's GPS coordinates in the form of a Google Maps link. However, if no "ON GPS" SMS is received by family members, the gadget does not reply. The coordinates of the residence correspond to the locations of Mawar block Tun Dr Ismail College. The Green Button's function is to notify a family member that someone is already aiding the elderly. Table 4.4.1 shows the results of smart tracking tests. Green Button is used to notify a family member that someone has previously assisted the elderly. If the old person falls and is aided by someone, the system will notify the family member twice by SMS.

Table 4.4. 1 Result Testing of Tracking System

Location Testing	Elderly Coordinate Position	"ON GPS" SMS status	Delay SMS Reply (sec)	Green Button Pressed	Remarks
In front of the Mawar block, Tun Dr Ismail College, UPM	2.9944829,101.7086795	Sent	5	Pressed	Two SMS reply received
	2.9944829,101.7086795	-	-	-	No SMS reply received
	2.9944829,101.7086795	-	-	-	No SMS reply received
	2.9944829,101.7086795	Sent	6	-	One SMS reply received
Bukit Ekspo, UPM	2.9868668,101.7103164	-	-	-	No SMS reply received
	2.9868668,101.7103164	Sent	5	Pressed	Two SMS reply received
	2.9868668,101.7103164	Sent	7	Pressed	Two SMS reply received
	2.9868668,101.7103164	-	-	-	No SMS reply received

The findings of the fall detection testing system are shown in Table 4.4.2. The scene unfolds when the elderly wander outside and fall. If the elderly is already getting help, the green button is used to inform a family member.

Table 4.4. 2 Result Testing of Fall Detection

Elderly Coordinate Position	Analog Value	Delay SMS (sec)	Green Button Pressed	Remarks
2.9944829,101.7086795	200	-	-	Safe
2.9944898,101.7086998	5400	5 (twice)	Pressed	Fall Detected, Helped
2.9944571,101.7086893	233	-	-	Safe
2.9944888,101.7086897	6370	5	-	Fall Detected
2.9944223,101.7086819	5332	5	-	Fall Detected
2.9944083,101.7086970	437	-	-	Safe

4.5 Power Supply Testing

The test is performed while the system is functioning to measure the voltage and current level produced by the battery. The voltage is measured by connecting the multimeter's negative and positive terminals in parallel to the battery. To do the current test, detach one of the battery connector's poles and connect it in series to the multimeter.

Table 4.5. 1 Battery extrapolation

Time (min)	Duration (min)	Current (A)	Voltage (V)	Power (W)
15.05	0	0.1671	9.41	1.57
15.25	20	0.1316	8.21	1.08
15.35	30	0.1251	7.70	0.96
15.45	40	0.1114	6.22	0.69
15.55	50	0.0956	4.69	0.45
16.10	60	0.0393	3.52	0.14
16.18	68	0.0	0.00	0.00

The battery has a capacity of 50 minutes at full charge. Beginning in the 60th minute, the battery can only run the Arduino, thus every one of the sensors are turned off. After the 60th minute, the battery was no longer capable of supplying power to the system. The extrapolation graph is shown in Figure 4.5.1. The battery, according to the graph, can power the system for 68 minutes with a residual voltage of 0 V and a current of 0 A. This test is also performed to notify family members that the lifespan of the battery system is governed by its power use.

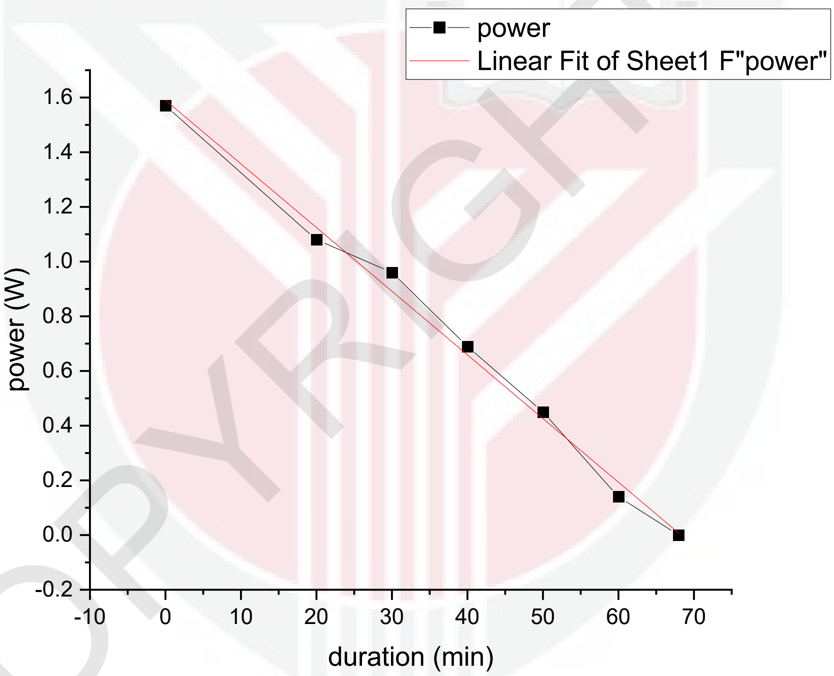

Fig 4.5. 1 The relationship between Duration (min) and Power (W)

CHAPTER 5

CONCLUSION

5.1 Conclusion

The smart-tracking and fall-detection systems have been started. This prototype's features all perform as planned, and the system can track, identify, and monitor elderly activities. This approach can be used in both outdoor and indoor locations that are near to window. The system's GPS integration can identify the place of a fall and help locate older people who have become disoriented. Based on their needs, Although the system may store up to three phone numbers in its database, it can only send SMS to the default number. The deviation of position between GPS and Google Maps is around 0.75-1 metres. Because the range is still visible, this deviation may be tolerated. The GSM system may send a message to a family member in a three-way format that contains longitude and latitude coordinates, and all messages provided can be transferred. This battery can still power the device for 50 minutes before cutting off the sensor function till the 60th minute of operation. The system will completely switch off in the 68th minute.

5.2 Recommendations for future study

The system can be enhanced in the future by utilising a smaller microcontroller, as the Arduino UNO appears to be too large for use in a wearable project device. The Arduino Nano should be an excellent pick. A battery alert function may also be added to improve the system. Aside from that, the system may be improved and developed with a large number of nodes in the network, such as a WSN. This system can make use of IoT technology through an android application and monitoring display that is linked to numerous cameras in the smart city architecture.

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APPENDIX DEVELOPMENT SOFTWARE USING ARDUINO IDE

pengujian_GPS | Arduino 1.8.19 (Windows Store 1.8.57.0)

File Edit Sketch Tools Help

pengujian_GPS §

```
#include <TinyGPS++.h>
#include <SoftwareSerial.h>

SoftwareSerial serial_gps(4, 5);
SoftwareSerial mySerial(9, 10);
TinyGPSPlus gps;

double latitude, longitude;
int vs =8; // vibration sensor
String response;
int lastStringLength = response.length();

long vibration() {
  long measurement=pulseIn (vs,HIGH);
  return measurement;
}

void setup()
{
  pinMode (vs, INPUT);
  Serial.begin(9600);
  mySerial.begin(9600);    // Setting the baud rate of GSM Module
  serial_gps.begin(9600);

}

void loop()
{
  while(serial_gps.available() > 0)
  {
```

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pengujian_GPS | Arduino 1.8.19 (Windows Store 1.8.57.0)

File Edit Sketch Tools Help

pengujian_GPS §

```
  {
    gps.encode(serial_gps.read());
  }
  if(gps.location.isUpdated())
  {
    latitude = gps.location.lat();
    longitude = gps.location.lng();
    Serial.print("Google Maps : ");
    String link = "www.google.com/maps/place/" + String(latitude, 7) + "," + String(longitude, 7) ;
    Serial.println(link);

    delay(500);

    long measurement = vibration();
    Serial.print("measurement = ");
    Serial.println(measurement);

    if (measurement>200)
    {
    SendMessage();
    }
    else
    {
    return measurement;
    }
  }

      if ( mySerial.available()>0){
      response =  mySerial.readStringUntil('\n');
      }
```

65

pengujian_GPS | Arduino 1.8.19 (Windows Store 1.8.57.0)

File Edit Sketch Tools Help

pengujian_GPS §

```
      if ( mySerial.available()>0){
      response =  mySerial.readStringUntil('\n');
      }


     if(lastStringLength != response.length()){
      //Perintah ON
      if(response.indexOf("FIND")!=-1){

          SendMessage2();
      }
     }



 }


  void SendMessage()
{
  String link = "www.google.com/maps/place/" + String(latitude, 7) + "," + String(longitude, 7) ;
  mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
  delay(1000);  // Delay of 1000 milli seconds or 1 second
  mySerial.println("AT+CMGS=\"+601111010048\"\r"); // Replace x with mobile number
  delay(1000);
  mySerial.print("The old citizen just fell at ");// The SMS text you want to send
  mySerial.println(link);
  delay(100);
   mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
}
```

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pengujian_GPS | Arduino 1.8.19 (Windows Store 1.8.57.0)

File Edit Sketch Tools Help

pengujian_GPS §

```
 }


  void SendMessage()
{
  String link = "www.google.com/maps/place/" + String(latitude, 7) + "," + String(longitude, 7) ;
  mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
  delay(1000);  // Delay of 1000 milli seconds or 1 second
  mySerial.println("AT+CMGS=\"+601111010048\"\r"); // Replace x with mobile number
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}
  void SendMessage2()
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  mySerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
  delay(1000);  // Delay of 1000 milli seconds or 1 second
  mySerial.println("AT+CMGS=\"+601111010048\"\r"); // Replace x with mobile number
  delay(1000);
  mySerial.print("The old citizen is at  ");// The SMS text you want to send
  mySerial.println(link);
  delay(100);
   mySerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
}
```

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VITAE

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