PETS LOCATION MOBILE TRACKING APPLICATION USING KALMAN ALGORITHM

BY

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ABSTRACT

This project is aimed to provide a solution for pet owners who wants to monitor and track their pets when they are gone missing. Other than that, users can set up a virtual safe zone which they will be notified when their pets leave the safe zone. Kalman algorithm has been used to increase the accuracy of obtaining the exact location of the pets. Although pet tracking system has been exist for about 9 years but majority of the pet owners do not have the idea of tracking pet's real-time location until they discover that their pets has been lost and nowhere to be found. Common methods including online advertising, searching in the neighborhood and microchip are very time-consuming and do not offer a high likelihood of finding back their pets. Most of the lost pets are either dead or lost forever. Therefore, with the help of the tracking device and the mobile application, pet owners can track their pets anytime anywhere. However, the implementation of pets mobile tracking system still faced a lot of issues like battery, size and water resistance for the tracking device. This proposed project can help families no longer worried of losing their pets again.

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LIST OF SYMBOLS

Φ	phi
π	pie
θ	theta
α	alpha
β	beta
x^T	transpose
Σ	sigma

LIST OF ABBREVIATIONS

MPP	Missing Pet Partnership
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
RFID	Radio Frequency Identification
WiFi	Wireless Fidelity
QR	Code Quick Response Code
NFC	Near-field communication
BLE	Beacons Bluetooth Low Energy
SNR	Signal to noise ratio
ACF	Autocorrelation Function
ALEE	Average Location Estimation Error
LER	Location Error Ratio
MS-SQL 2000 DBMS	Microsoft Structured Query Language 2000 Database Management system
WSN	Wireless Sensor Network
API	Application Programming Interface

CHAPTER 1 INTRODUCTION

1.1 Introduction

This proposed project mainly focuses on developing a pet location tracking system (PLTS) by using the Global Positioning System (GPS) to monitor and track the position of the pets. By using live tracking, users are able to track back their lost pets. Other than that, users can set up the geofence in a specific range and pet owners will be notified when the pets leave the safe zone. Research had showed when people lose their families and pets, whether they are missing or found dead, that generally has a significant impact on the owner [1]. In the past six months, similar applications such as Tractive have had a total of nine hundred thousand visits that increase by 3.97% half-yearly [2]. This indicates that pets are taking on a larger role in the family [3]. In addition, Kalman filtering will be used to improve the accuracy of the location coordinates. Hence, this project also plans to develop and design a user-friendly interface mobile application to improve user's experience. The outcome of this proposed project is a tracking device and a mobile application.

1.2 Background study of the current pets location tracking system that exists in Malaysia

In Malaysia, the pet owners do not have the idea of tracking the pet's real-time location until they discover that their pets have been lost and are nowhere to be found. Most of the location tracking systems are sold by unknown sellers in e-commerce websites. Other than that, pet owners in Malaysia may presume the price of the location tracker is unbearable and fail to recognize the importance of tracking their pet's location until the disaster occurred. Thus, the majority of Malaysian will search physically around the neighborhood or posting advertisements online hoping their pets will be found. Other than that, microchip technology has been invented which these chips are stored the pet and owner's information which required someone to scan the pet using a microchip scanner to retrieve information to contact the pet owner. Besides that, tattoos can be used for tracking lost pets but are also more expensive. Some first-world countries make tattooing or chip implanting mandatory but in other countries, including Malaysia it is virtually unheard-of. While these approaches have increased the pet recovery rate, it does not provide a real-time pet tracking system which will help the owner to immediately locate the pet’s location.

To overcome the problems above, the proposed project is provided for remotely monitoring the pet’s location. It includes a device which acts as a location receiver, a tracking device, a network, one or more remote servers and at least one wireless computing device. The location receiver will track the location of the pets and transmit the results to the server and then stored in a database. The mobile application will then retrieve the data and viewed by the users in the mobile application.

Tracking technology

In the 21st century, location tracking applications and identification systems have been generalized for everyone. When their pets go missing, pet owners have no reason to be unprepared and irresistible. There are several technologies when it comes to location tracking including:

1. GPS (Global Positioning System)
2. RFID (Radio Frequency Identification)
3. WiFi
4. QR Code (Quick Response Code)
5. NFC (Near-field communication)
6. BLE Beacons (Bluetooth Low Energy)

An improved real-time tracking system is recommended with the following features:

a) Accuracy: accurate position tracking and alerts.
b) Flexible: customizable geofencing and safe zones.
b) Durability : battery that lasts enough for a day long.
c) Water resistant: waterproof which is eligible for pets that love to swim.
d) Small in size: available to attach to small animals.
e) Reliable: able to send notifications or alert to the wireless device.
f) Affordable: the cost should be affordable by normal citizens.
g) Wide range: the range of coverage must be wide

1.3 Problem Statement of Existing Solutions

1. The possibility of finding pets back is low

The methods that are often used when a pet is gone missing is physical searching and it requires a lot of manpower and time. Statistics had shown that 566 cats where a physical search was conducted and there were only 482 cats found alive while others are either missing or dead. In the meanwhile, people would post online regarding their missing pets or put out posters in the neighborhood. These methods usually last for 21 days and the percentage of the pet found after 21 days is very low. From 1044 cats, 601 were found live and 17 cats were found dead and the others have never been found [4].

2. Pets could have been killed while searching

Without a real-time tracking device, pets could be facing danger while the owner spends time to look for it. A pet including pigs could have been killed and turned into a very hearty meal if the owner could not find it earlier. People who live in the neighborhood could make the decision to slaughter someone’s pet pig without the owner's permission and no responsibility will be held by the one who kills [5].

3. Microchip and Bluetooth technology insufficient to solve the problem

Existing solutions such as microchip technology have been invented to solve the problem. However, there is often a misconception that pets can be tracked by using microchips. In reality, a microchip is only one of the methods for finding a lost pet but not the best one because it could not track the pet's real-time location. The microchip only has the size of a grain rice and it is placed beneath the animal's skin. It provides a permanent identification for the pet and acquires the technology of radio frequency identification (RFID). It saves information about the pet, such as the chip's unique ID, the animal's breed, description, immunization schedule, owner information, and the veterinarian's contact information. However, it requires the pet to be scanned by a microchip scanner to identify its information [6].

Other than that, Bluetooth technology also has been used to set up a customized safe zone for the pets. Once the pet leaves the safe zone an alert will be notified to the owner. However this approach could be useful if it is an indoor pet, it is not suitable for an outdoor pet which they are allowed to wander around the neighborhood [2].

4. There exists too many stray pets in Malaysia which impossible for microchip implantation

Implantation of microchips have been made mandatory by some countries but not including Malaysia. This concludes that if the pet has gone missing it can’t be tracked by microchip. On the other hand, stray dogs and cats have been increasing year by year without any control.

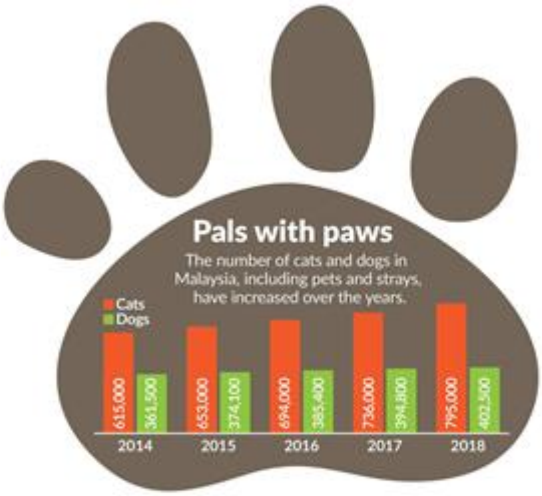


Figure 1.2.1 The increase of stray animals from 2014 to 2018 [7].

Source: https://www.thestar.com.my/news/nation/2019/12/01/pet-peeves-in-animal-welfare

Figure 1.2.1 had shown that without having the stray animals neutered the number of stray animals could be increased in exponential rate. A female cat can become pregnant as early as 16 weeks of age and have two or three litters each year, according to data. As a result, a single mother cat and her children may produce 420,000 additional cats in just 7 years. It has been calculated that a single mother cat and her kittens may generate 420,000 additional cats in 7 years. In addition, if the pet has been lost it is possible that it would straight end up with the strays and could never be found in the pet's lifetime [7].

1.4 Motivation

Pet owners always had the problem of tracking their pets. Despite the owner's substantial effort to be vigilant of their pets, pets often mange to break free from their confines and roam freely. If the pets are not found, they are usually do poorly because they lack survival skills. These animals will most likely starve to death, become ill, eaten by predators or even run over by vehicles. In addition, it is heart-breaking to see pet owners wonder when their pets will come home.

The motivation for this proposed project is to develop a location tracking system using mobile application. This project will be using the Kalman algorithm which provides a predetermined accuracy for the pet's position. The proposed project provides a solution for pet owners to track their pets when their pets are lost. The GPS tracker will be attached to the animal and users can remotely connect with the server via the mobile application. The mobile application offers a map of the tracked animal's real-time location and users can view the places that their pet went. A set of notifications are selectable for adjusting the tracking preferences. Other than that, a safe zone will be set up once the pet is out of range, the owner will receive an alert which could be configured by the user. It gives the pet owners a chance to reunite with their beloved dogs and cats. The mobile application also stores identification about their pets. Owners can monitor their pets time to time while working. Besides that, Pet owners can post pictures of their pets and communicate with the community through likes and comments. Hence, this project could let pet owners not have to live in fear of losing their pets anymore and save thousands of lives.

1.5 Project Scope

The project aims to build a real-time location tracking system using Kalman algorithm for mobile platforms to further improve the current existing location tracking system and provides a solution for tracking lost pets. A GPS tracking device will be used and a mobile application will be developed for the pet owners to register, login, connect the tracking device with Bluetooth to the application, store pets basic information, set up a virtual safe zone, interact with the community and view the pets live location when the pets are missing. The process of mobile location tracking system could be deployed with several phases including tracking device registration, users registration, pets registration, set up a virtual safe zone and view the live location and history of their pets on the application. A GPS chip named SIM808 module will be selected to track the pets position and coordinates will be sent to the remote database. The mobile application will obtain the coordinates from the database and show the pet's whereabouts. In addition, Kalman algorithm will be used to process the position information to improve the location tracking. Location information is expected to be updated at regular intervals but may be updated sooner if solicited by users. This project will be completed by May 2022.

Proposed Functions

Several functions and modules will be developed in this proposed project:

a. Sign up and sign in to the mobile application.
b. Connect the tracking device to the application using Bluetooth.
c. Create a pet profile.
d. Receive coordinates from the tracking device to the remote database.

e. Track the live location of the pets
f. Set up a virtual safe zone using GPS technology.
g. Able to post news feed.

1.6 Project Objective

The objectives of this project are:

1. To determine user requirements by using online survey questionnaires.

   Sub-objectives:

   - Questions will be designed to determine the user requirements on the proposed system.

2. To authenticate users which provide sign up and sign in functions in the mobile application.

   Sub-objectives:

   - Users are able to sign up and sign in using Google and email which implements through Firebase.

3. To connect the tracking device with the mobile application.

   Sub-objectives:

   - Users will be able to use Bluetooth to pair the tracking device with the mobile application.

4. To set up a virtual safe zone for the pets which the owner will be notified when the pets leave.

   Sub-objectives:

   - Users are able to use the function of setting up a virtual safe zone using GPS technology through the user interface of the mobile application.
   - Users would receive an alert if the pets left the safe zone.

5. To store data of the pets.

   Sub-objectives:

- Pets data will be stored in the firebase real-time database.
- Users are able to store and view the data of their pets.

6. To receive coordinates from the tracking device to the remote database.

   Sub-objectives:

   - The tracking device will upload the location coordinates *(X(k), Y(k))* and time instant k to the remote database (Firebase) and the data obtained will be filtered using Kalman algorithm to increase the accuracy. The filtered location data will be used by the mobile application to track pets location.

7. To track the live location of the pets.

   Sub-objectives:

   - Coordinates are obtained from the remote database (Firebase) and filtered with Kalman algorithm. Users are able to view the location of their pets in Google Maps.
   - Track the path and history that the pets have gone.

8. To post details about their pets in the news feed.

   Sub-objectives:

   - Users are able to publish the images and status of their pets and interact with other users.

1.7 Innovation/Contribution of Project

The main contribution of this project is to develop a location tracking system using the mobile application for pet owners which can track the real-time location of their pets in daily activity and even track down them when they are gone missing. In addition, using the Kalman algorithm to filter the coordinates will increase the accuracy of tracking the pet's location which is more efficient and trustable. Other than that, some pets like to wander outside on their own. Some of the pet owners want to be able to let their dogs or cats roam around the neighborhood without the need to constantly watch over them or try to keep them within a certain space. This project would help the owners to feel safe with the ability to track the location of their pets.

Moreover, posts about missing pets are frequently posted on social media which is heart-breaking. It is important for pet owners to find back their valuable family and no longer suffer from anxiety of losing their pets. Other than that, most of the pet trackers today only support overseas which Malaysia does not have a method to track their pets yet. The developed project is able to help pet owners find back their lost pets and track their pet's daily activity.

1.8 Report Organization

This report is divided into 6 chapters. The first chapter is the introduction of the proposed project. This chapter included the project background, problem statement, motivation, project scope, project objectives and innovation/contribution of the project. The second chapter is regarding the literature review which discusses the different types of location tracking technology and reviewing existing systems and applications to track the pet location. This research that has been done in this chapter is significant because the conclusion of this chapter decides the outcome of the project. In chapter 3, RAD methodology has been used to develop in this project and the details of the hardware that will be used to set up the tracking device. Other than that, it has illustrate the flows and functionality of each module using UML diagram. In chapter 4, it has stated the user requirements, verification plan (testing), issues and challenges during implementation and the overall timeline of the whole project. Finally, in chapter 5, screenshots of each module have been documented. Besides that, each module will be tested and documented in the test case. There is also a comparison between the coordinates before and after filter with Kalman Algorithm. After that, a survey has been conducted based on the functions obtained from the existing applications. The result of the survey has been analyzed and discussed. Lastly, chapter 6 will summarize the whole report, limitations, and recommendations of this project.

1.9 Conclusion

In conclusion, pets have played a significant role in our daily life especially for the people who lived alone in the pandemic. When losing a pet, it can be incredibly stressful because no one knows when they're going back. This chapter has briefly discussed background study of the current pets location tracking system that exists in Malaysia, the tracking technologies, the existing solutions when the pet is missing, objectives to be achieved in this project and the impacts or contributions of the project towards the community. Therefore, a pet location tracking via mobile application is needed to resolve the issues that aforementioned in the problem statement. There will be more details about how location tracking works, related research papers, articles and reviews on existing similar systems in the next chapter.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

To solve the issues above, a location tracking technology that can track the pet for a long distance, have a sustained battery life and have predetermined accuracy are taken into primary consideration. As technology continues to march forward, many options are available when it comes to location tracking.

2.2 Types of Location Tracking Technology

2.2.1 GPS

When it comes to position tracking, the most common method is to use the Global Positioning System (GPS). The GPS receiver delivers and receives signals from four or more GPS satellites, calculating time offsets as needed to determine the receiver's precise location [8]. A GPS tracking system makes use of the Global Navigation Satellite System (GNSS) network. The network is made up of a number of satellites that send microwave signals to GPS devices in order to give position, speed, time, and direction information.

There are two types of GPS system that can be classified:

1. Passive: a passive GPS tracking system will continuously monitor and record data such as GPS position, speed, heading, and, on rare instances, a trigger event. It may record where the gadget has been in the past several hours. Data is often saved in internal memory or on a memory card, which may then be transferred to a computer for subsequent processing. In certain situations, the data may be transmitted automatically for wireless download or requested at a specified point during the route.
2. Active: an active GPS tracking system is referred regarded as a real-time system since it sends data from the GPS system to a remote database server automatically. It is commonly used for commercial purposes including people monitoring, object tracking or animal tracking.

An active GPS tracking gadget on any route may give both real-time and historical navigation data. The operation of the system is based on a basic mathematical theory known as trilateration. It is classified into two types: 2-D Trilateration and 3-D Trilateration. The GPS receiver's location must be traced by at least three satellites above the area [9].

2.2.2 RFID

Radio Frequency Identification (RFID) is a technology that uses electromagnetic waves to identify and track tags that are affixed to items. An RFID system is made up of a small radio transponder, a radio receiver, and a radio transmitter [10].There are two types of RFID tags:

1. Passive: A passive RFID system makes use of high-power readers that emit a low-frequency, high-power RF signal that does not require a battery. It's frequently used to keep track of inventories and deter theft. It is approximately range 1 - 5 meters away from the RFID tags.
2. Active: An active RFID tags are battery-powered tags that broadcast their identity to multiple access points or readers. The position of each tagged object will subsequently be sent to a gateway via these access points. These access points then will transfer the location of each tagged item to a gateway. The range of active RFID can be greater 100 meters between the RFID tag and reader.

2.2.3 Wi-Fi

Wi-Fi positioning system is a geolocation system that uses the characteristics of "fixed" anchor points providing a static known position. However, Wi-Fi location tracking required at least 3 access points to "hear" each tag transmission. It can be lower costs than GPS when the position required is indoor [11].

2.2.4 QR code

QR codes don't have passive or in the background tracking capability like other tracking technology. They are very similar to NFC which require a close proximity scan and require the user to open a scanner or application to scan the QR code. These characteristics show that it is not suitable for real-time tracking.

2.2.5 NFC

NFC systems are a type of passive RFID which is mostly built into Android and Apple devices for payment and ticketing applications. NFC tags are inexpensive to implement and they work with any contactless terminal. However, as its name is "near-field" communication system means that it only works with 4-inch range of a terminal.

2.2.6 BLE Beacons

Bluetooth low energy beacons (BLE Beacons) are tiny wireless transmitters that use low-energy Bluetooth technology to deliver signals to other nearby smart devices. It uses a battery power supply and consumes very little energy. However, it is mainly used for indoor position tracking [11].

2.2.7 Comparison between Tracking technologies

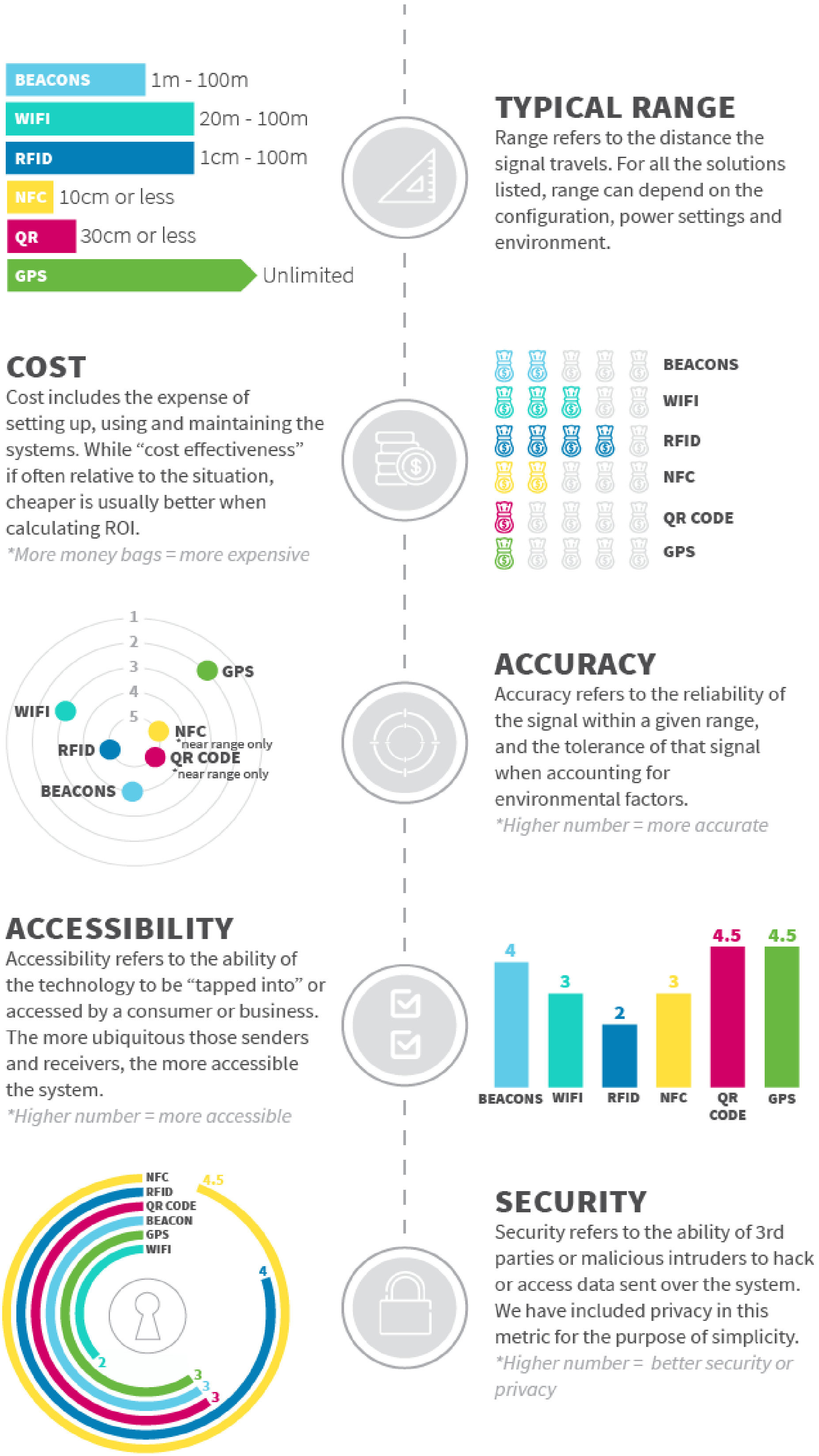


Figure 2.2.7.1 Comparison between different tracking technologies [11]

Source:https://locatify.com/blog/indoor-positioning-systems-ble-beacons/#:~:text=BLE%20Beacons%20are%20small%20devices,on%20a%20single%20battery%20charge

Method	Advantages	Limitations
GPS	● Suitable for outdoor environments ● Unlimited range ● Easy to integrated with other technologies ● ROI is high ● 100% coverage on the planet	● Can be affected by ionospheric scintillations which causes the navigation errors or failure ● Can be affected by animal movement including fading and shadowing ● Power hunger (often drains the battery) which lasts between 9 to 12 hours ● High budget required
RFID	● Suitable for indoor environments ● Low power utilization to conserve battery life of device ● With the help of proximity detection, it ensures a high accuracy	● Not suitable for outdoor environments ● Normally used for asset ● More suitable for track location in multiple access point ● Short range of communication range ● High cost
WiFi	● Average range (20m - 100m)	● Require at least 3 access points to get accurate location

QR code	• Able to view the real-time location when the QR code is scanned	• Short range (30cm or less) • Require scanning
NFC	• Perfect solution for paying with mobile device	• Short range (10cm or less) • Not suitable for real-time location tracking
BLE Beacons	• Small devices that can be easily mounted • Perfect solution for indoor positioning • inexpensive	• Average range (1m - 100m) • Not suitable for real-time location tracking

Table 2.2.7.2 Advantages and disadvantages of tracking technologies

2.3 Summary on Tracking Technologies

In short, after reviewed all of the tracking technology, GPS is best suited for pet location tracking because it can be tracked unlimited range and with a predetermined accuracy. Since the commercialization of GPS-based animal monitoring devices in 1991, several configurations have been developed for research in various settings. Aside from that, GPS systems have seen various advances in terms of size and performance, as well as a significant reduction in cost. Geographic coordinates and satellite identification numbers obtained after "differential correction," dates and times of location estimations, and optional sensor information are expected to be kept in GPS devices connected to the animals until retrieval. Furthermore, the precision of GPS positions is largely influenced by the synchronization of clocks between the receiver and satellites that transmit continuous spread-spectrum radio signals [12].

2.4 Analysis of Location Estimation

GPS can be improved by using distributed Kalman-based filters. It combines the measurement and prediction to find the optimal estimate of the animal's location [13]. The smoothing procedure via linear regression in the Kalman filtering method improves the accuracy of the calculated location compared to the GPS approach. The Kalman Filtering method calculates velocity and location, which are then used in the following estimating procedure. Unfortunately, the calculated velocity has a significant estimation inaccuracy [14].

To completely understand how the Kalman filter works and to become acquainted with the equation, a basic example will be presented. It is not sufficient to use a single measurement device to determine the position of an object since the likelihood of one's exact location is a well-known notion that readily allows dynamics to be brought into the situation. Figure 2.4.1 depicts the filter that employs measurements as well as the degree of certainty in those measures.

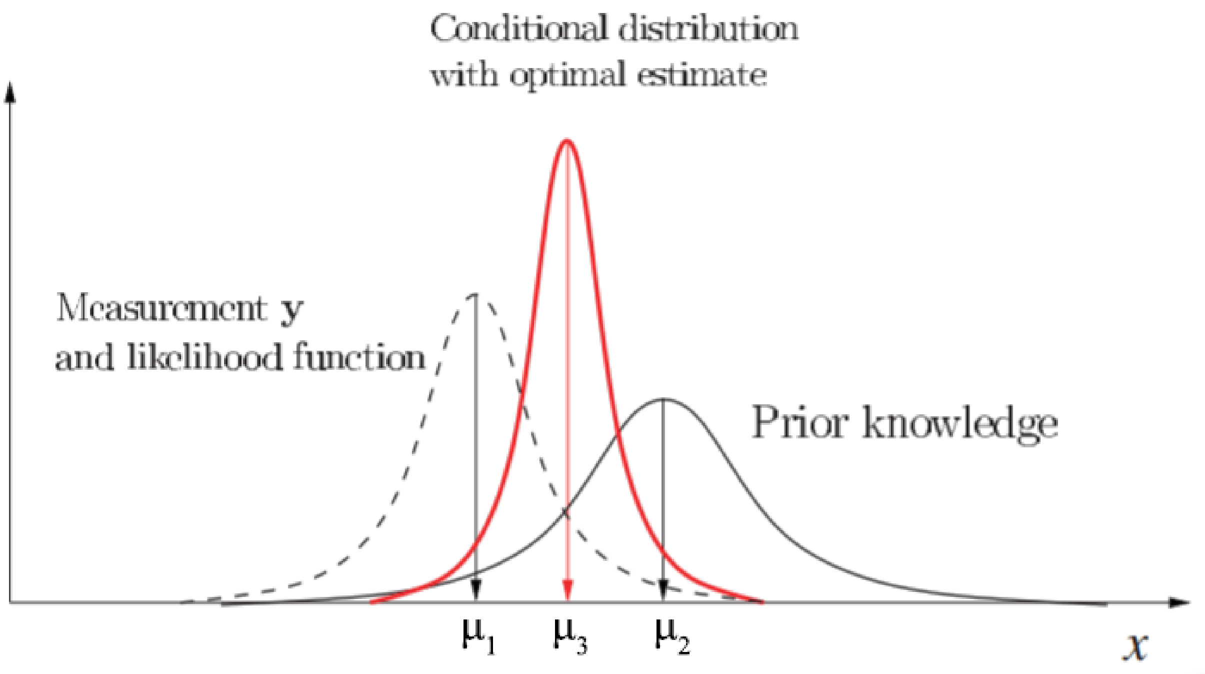


Figure 2.4.1 Conditional probability density of position based on measurement μ_1 and prediction μ_2 [15]

Source:

https://www.researchgate.net/publication/224564437_Location_tracking_in_GPS_using_Kalman_Filter_through_SMS

It is important to note that the narrower peak is due to a lower variance, suggesting that the position is very certain based on measurement and forecast [16].

The Kalman filter implementation is divided into many phases. The location data specified as S(k) :

$$S(k) = (X(k), Y(k), V_x(k), V_y(k))^T \qquad (1)$$

The coordinates (x and y) of a GPS's location at time instant k are X(k) and Y(k). In equation (1), Vx(k) and Vy(k) represent the x-axis and y-axis directional velocities of a GPS receiver at time instant k, respectively.

The state model of Kalman filter is

$$S(k) = AS(k) \; (2)$$

The transformation matrix A between first and next measurement

$$A = \begin{bmatrix} 1 & 0 & d & 0 \\ 0 & 1 & 0 & d \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The time increasing unit is denoted by *d*. Based on equations (1) and (2), process of Kalman filtering method can be described as the following: Firstly, forecast $S(k|k\text{-}1)$ and minimum predicted Mean Square Error (MSE) $M(k|k\text{-}1)$ can be obtained by

$$\begin{gathered} S(k|k-1) = AS(k-1|k-1) \\ M(k|k-1) = AM(k-1|k-1)A^T + BQB^T \end{gathered} \qquad (3)$$

where B is an optional control input to current state

$$B = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ d & 0 \\ 0 & d \end{bmatrix}$$

and Q is the dynamic noise of the system. According to (3), Kalman gain may be defined as

$$K(k|k-1) = M(k|k-1)H^T.\{R+HM(k-1|k-1)H^T\}^{-1} \text{ (4)}$$

where R is receiver noise and H is the measurement sensitivity matrix

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

Finally, Kalman filtering estimated vectors can be updated by

$$S(k|k) = AS(k|k-1) + K(k)\{L(k)-H(k)AS(k\}k-1)\} \text{ (5)}$$

$L(k)$ in (5) is defined as

$$L(k) = (l_1(k),l_2(k))^T \text{ (6)}$$

where $l_1(k)$ and $l_2(k)$ are GPS-estimated coordinates (x and y). When a new GPS estimated position L(k) is supplied to the Kalman filter, the Kalman filtering process is repeated recursively.

Furthermore, the Kalman filtering method estimates the velocity and location of a GPS receiver and uses them for future estimation. It starts with 0m/s and works its way up to the original velocity of the GPS sensor via a recursive Kalman filter method. As a result, the first section of the predicted velocity has a large inaccuracy, and transient time is required to achieve correct estimates. This also happens when the GPS receiver's velocity changes. The estimated position and velocity data will also impact the next estimation, thus wrongly estimated velocity causes Kalman filtering technique location estimation inaccuracy. In the next section, an improved location tracking method is presented to decrease error [15].

2.5 Location Tracking with velocity estimation

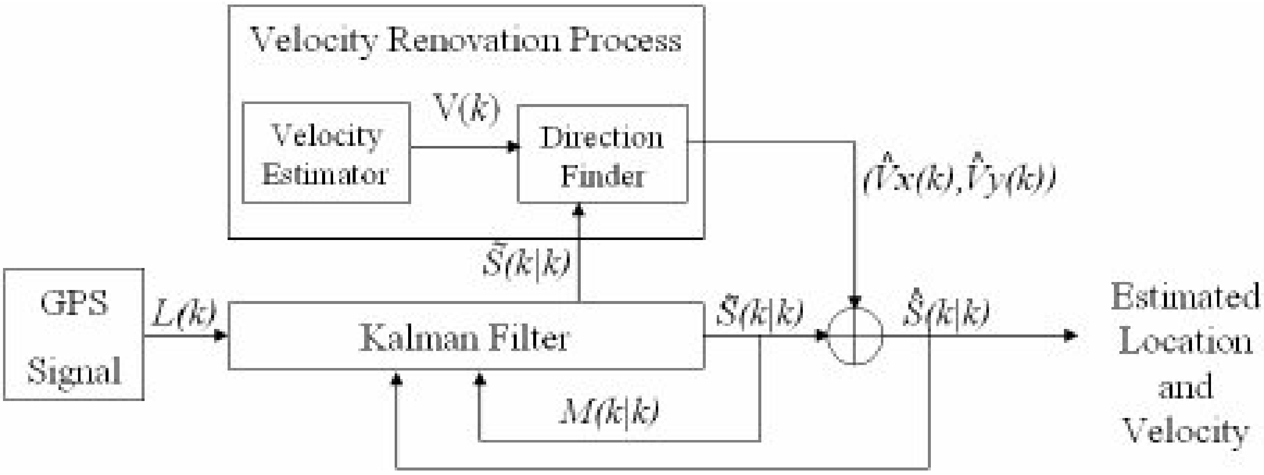


Figure 2.5.1 The block diagram of the proposed location tracking algorithm [15].

Source:
https://www.researchgate.net/publication/224564437_Location_tracking_in_GPS_using_Kalman_Filter_through_SMS

Figure 2.2.8.2.1 depicts the block diagram of the proposed method position tracking algorithm, which employs a velocity renovation process with a Kalman filter. The velocity renovation method is used to properly estimate velocity in the Kalman filter to improve location estimation accuracy. It is divided into two sections. The first is a velocity estimator, and the second is a direction finder. In the velocity renovation procedure, y estimated velocity and direction, x-axis and y-axis directional velocities may be determined. The Kalman filter is fed estimated velocities [15].

I. Velocity Estimator

There are several traditional techniques for estimating velocity, however SNR information is necessary to eliminate noise and interference that may impact the calculation. SNR-independent velocity estimation, which removes the influence of noise and interference in the absence of SNR information, is proposed in [17] and [18]. In the velocity renovation process, the journal's IQ-based ACF estimate technique, which is one of the SNR-independent velocity estimation methods, is utilized as a velocity estimator [18].

Auto-correlation function of in-phase component channel is defined as

$$\Phi_d = E[x(i).x(i+d)]$$

and ratio $\Phi 1$ to $\Phi 0$ and ratio of $\Phi 2$ to $\Phi 0$

$$R1 = \frac{\phi 1}{\phi 0} \qquad R2 = \frac{\phi 2}{\phi 0} \quad (7)$$

Where $\Phi 1$, $\Phi 1$ and $\Phi 2$ are estimated via [17]

$$\phi 0 = \frac{1}{N}\sum_{i=1}^{N} E[x_i x_i]$$
$$\phi 1 = \frac{1}{N-1}\sum_{i=1}^{N-1} E[x_i x_{i+1}] \quad (8)$$
$$\phi 2 = \frac{1}{N-2}\sum_{i=1}^{N-2} E[x_i x_{i+2}]$$

Maximum Doppler frequency estimated by IQ-based ACF estimation method can be defined by$f_m = \sqrt{\frac{D_1 - D_2 - D_3}{\pi^2(4D_1 - D_2)}}$ (9)

where D_1, D_2 and D_3 are

$$D_1 = sinc(B.T_s) - R_1$$
$$D_2 = sinc(2B.T_s) - R_1 \quad (10)$$
$$D_3 = R_1 . sinc(B.T_s) - R_1\, sinc(2B.T_s)$$

and

$$sinc(x) = \frac{sin(\pi x)}{\pi x}$$

B and T_s are bandwidth of receiver and sampling period. By estimated maximum Doppler frequency, velocity of a GPS receiver can be estimated as

$$V = \frac{c.f_m}{f_c} \quad (11)$$

where *c* and f_c are speed of propagation and carrier frequency.

II. Direction finder

The velocity renovation process's direction finder is simply constructed utilizing variations in projected locations. The GPS receiver's estimated direction may be determined by

$$\theta_k = \begin{cases} tan^{-1}(D_k), \ when\, \widetilde{X}(k) > \tilde{X}(k-1) \\ tan^{-1}(D_k) + \pi, \ when\, \widetilde{X}(k) < \tilde{X}(k-1) \end{cases} \quad (12)$$

where *D(k)* is defined as *{Y(k) - Y(k-1)|X(k)-X(k-1)}*. *(X(k), Y(k))* are the estimated position coordinates by Kalman filtering at time instant *k* and *X(k-1),Y(k-1))* are the estimated location coordinates by the proposed algorithm at time instant *k-1*. Estimated direction θ_k varies greatly because the estimated position coordinates which are used in (12) are inaccurate, particularly *(X(k), Y(k))*. Instead of just taking estimated data, the smoothing approach is used to reduce the variance of θ_k.

The smooth value of direction θ_k can be calculated by taking the average of predicted directions inside the window size as shown below

$$\theta_k = \frac{1}{W}\sum_{i=k-(W-1)}^{k} \theta_k, \ when\ k \geq W \quad (13)$$

where *W* is the size of the window.

III. Replacement of estimated velocity

The x-axis and y-axis directional velocities in the velocity renovation process at time instant k may be calculated using (11) and (13) which can be obtained by

$$(V_x(k), V_y(k))^T \;=\; (Vcos\theta_k, Vsin\theta_k)^T$$

The *x-axis* and *y-axis* directional velocities in the Kalman filtering technique estimated vector *S(k|k)* are substituted by $(V_x(k), V_y(k))^T$ in (14). Finally, estimated vector *S(k|k)* by proposed algorithm is represented by

$$S(k|k) = [X(k), Y(k), V_x(k), V_y(k)]^T$$

IV. Calculate ALEE and LER

Average Location Estimation Error (ALEE) is defined as

$$ALEE \;=\; \frac{1}{N}\sum_{k=1}^{N}\sqrt{\{X(k) \;-\; X'(k)\}^2 + \{Y(k) - Y'(k)\}^2} \quad (15)$$

where *(X(k),Y(k))* and *(X'(k),Y'(k))* are the actual and estimated location coordinates.

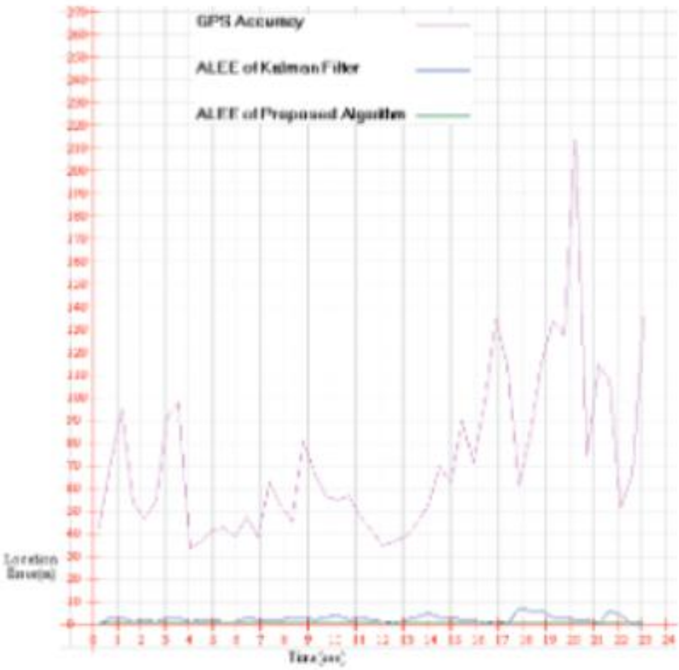


Figure 2.5.2 - Comparison of ALEE graph for Kalman filter and average GPS accuracy [15].

Source:
https://www.researchgate.net/publication/224564437_Location_tracking_in_GPS_using_Kalman_Filter_through_SMS

Location Error Ratio (LER) is defined as

$$LER(\alpha/\beta) = \frac{ALEE\ of\ \alpha}{ALEE\ of\ \beta} \quad (16)$$

where α and β are algorithms for comparing.

From Figure 2.5.2 and Figure 2.5.3, it stated that the LER of average GPS accuracy is higher than the ALEE of Kalman Filter and Proposed Algorithm.

Figure 2.5.3 Comparison of LER graph for Kalman filter and average GPS accuracy [15].

Source:
https://www.researchgate.net/publication/224564437_Location_tracking_in_GPS_using_Kalman_Filter_through_SMS

The proposed location tracking algorithm had used velocity renovation and direction finding in Kalman filter which had reduced the location estimator error. In addition, the proposed algorithm has improved the ability of location tracking and it is verified by the outage probability and LER [15].

2.6 Review on Existing Pet Location Tracking System

2.6.1 Animal Situation Tracking Service Using RFID, GPS and Sensors

Even though several studies have recently used detector, GPS, and associated RFID technology to observe the behavior of the animal and the interactions with the environment, the researchers discovered that there is still scarcity of research and services using GPS, RFID and sensors to zoological gardens and tracking the positions of animals and zookeepers in the reviewed journal.

As a result, an intelligent animal monitoring service for zoological parks is planned, with features such as measuring animal blood heat mistreatment sensor nodes, finding animals and zookeepers using GPS, and differentiating animals, zookeepers, and veterinarians using RFID.

The prototype system can give real-time information such as animal temperature and whereabouts to zoo visitors via their websites. In addition, if the animals left their cages, the technology are able track them down. Web-based open APIs are included in the prototype, allowing users to access the system quickly and easily. In addition, users can check the status of animals in the system remotely using the open API.

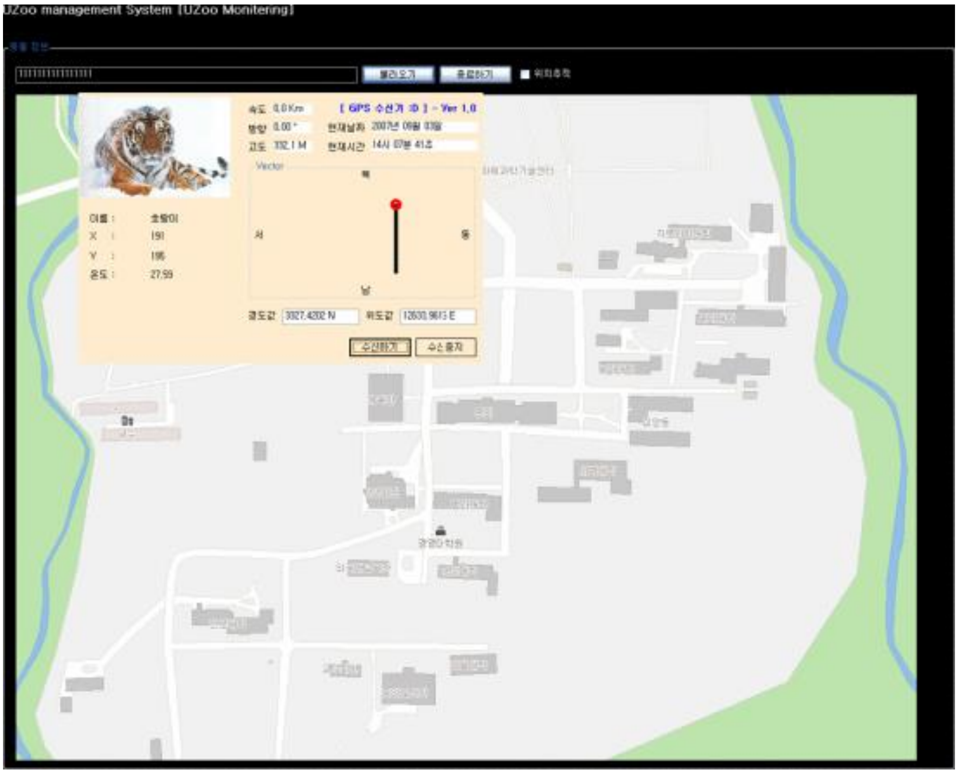


Figure 2.6.1.1 A display of animal location information on map using RFID information [19].

Source:
http://ieeexplore.ieee.org.libezp2.utar.edu.my/stamp/stamp.jsp?tp=&arnumber=5474518&isnumber=5474422\

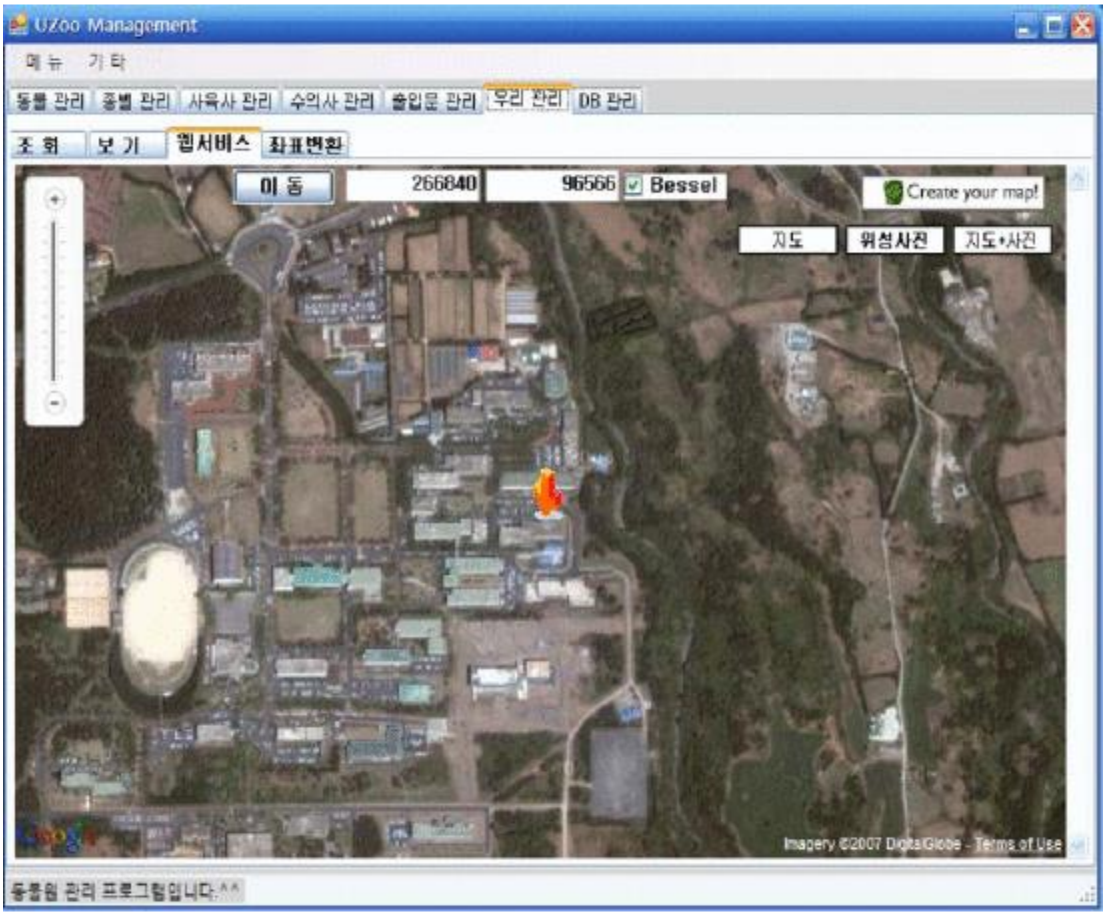


Figure 2.6.1.2 Mark of animal cages on map [19].

Source:
http://ieeexplore.ieee.org.libezp2.utar.edu.my/stamp/stamp.jsp?tp=&arnumber=5474518&isnumber=5474422\

The prototype was created utilizing a Windows 2003 server and the MS-SQL 2000 database management system. Client systems use Windows XP as their operating system. Users may access the database through a web service and obtain information such as their current position, body temperature, and images. It also displays the cage's position on a map using the coordinate transition formula.

2.6.2 GPS-Arduino based Tracking and Alarm system for protection of wildlife animals

The research in this journal were dealing with the issue of animal movement from a forest to a residential area. As a result, they proposed GATA, a monitoring and alarming system for wildlife animal protection. GATA was coupled with Wireless Sensor Network (WSN) and GPS technology to tackle the problem. Auto-generated location tracking and movement patterns have been used to track wildlife creatures that have escaped from wildlife sanctuaries and natural parks. Movement and position tracking has been accomplished using GPS, the accelerometer, and the Wi-Fi shield. If the wildlife animals depart the zone, an alarm will be sent to a stationary base station (BS).

It is seen to be an important component in wildlife surveillance and monitoring, aiding rangers in the administration of wildlife sanctuaries and natural reserves under consideration. Surveillance prevents a wide range of animals from leaving the sanctuary and ensures that the reserves are preserved for future generations. Real-time animal monitoring with GATA is a straightforward and easy process when compared to older technologies such as radio tracking and picture identification.

The difficulties encountered are labor and the high cost of monitoring all of the animals in a group. This is because there hasn't been enough research into how to implement a power-efficient monitoring module based on a microcontroller.

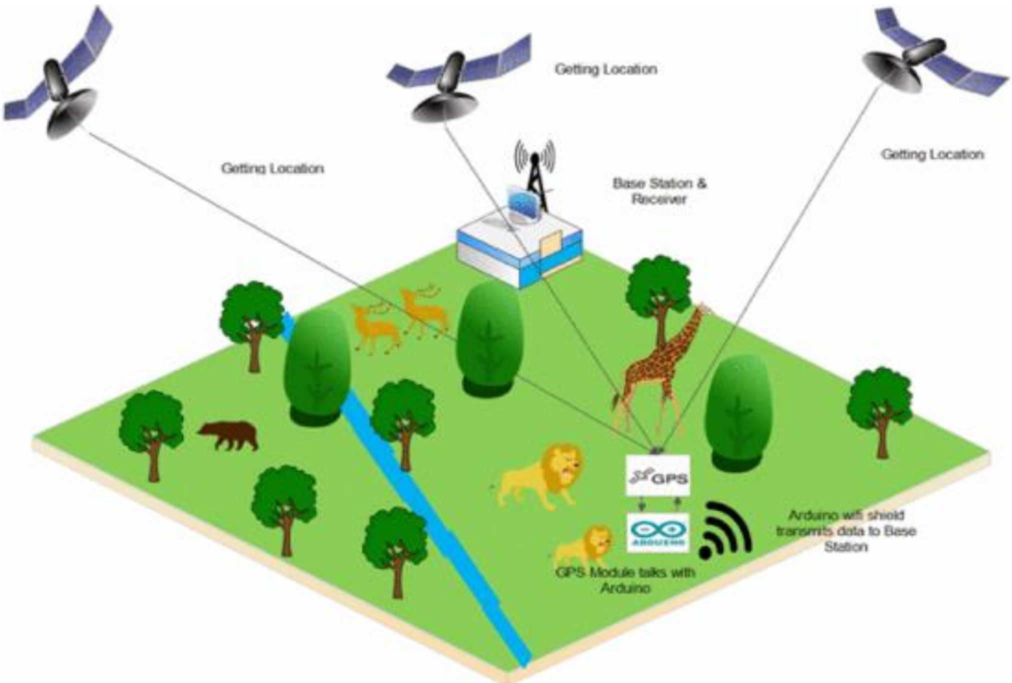


Figure 2.6.2.1 System architecture of the proposed system [20].

Source:http://ieeexplore.ieee.org.libezp2.utar.edu.my/stamp/stamp.jsp?tp=&arnumber=8035325&isnumber=8035266

Arduino Microcontroller and Wi-Fi shields were used between base stations and wireless networks as shown in Figure 2.6.2.1. For real-time tracking, the proposed system made effective use of GPS technology. This would prevent human and animal deaths and injuries, as well as assisting forest departments and other responsible authorities in tracking their movements and ensuring that they do not leave their habitation zone.

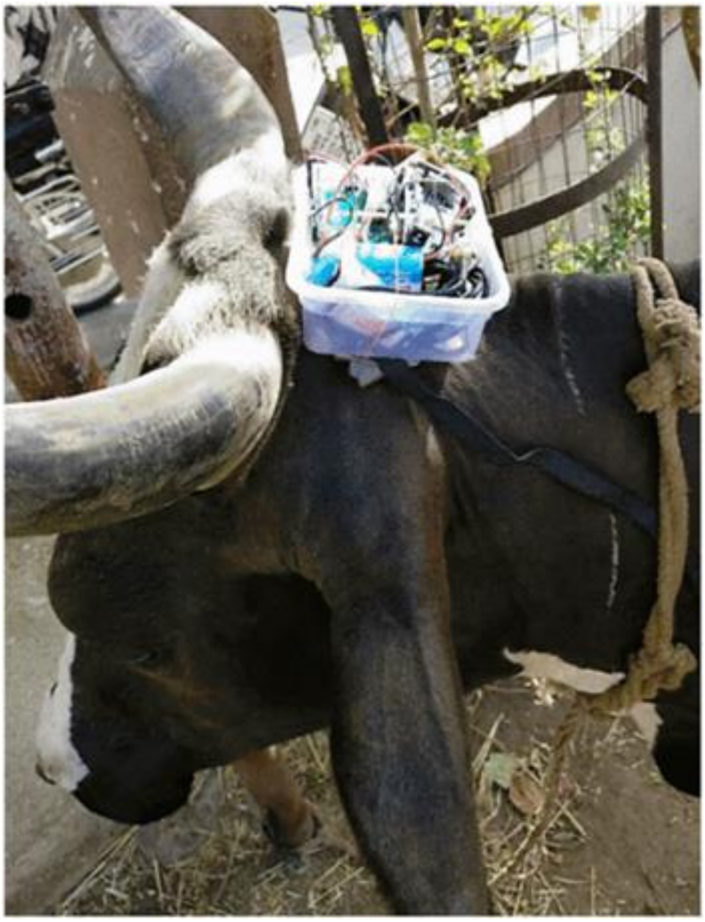


Figure 2.6.2.2 Hardware module attached to the animal [20].

Source:http://ieeexplore.ieee.org.libezp2.utar.edu.my/stamp/stamp.jsp?tp=&arnumber=8035325&isnumber=8035266

2.6.3 wildCENSE: GPS based Animal Tracking System

For real-time tracking, the proposed system made effective use of GPS technology. This would prevent human and animal deaths and injuries, as well as assisting forest departments and other responsible authorities in tracking their movements and ensuring that they do not leave their habitation zone. The search was aided in some cases by implanting the animals with the radio transmitters, allowing them to be easily identified, but the apparently more essential aspect of the picture went unaddressed: effective data collection. Other than that, there are a variety of reasons why regular excursions to the site are difficult and not advised. To begin with, it is almost impossible to study a species without any interacting. Hence, The effects of frequent human visits or disturbances on the species are unknown. Second, following animal behavior after nightfall becomes an experience rather than a research or experiment.

As a result, an automated method for outfitting natural environments with multiple network sensor nodes, allowing for long-term data gathering at times, has been proposed. It's a wireless sensor network (WSN) technology that attempts to follow the animal's activities and movement patterns. The technology is currently still in development which might handle species with a medium to big size. To enable wildlife monitoring, the hardware includes a GPS, a radio transmitter, and a number of additional sensors.

Figure 2.6.3.1 A collar belt along with the node and power supply was attached to the animal [21].

Source:
https://www.researchgate.net/publication/224375698_wildCENSE_GPS_based_animal_tracking_system

As illustrated in the diagram above, the prototype's battery quickly depleted owing to the lack of sleep mode activation. Because the belt was sloppy, the node moved from one side to the other of the neck, resulting in skewed neck movement measurements and an increase in GPS fixing time. As a consequence, a belt improv was created. The node was hanging at the top, while the battery pack was suspended at the bottom. The study lasted 46 hours without any human involvement, and data was gathered and transferred to servers through the base station.

The final prototype has achieved energy efficiency and provides position with a very high accuracy. A continuation of research on solar recharging mechanisms will be done to enhance the node lifetime.

2.7 Comparison on the Reviewed Location Tracking System

A further analysis had been conducted of the three animal tracking systems.

Journal Title	Modules	Advantages	Disadvantages
Animal Situation Tracking Service Using RFID, GPS and Sensors [19]	Able to track the animal's location and temperature. Able to notify the user when the animals escape their cages.	Can check animal condition through a remote system	Outdated web-based system and not user friendly.
GPS-Arduino based Tracking and Alarm system for protection of wildlife animals [20]	Able to track animal location Able to notify users when the animal is out of the protected area	Combination of WSN and GPS able to track the wildlife animals location and movement patterns	Requires to set up Base station and Receiver. Hardware size are too big (may not fit in small animals)

wildCENSE: GPS based Animal Tracking System [21]	Able to track animal location with very high accuracy	Suitable for species with a medium to large size Energy efficient	Hardware size are too big (may not fit in small animals)

Table 2.7.1 Comparison on the reviewed Location Tracking System

From Table 2.7.1, it shows that GPS is still a widely used technology to track the animal's location.

2.8 Review on Commercial Mobile Application for Pet Tracking

2.8.1 Tractive

https://tractive.com/en/

This is a real-time GPS tracking for cats and dogs which is small, waterproof, offers up to 5 days battery life, has global coverage and provides live tracking for pets. In addition, it is able to set up safe zones for pets and get notification when the pets leave the safe zone. It is approximately RM250(49.99 euro) plus subscription fees RM300(59.99 euro) for every year in order to live tracking the pets.

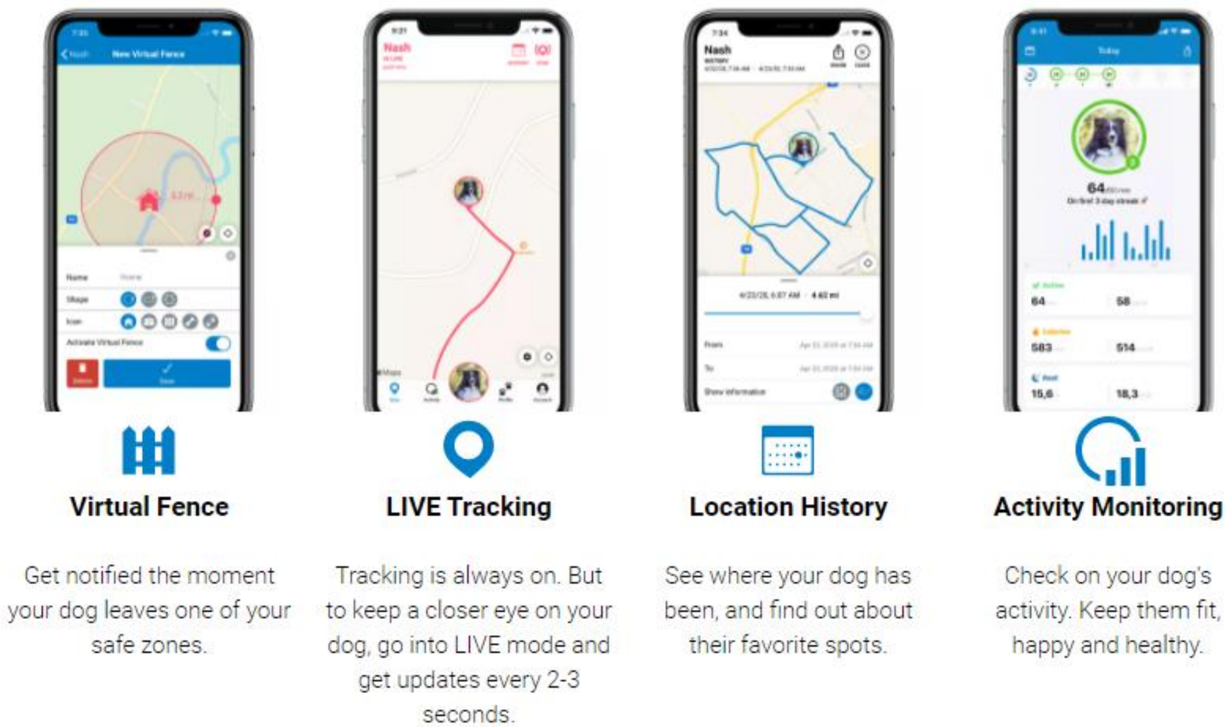


Figure 2.8.1 Tractive Application Interface

Source: https://tractive.com/en/pd/gps-tracker-dog

How does this app work?

- Request users whether they have the Tractive tracker bought or not.
- If not yet bought it will redirect users to the websites

- If bought it will require users to create an account
- Request users whether they have a cat or a dog
- Connect the tracking device to the mobile application
- Set up a virtual safe zone
- Able to actively monitoring the pets
- Able to live tracking the pets
- Able to check the location history of the pets

2.8.2 Findster Duo+

https://getfindster.com

Findster Duo+ is a GPS Pet tracker without paying for a monthly subscription. It has been advertised as the best GPS pet tracker which provides real-time GPS tracking, pet activity monitoring, waterproof and track up to three pets. It comes with two devices, two modules which the pet module that is equipped with GPS communicates the pet's location to the guardian module. The guardian module is connected to the owner's phone via Bluetooth which allows to view pet's activity and location information in the dedicated Findster application. It costs about RM749($184.99) which the application is available in Android or iOS.

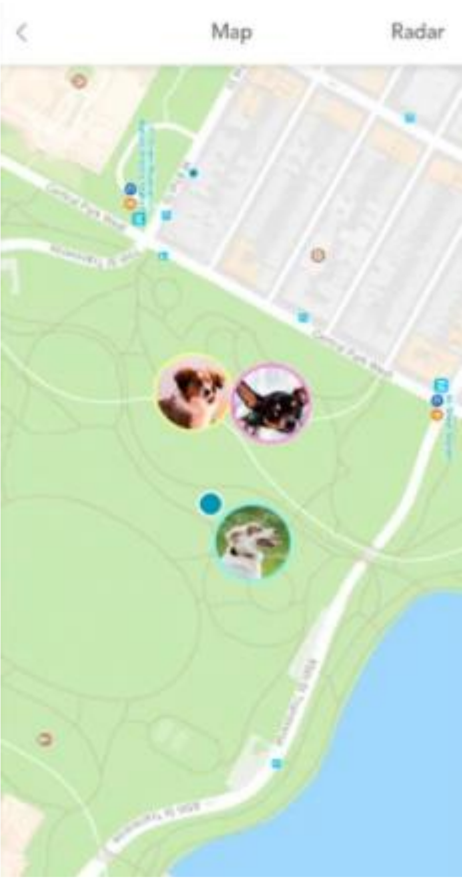


Figure 2.8.2.1 Application shows able to track pets using GPS

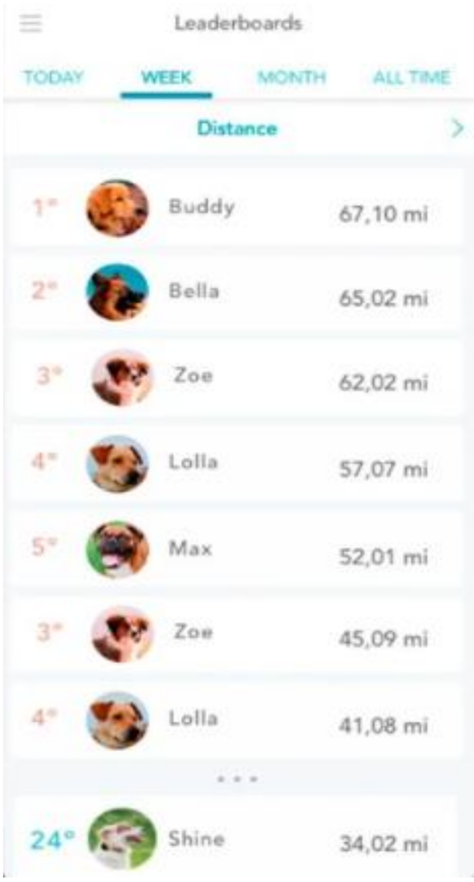


Figure 2.8.2.2 Application shows leaderboards to compare the owners pet's stats with others

Source: Application downloaded from Play Store

How does this app work?

- Pairing the modules to the mobile application
- View the pet's real time location
- Able to view distance of the pets walked
- Able to compared pet's activity with other users

2.8.3 Fi Smart Dog Collar

https://tryfi.com

The Fi Smart Dog collar monitors the pet's activities and whereabouts while providing an unrivalled battery life. It costs around RM606 ($149) per year, which excludes the GPS package for position monitoring and data storage, which is RM402 ($99) per year. For setup and monitoring, the Fi Collar comes with a mobile app for Android and iOS. It’s been earned Editor’s Choice in PCMAG.com due to the battery life that could last for a month.

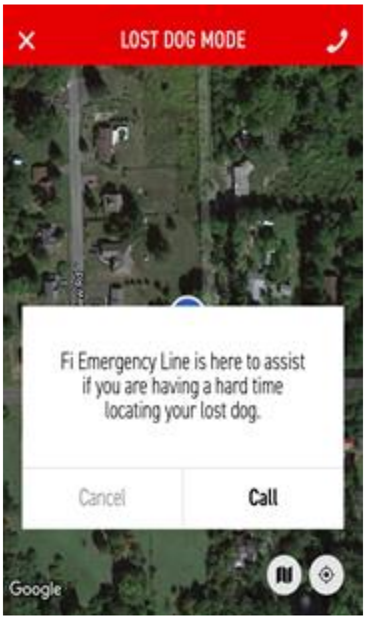


Figure 2.8.3.1 Application is in lost dog mode

Figure 2.8.3.2 Application shows total steps that the dog walks

Source:https://sea.pcmag.com/fi-smart-dog-collar/33296/fi-smart-dog-collar

How does this app work?

- Connect the tracking device to the mobile application
- Create a profile for the dog and attaching the base station to the home WiFi
- Set up safe zone are around the base and specify its size
- If subscribe for GPS plan a real time location of the dog can be viewed
- An alert will be notified if the dog is out of the safe zone

2.8.4 Comparison on Commercial Mobile Applications For Pets Tracking

A further evaluation has been made based on the three reviewed existing commercial mobile applications for pets tracking and shown in Table 2.8.4.1 and Table 2.8.4.2.

App Name	**Rating**	**Total Download**	**Available Platform**	**Price for Application**	**Total Price for Tracking Device and subscription**
Tractive	Play Store: 4.6 App Store: 4.5	Above 500,000	Android iOS	Free	Tracking device: RM250 Subscription for GPS: RM300 per year Total: RM550
Findster	Play Store: 3.9	Above 10,000	Android iOS	Free	Tracking device: RM749 Subscription not needed

	App Store: 4.0				
Fi - GPS Dog Tracker	Play Store: 4.1 App Store: 4.2	Below 1000	Android iOS	Free	Tracking device : RM606 Subscription for GPS: RM 402 per year Total: RM1008

Table 2.8.4.1 Comparison of Mobile Application for Pet Tracking Part 1

App Name	Strength	Weakness	Modules

Tractive	• Able to set a safe zone which user will be notified when the pets leaves the safe zone • Activity tracking included • Waterproof and small tracking device • Battery lasts up to 5 days	• Subscription services is needed for every year which is expensive • Unreliable and live tracking not stable	• Able to create a personal profile for pets • Able to track the pets anytime from anywhere • Able to set up safe zone
Findster	• Able to set a safe zone which user will be notified when the pets leaves the safe zone • Activity tracking included • Waterproof tracking device	• Remote location not provided as advertised • Terrible connection • Application crashes frequently	• Capable to track the real-time location of the pets • Able to set up safe zone • Able to track multiple pets • There are challenges leaderboards for pets • Able to view history of the pets location • Able to track their daily steps

Fi - GPS Dog Tracker	• Battery life that lasts for a month • Able to set multiple owners and safe zones • Waterproof tracking device	• Subscription service is needed which is expensive • Requires a base station	• Able to create a personal profile for pets • Able to track the pets anytime from anywhere • Able to track their daily steps • Able to set safe zones

Table 2.8.4.2 Comparison of Mobile Application for Pet Tracking Part 2

2.9 Proposed Application

After reviewing the algorithm, technologies, the strengths and weaknesses of each journal and application. An application will be proposed which the following features:

- Kalman filtering to improve location accuracy
- A small, light and waterproof tracking device that can be attached to the animal
- A well tested mobile application
- A tracking device with sustainable battery
- Able to connect the tracking device to the application
- Able to provide live tracking
- Able to interact with other users
- App able to view the battery status of the tracking device

2.10 Conclusion

In conclusion, the purpose of literature review was to research and study existing solutions that have been provided to solve the problem statement. After the research, the requirements for solving the problem of lost pets is known. Other than that, three existing pet tracking systems and three commercial mobile applications also have been reviewed and compared in this chapter. The strengths, weaknesses and modules of the existing systems have been evaluated for the purpose of implementing the proposed system. In addition, a proposed application has been proposed after reviewing the existing systems.

CHAPTER 3: SYSTEM METHODOLOGY

3.1 Introduction

This chapter will mainly discuss the method that will be selected to match the proposed project and each phase will be discussed in detail regarding how the project is analyzed, designed, developed and implemented to build up a location tracking application to achieve the project objectives.

3.2 Design Specifications

3.2.1 Project Methodology

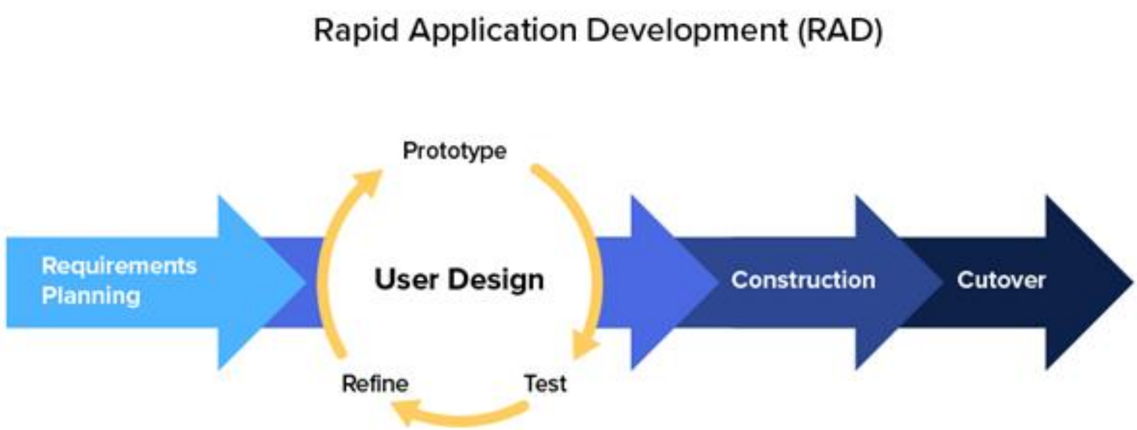


Figure 3.2.1.1 Rapid Application Development

Source: https://kissflow.com/rad/rapid-application-development/

Rapid Application Development (RAD)

RAD is a system development methodology is a fact-paces system which provides a system to the user more quickly. It's a design approach that prioritizes quick prototyping and feedback over lengthy development and testing cycles. The main benefit of using RAD is that it allows the developer to quickly make multiple iterations and updates to the software without having to start from scratch each time. It verifies that the requirements meet the expectations of the user. This method will begin by defining the requirements, followed by a prototype, feedback, and the finalization of the software. The location tracking system using mobile application will be iteratively improved throughout the process to achieve the objectives stated in the previous chapter.

3.2.2 Requirements Planning Phase

In the requirements planning phase, requirements gathering techniques have been used to have a better understanding of ways to achieve the objectives. Users were heavily involved in this phase, which required them to provide and prioritize new system requirements as well as evaluate the system's iterations. By using an online survey questionnaire, this study used the survey technique as the primary method of data collection. One of the main advantages of a questionnaire-based survey method is that it may reach a wide sample of the population in a cost-effective manner [22]. The five essential steps in the sample design process include identifying the target population, selecting the sampling frame, choosing a sampling technique, deciding the sample size, and finally performing the sampling process [23]. The sampling method will be convenience sampling because it is an easy and inexpensive way to gather initial data. A sample target size of 120 is adopted. Data collection method will be an online questionnaire using Google Form because it is easy to use and able to set up various types of questions and provide a summary report regarding the results of the survey. The target audience of the questionnaire will be conducted between the age of 15 and 60 of the pet owners who have at least one pet in their home.

An introduction will be written before conducting the online survey to let users have a brief idea regarding the pet location tracking mobile application. After that, the online questions will be designed into two sections:

- **Section A: Demographic information**
    - This section will ask general questions such as name, age etc.
- **Section B: Preferred features**
    - This section will ask about the features that pet owners preferred.
    - This section will ask regarding their expected outcomes of the mobile application.
    - Likert scale type questions will be used ranging from strongly disagree (1) to strongly agree (5).

3.2.3 System design phase

In the system design phase, extensive analysis by reviewing research papers and existing products will be performed to analyze business activities that are associated with the proposed system area. Unified modelling language (UML) diagrams will be constructed which will be used to represent the flow of data. The diagrams that will be used are use case diagram, activity diagrams for each module, sequence diagram and class diagram. The diagrams will help in having a better understanding of the distinct features and functions. For example, use case diagram will summarize the relationship between the use cases, actors and systems. Activity diagrams will model the workflows between each use cases and can have a more detail understanding of how each use case interact within. Next, sequence diagram can capture the high-level interaction between the user of the system and the system. Lastly, class diagram model the systems from a business perspective it shows the structure of classifiers in the system. Other than that, several prototypes of the proposed project will be built to be reviewed by the user. Requirements and features will be re-examination and validated during this phase until users are satisfied.

The mobile application's user interface will be designed using Material design which was developed by Google for developers in the Android environment. Other than that, the data that has been input by the user will be validated through several particular functions including regular expression and authentication will be done using Google Firebase.

3.2.4 Development phase

In the development phase, the refinement of the prototypes developed in the previous phase will be improved and modified according to the feedback from the user. The prototype will be iteratively evaluated and continues with all the received feedback taken into consideration until a final product has been delivered. The hardware that will be used are Arduino UNO and SIM808 GPS Chip in order to set up the tracking device. Other than that, Android Studio and Firebase will be used to build the mobile application and store the user data in the firebase database. Firstly, the GPS coordinates will be captured by the tracking device and send to a server. Then the data will be transferred from the server to firebase database. Next, the data will be retrieved in the mobile application and show the location of the pet using the application. After that, the final product will be tested by functional testing and performance testing. Functional testing is often accomplished through user interface-initiated test processes that validate the application's compliance with the requirements. Furthermore, performance testing will be carried out to assess the application's performance in unusual situations such as low memory in the device, an extremely low battery, and bad network coverage. Besides that, documentation will be developed which explains how the system is operated by users.

3.2.5 Cutover

In this last phase, there will be finalization of the features, functions, interfaces and everything related to the project. A task checklist will be written to ensure that everything is complete and run smoothly. Assuring the project is in the desirable level of maintainability, stability and usability before delivering the final product. After that, the final product of this proposed project which fulfilled the objectives will be fully complete in FYP2 in May 2022.

3.3 Justification of RAD

There are several reasons to use RAD methodology in this project:

- Extensive user involvement: the users are closely involved throughout the development process. This could ensure that the final product satisfied the users requirements.
- Incremental delivery: the proposed project is developed in increments until the user is satisfied.
- Embrace change: changes can be easily made on the proposed project during the process of delivering.
- Rapid delivery: users can review the prototype of the proposed project earlier in the development.

3.4 User Requirements

According to the survey conducted in requirements planning phase, the proposed application is required to meet user requirements to build a quality pets location tracking mobile application. The requirements can be classified into functional requirements and non-functional requirements.

3.4.1 Functional Requirements

A. Pet owners' registration - users can register an account either through email or social media account.
B. GPS tracker connected - users can use Bluetooth to connect the tracking device with the application.

C. Pet profile registration - users are required to fill in the details of the pet to track the pet.
D. Set up a safe zone - users can set up a virtual safe zone.

E. Post news feed – users can share their information about their pets.

F. Live tracking – users can track the real-time location of their pets.

3.4.2 Non-functional requirements

A. High accuracy of live location tracking: The coordinates of the location should be able to provide the users real-time location of the pets.
B. Performance: The application must be accessible 24 hours a day, 365 days a year.

3.5 System Design Diagram

In the system design phase, extensive analysis by reviewing research papers and existing products will be performed to analyze business activities that are associated with the proposed system area. Unified modelling language (UML) diagrams will be constructed which will be used to represent the flow of data. The diagrams will help in having a better understanding of the distinct features and functions. Other than that, several prototypes of the proposed project will be built to be reviewed by the user. Requirements and features will be re-examination and validated during this phase until users are satisfied.

The mobile application's user interface will be designed using Material design which was developed by Google for developers in the Android environment. Other than that, the data that has been input by the user will be validated through several particular functions including regular expression and authentication will be done using Google Firebase.

3.6 UML Diagram

According to the information gathered from the requirements or planning phase the business modeling, requirements and analysis workflow are converted into the unified modelling language (UML) diagram. The diagrams will help in having a better understanding of the distinct features and functions of the proposed project.

3.6.1 Use Case Diagram

By using a use case diagram, it can summarize the user's possible interactions with the system. It is used to define and organize functional requirements in a system and represents the basic flow of events in a use case.

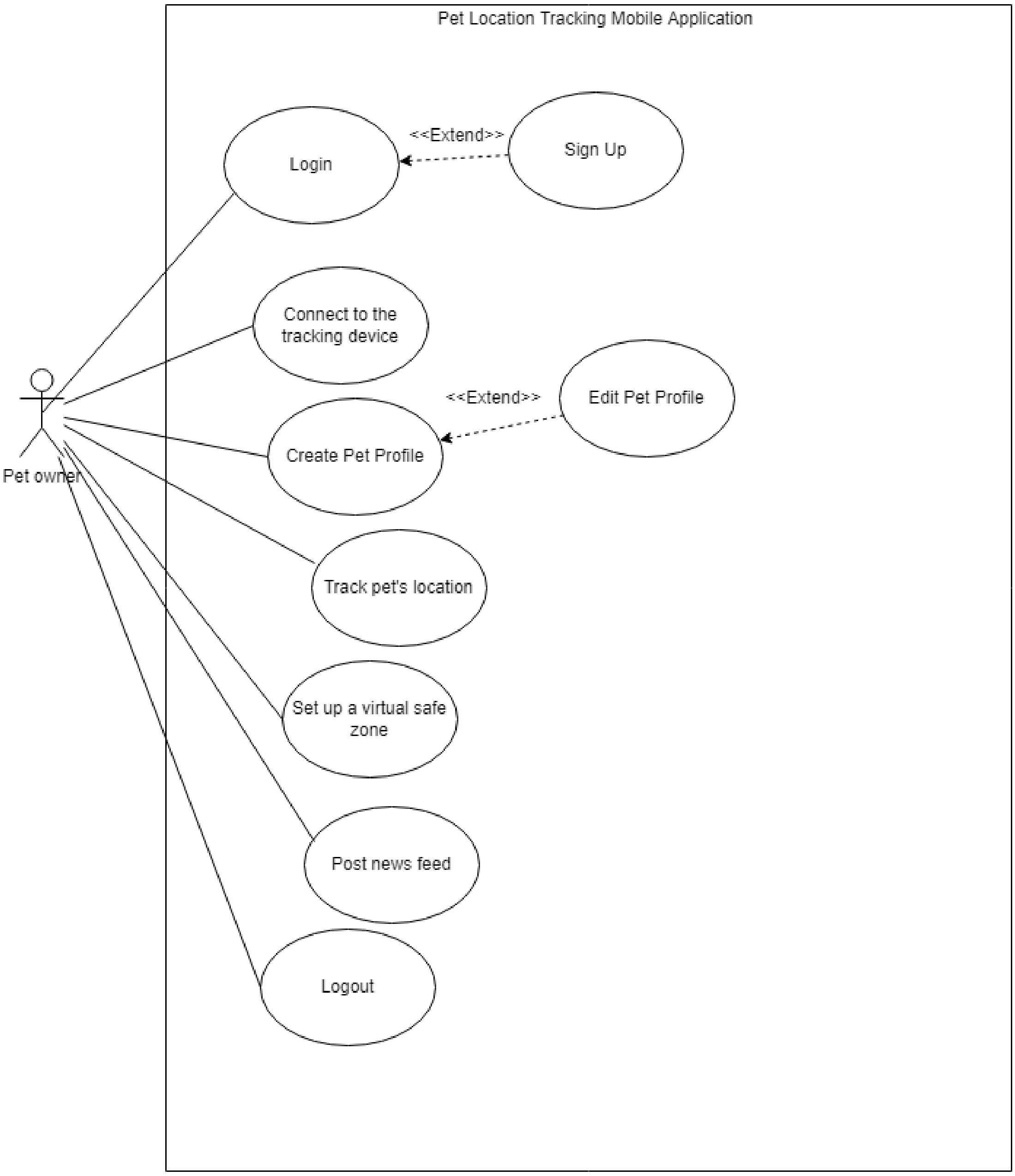


Figure 3.6.1.1 Pet Location Tracking Mobile Application use case diagram

From Figure 3.6.1.1, it consists of one actor who is a pet owner. All actions and relationships of the actors and use cases are depicted in the use case diagram. The pet owner is able to login, connect to the tracking device, post news feed, create a pet profile, edit pet profile, track pet's location, set up a virtual safe zone, interact with other users and check the battery status of the tracking device.

3.6.2 Activity Diagram

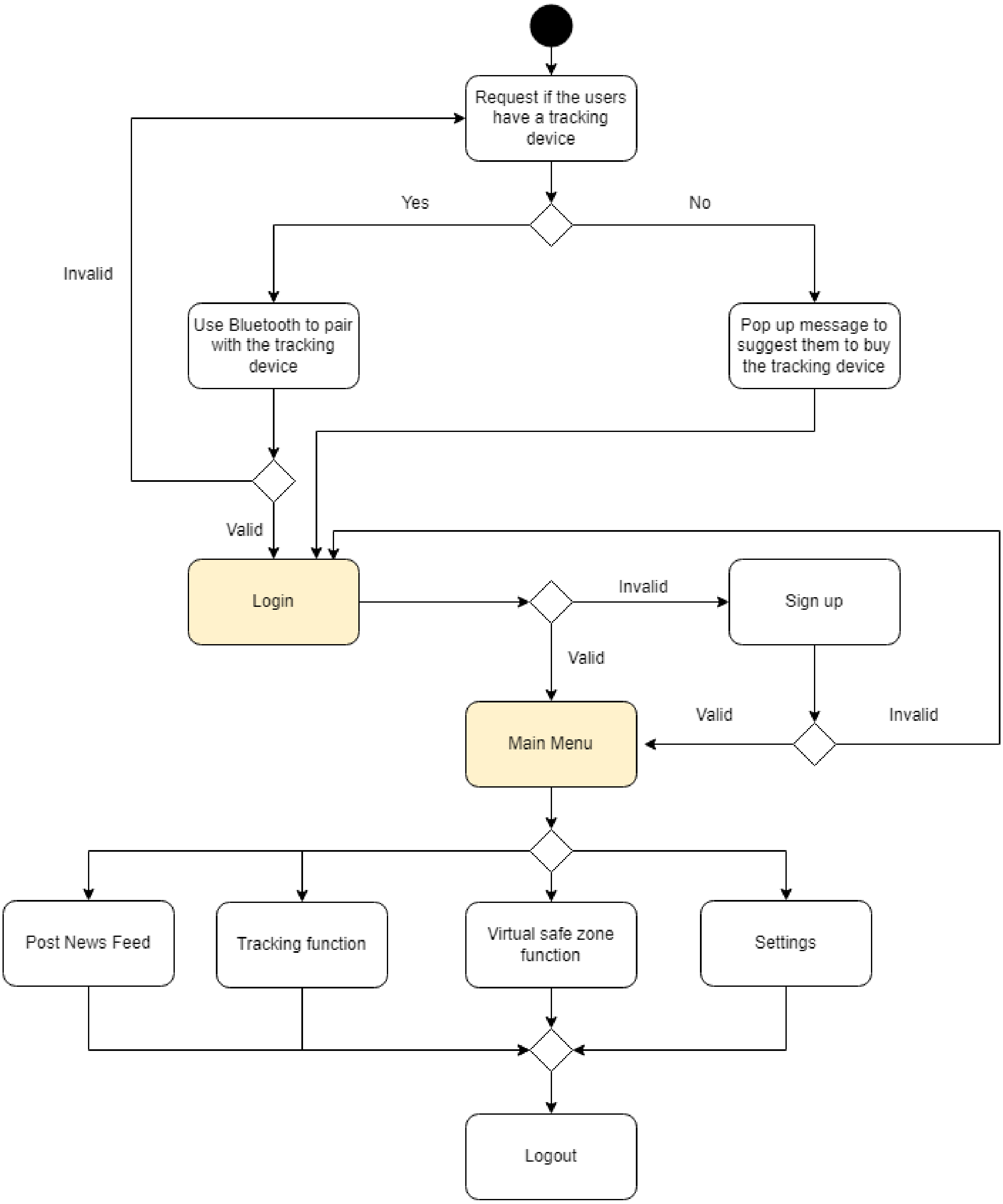


Figure 3.6.2.1 Activity diagram of the overall pets location tracking mobile application.

To simplify the overall of the system design, an activity diagram of the system has been drawn including four activities which are login, sign up, create a new pet profile, post news feed, virtual safe zone function, check battery status, configure settings and tracking function.

3.6.3 Login Activity Diagram

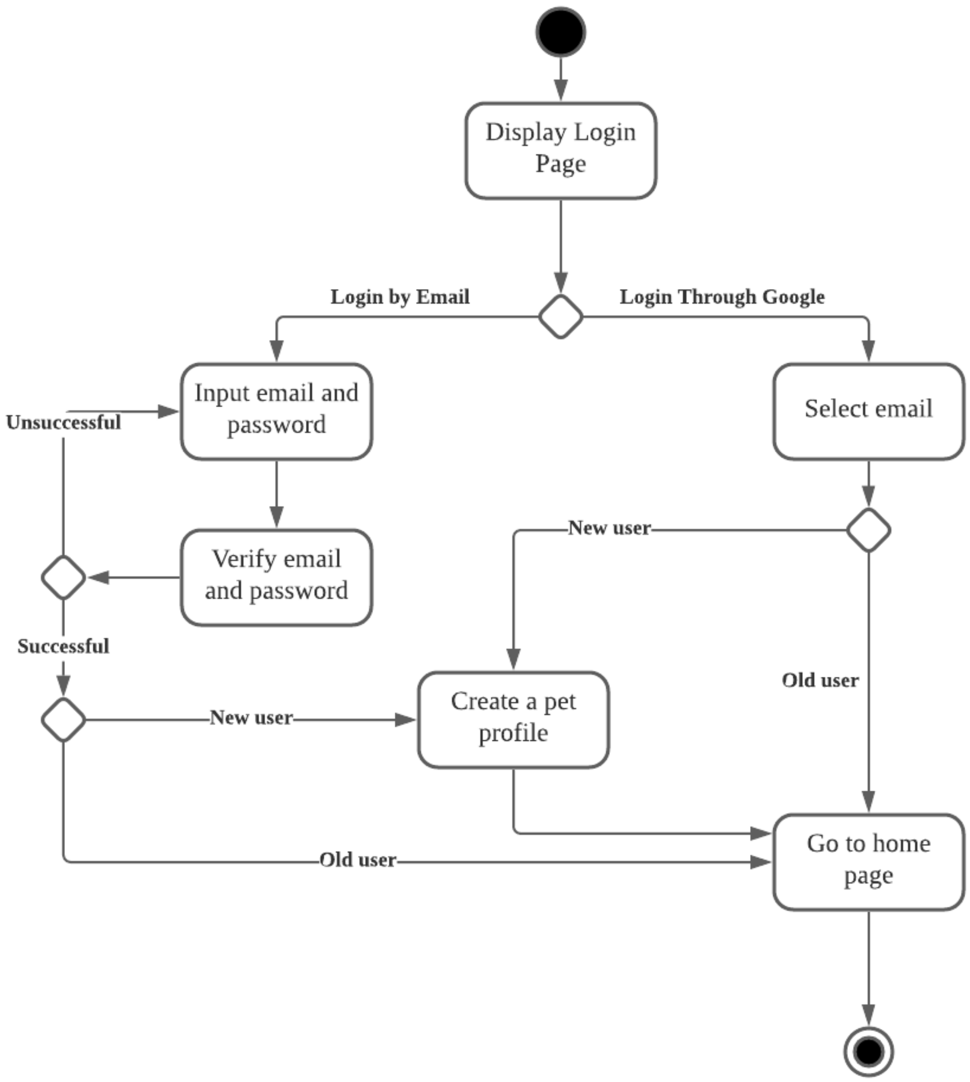


Figure 3.6.3.1 Login Activity Diagram of the pet's location tracking mobile application.

According to Figure 3.6.3.1, the user will be able to login by email or through Google. After authentication, the system will check if it is a new user or old user. If it is a new user, it will let them create a pet profile whereas it will straight direct them to the home page.

3.6.4 Home Page Activity Diagram

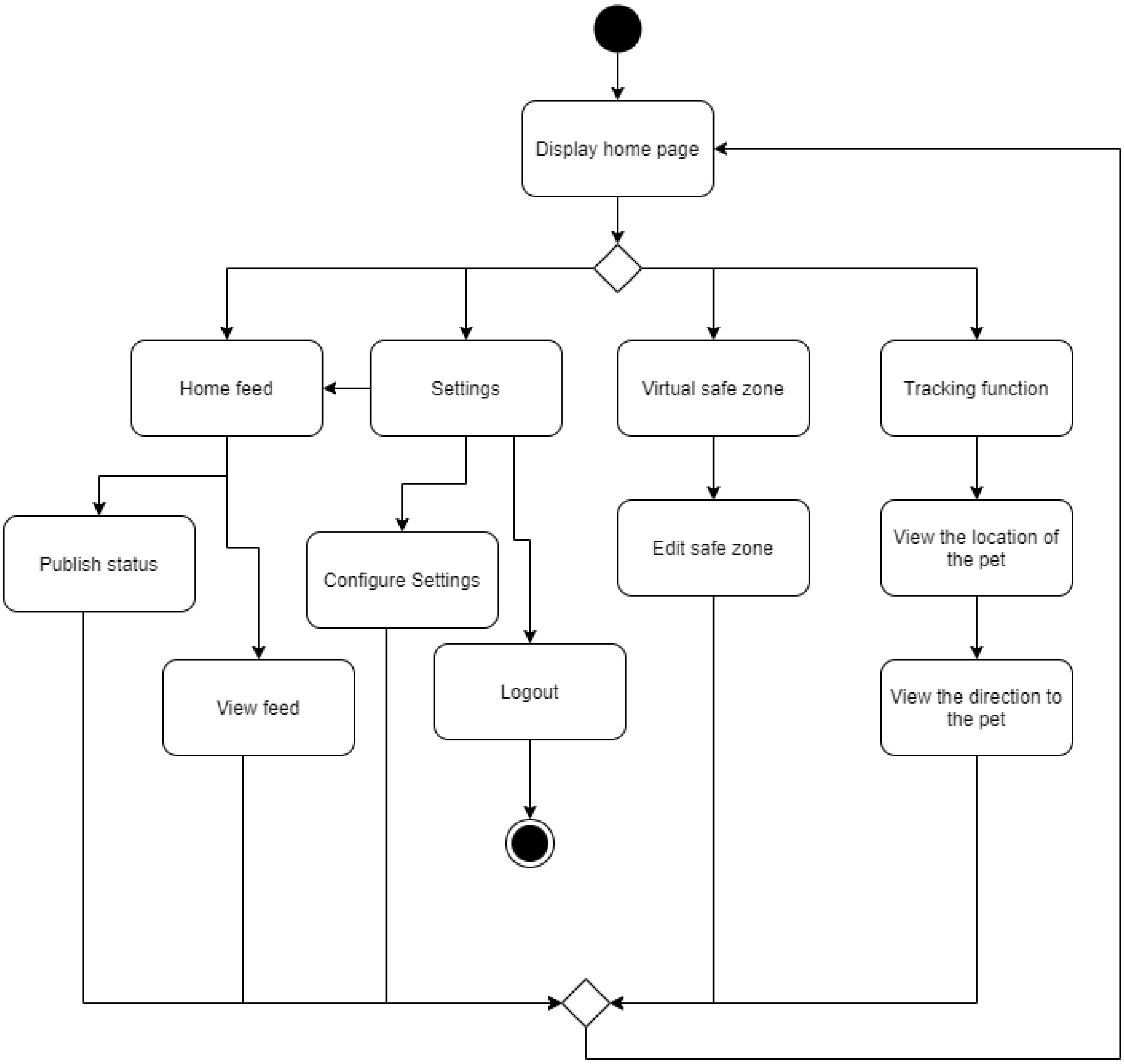


Figure 3.6.4.1 Virtual safe zone function of the pet's location tracking mobile application

Based on the figure above, the users can view the home page and perform several functions including publish status and view feed, configure settings, view and direct to the location of the pet and logout.

3.6.5 Sequence Diagram

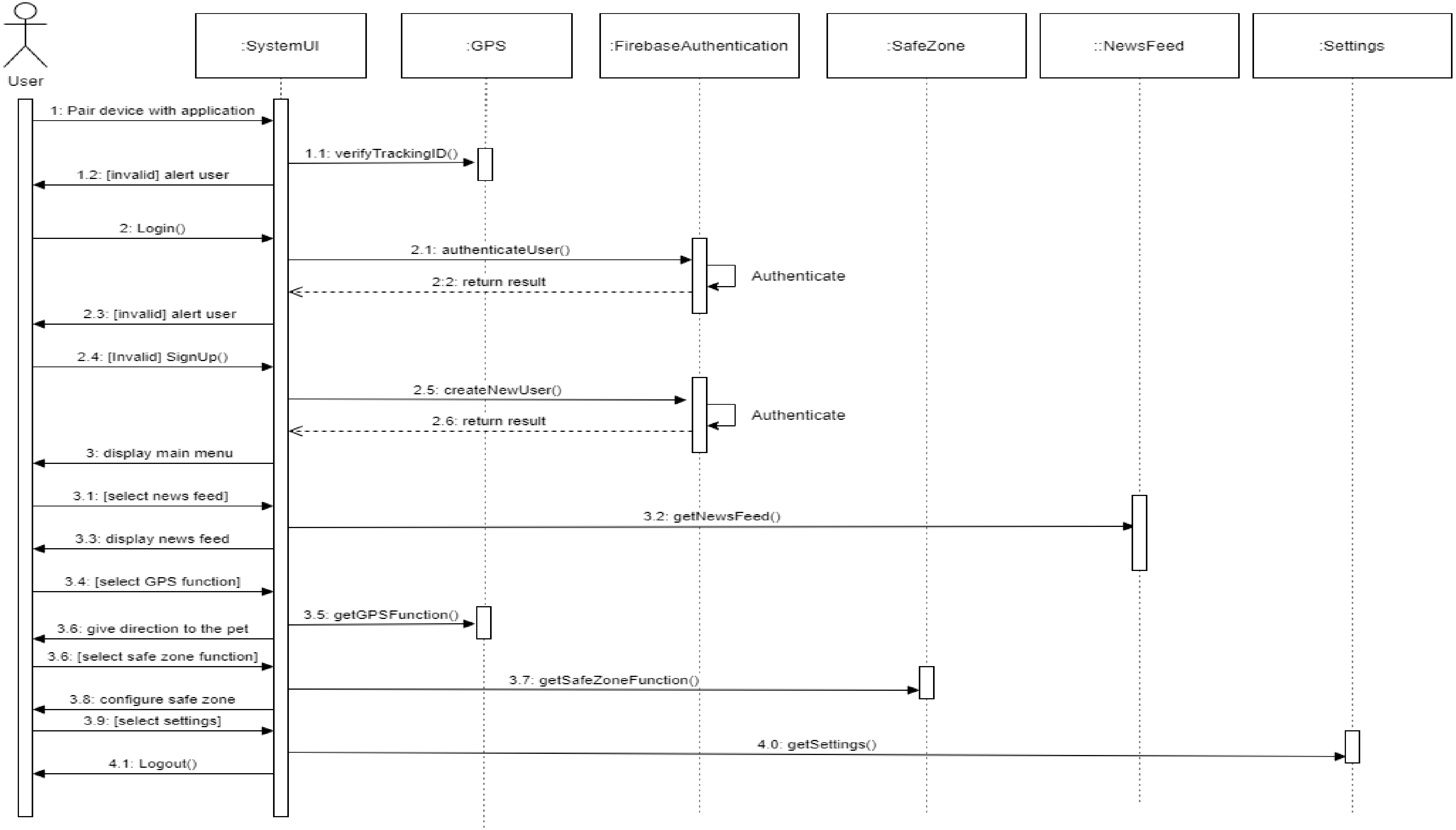


Figure 3.6.5.1 Sequence Diagram of the overall pets location tracking mobile application

3.6.6 Login Sequence Diagram

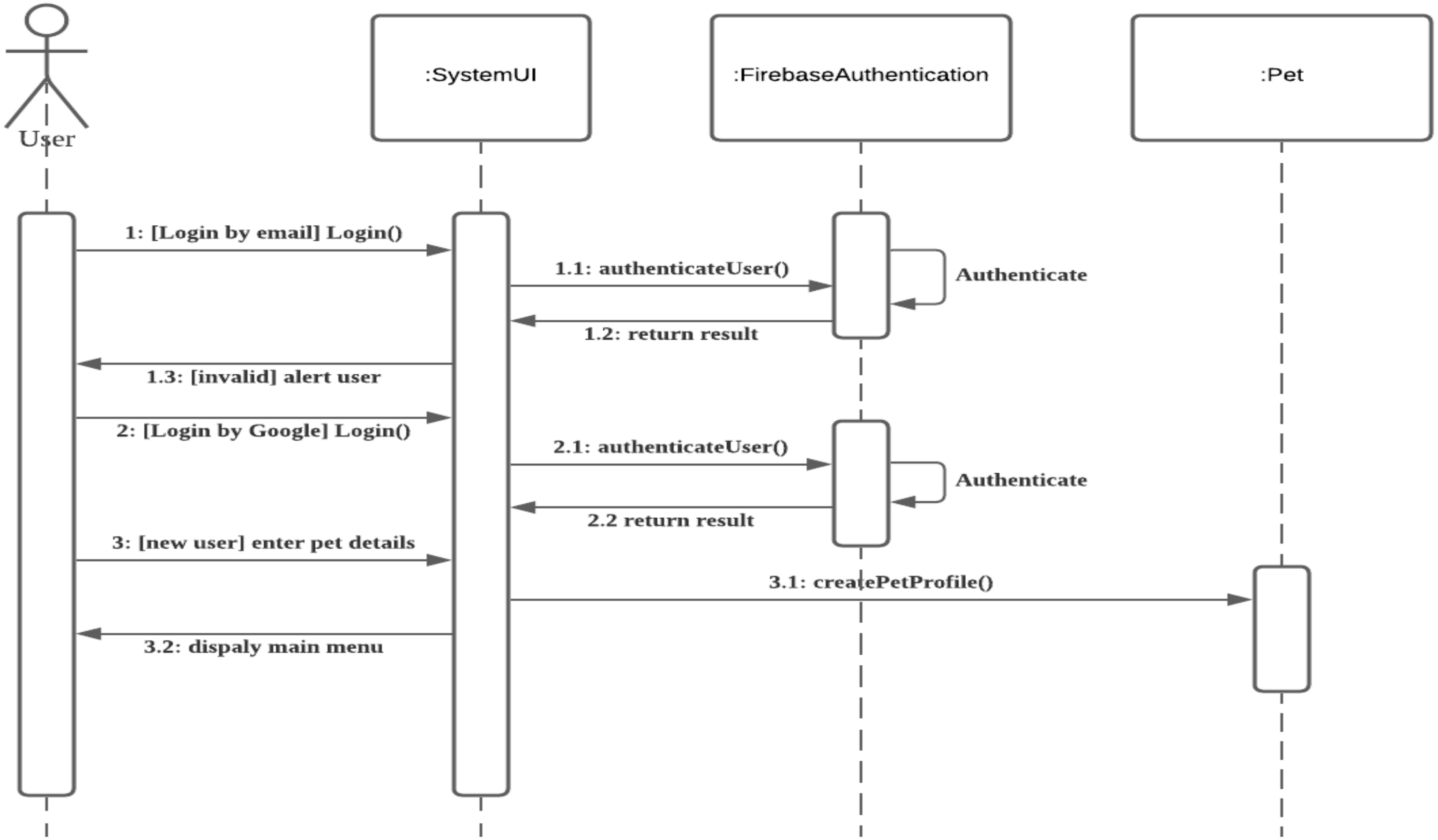


Figure 3.6.6.1 Sequence Diagram of the Login function

3.6.7 Class Diagram

A class diagram is a sort of static structural diagram that depicts the relationships between classes and illustrates the structure of the system. The important classes and processes are depicted in Figure 3.6.7.1.

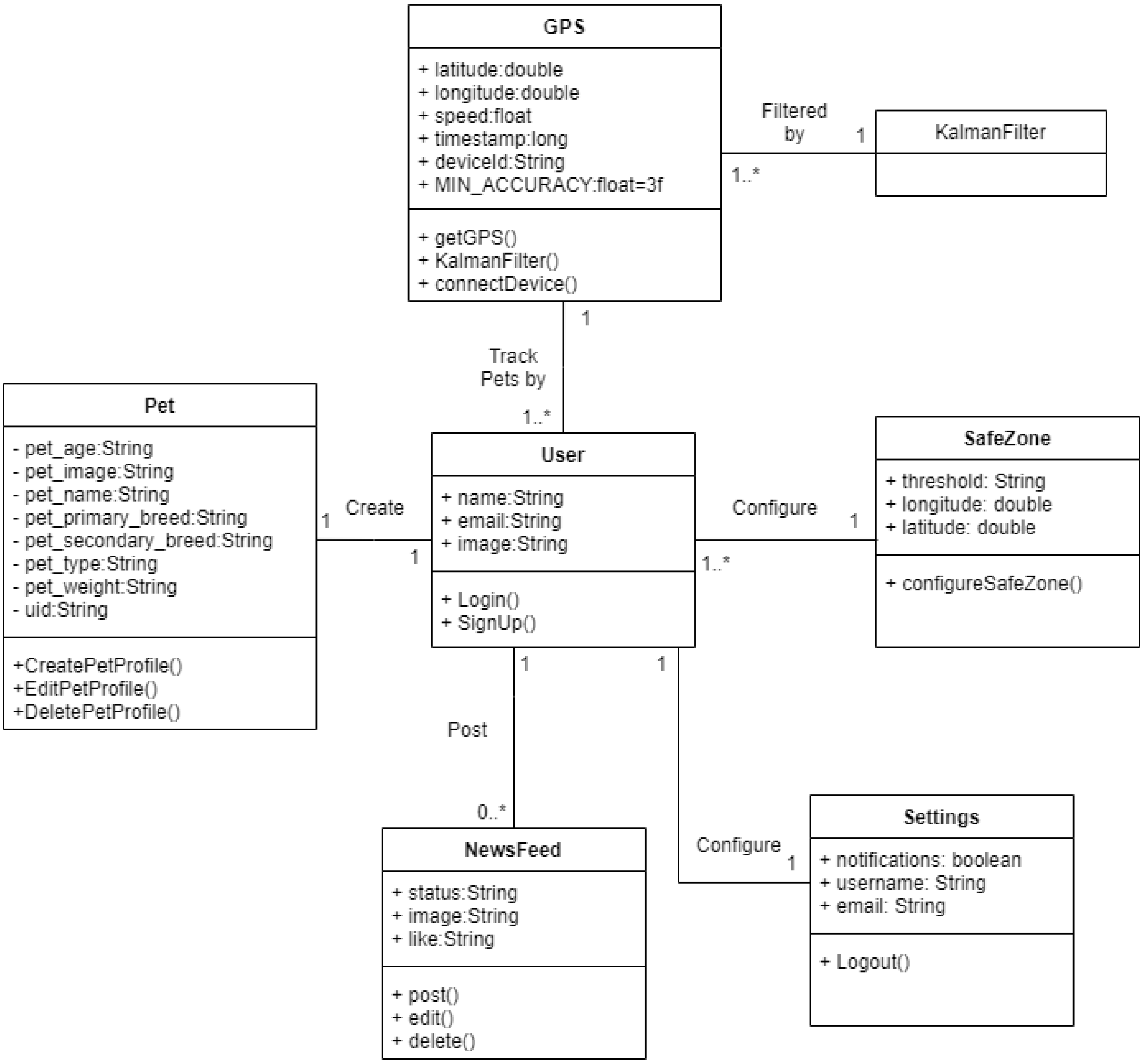


Figure 3.6.7.1 Class Diagram of the proposed system

3.7 Conclusion

This chapter has provide detailed documentation guideline for other programmers to set up the tracking device and develop the application using Android Studio. Besides that, this chapter has discussed various UML diagrams for users in order to have a better understanding of the proposed project.

CHAPTER 4: SYSTEM DESIGN

4.1 Introduction

This chapter will mainly discuss the method that will be selected to match the proposed project and each phase and implemented to build up a location tracking application to achieve the project objectives will be discussed in detail regarding how the project is analyzed, designed and developed.

4.2 System Setup and Configurations

This system setup act as a documentation for other programmers to have a reference if they want to build up this project on its own local development in the future.

4.2.1 Arduino UNO and SIM808 set up for GPS function

The initial stage of the implementation began with the visual layout of the tracking device and mobile application.

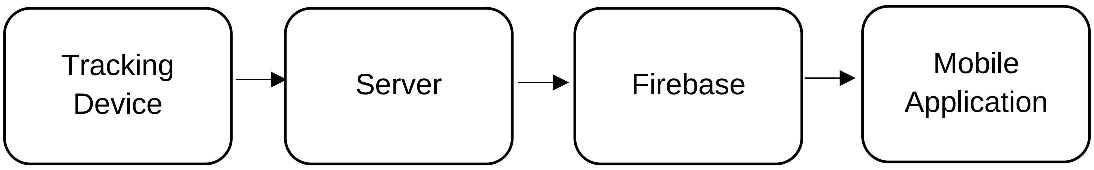


Figure 4.2.1.1 Process flow of the data from tracking device to the mobile application.

Figure above shows the logic and process flow of the data from tracking device to the mobile application. The tracking device is responsible for real-time tracking of the pets, safe zone implementation and sending it to a server. The server would then send it to the firebase. Finally, the mobile application will retrieved data from the Firebase and provide an interface for viewing the tracking information of the vehicle. The implementation starts with the design and building of the tracking device.

4.2.2 Tracking Device Setup

The hardware tools needed are listed below:

- Arduino UNO
- Battery holder with DC Jack x2
- 3.7V Battery x 4
- Female and Male jumper wires
- SIM808 shield with GSM and GPS antennas and a USB 2.0 Cable Type A/B
- USB cable (to upload the codes to Arduino)

- SIM card

4.2.3 Tracking Device

Figure 4.2.3.1 Arduino UNO with SIM808 shield

The installation shown in Figure 3.3.1.1 was guided with the help of documentation. The SIM card was unlocked and inserted to the SIM card holder, the GSM and GPS antennas were connected, the 3.7V batteries was connected to the SIM808 shield and then finally stacked on top of the Arduino UNO. The plastic wrapped on the tracking device may provide the function of water resistance.

Connections

- Tx to pin 10
- Rx to pin 11

The most important parts of the code to obtain GPS codes can be viewed in the Listing below.

```
SoftwareSerial mySerial (PIN_TX, PIN_RX); //10, 11

        DFRobot_SIM808 sim808(&mySerial); //Connect RX, TX

        if (sim808.getGPS()){

                latitude = String(sim808.GPSdata.lat, 6);
```

```
            longitude = String(sim808.GPSdata.lon, 6);

      }
```

Listing 4.2.3.2: Section of the code for initializing and enabling GPRS.

As it can be seen from the listing above, the software serial communication is enabled through the connection of pins RX and TX to 11 and 10. The global variables will be holding the GPS data which declared as String value to send to the Firebase easily. The line **sim808.getGPS()** function is to retrieve ethe GPS data i.e. latitude, longitude, speed and timestamp.

After that, it is required to set up HTTPS connection between the database and the tracking device to transmit GPS data. However, SIM808 only supported HTTP communication while Firebase only accept HTTPS requests. So it is required to build a server to provide the linkage. The design illustration is shown in Figure 3.3.1.2. Firstly, the Arduino will send the GPS data using HTTP to the server. Listing 3.3.1.3 below shows that how the URL link was built. The device ID is also appended to the base URL together with the GPS data.

```
//build the URL to the server
String url = "http://nasal-designation.000webhostapp.com/firebase.php?arduino_data=";
  url += ":deviceId:";
  url += deviceId;
  url += ":lat:";
  url += latitude;
  url += ":long:";
  url += longitude;
  url += ":speed:";
  url += the_speed;
```

Listing 4.2.3.3 URL link to server

Then the server will forwards the data using HTTPS to the Firebase Realtime database. Listing 3.3.1.3 will show the PHP file implemented to create an interface for linking the Firebase to the Arduino.

```
<?php
```

```
  require_once 'firebaseLib.php';

  $t = time();

   --- This is the Firebase URL

  $url = 'httpsfyp1-87470-default-rtdb.asia-southeast1.firebasedatabase.app';

   --- Token from Firebase here

  $token = 'DQSvjVJcpVOWSFvJYszyqIJxr3UuGl1Zr6qHG03K';

   --- Parameter from the http GET

  $arduino_data = $_GET['arduino_data'];

   --- Set up Firebase url structure here

  $firebasePath = 'GPS' . $t;

   --- Making calls

  $fb = new fireBase($url, $token);

  $response = $fb-set($firebasePath, $arduino_data);

?>
```

Listing 4.2.3.4 Section code of the PHP file for connecting to the Firebase database.

The set up of the server is done on a free website hosting server named 000webhost.

Figure 4.2.3.5 Screenshot of files in the server.

After setting up the server, it is required to test the communication between the server and the Firebase Realtime database. This can be achieved by the AT commands.

Syntax	Description
AT+SAPBR=3,1,"APN","diginet"	Set the APN of the provider.
AT+BTPOWER=1	Turn on the bluetooth.
AT+SAPBR=1,1	Open the GPRS context.
AT+HTTPINIT	Initialize HTTP service.
AT+HTTPACTION=0	Start GET session
AT+HTTPREAD	Read data from HTTP server

Table 4.2.3.6 SIM808 AT commands.

Figure 4.2.3.7 Firebase Realtime Database.

The figure above shows the data that stored in the Firebase Realtime Database. The numbers are represented as timestamp stored in the database. The data is updated in real-time. . Finally, it is retrieved from the Firebase to the mobile application.

Safe Zone Setup

In order to let users configure the safe zone radius it is required to retrieve data from Firebase to calculate the distance between the location of the pet and the radius of the safe zone.

```
use Kreait\Firebase\Factory;
$factory = (new Factory)->withServiceAccount('fyp1-87470-firebase-adminsdk-6p96l-5a6c2ae486.json')
    ->withDatabaseUri('https://fyp1-87470-default-rtdb.asia-southeast1.firebasedatabase.app/');

$database = $factory->createDatabase();
$reference = $database->getReference('SafeZone');
$snapshot = $reference->getSnapshot();
$value = $snapshot->getValue();

$distance = $value['distance'];
$lat = $value['lat'];
$long = $value['long'];
```

Listing 4.2.3.8 Section code of the PHP for retrieving data from Firebase Realtime database.

To retrieve data from your own Firebase Realtime database, it is required to replace the json file (can be download from Firebase) and the string Uri (can be copied from Firebase Realtime database). After that, to retrieve the coordinates and distance from the server to SIM808 to calculate the distance. Users are required to get the response using "AT+HTTPREAD" and retrieve the data from the serial monitor.

```
void buffering() {
  resp = "";
  uint32_t prev = millis();
  uint32_t waitTime  = 1000;
  while (1) {
    delay(1);
    char c = mySerial.read();
    if ( (c > 10 && c < 130) || c == '\n' || c == '\r' ) {
      resp += c;
```

```
  }
  if ( resp.length() >= 100 ) {
    break;
  }
  if ( millis() - prev >= waitTime ) {
    break;
  }
  if ( resp.indexOf("OK") >= 0  ||  resp.indexOf("ERROR") >= 0 ) {
    break;
  }
 }
 String mm = resp.substring(resp.indexOf("d"));
 String myData[5];
 byte counter = 0;
 for(int i = 0; i < mm.length(); i++){
  if(mm.charAt(i) == ':'){
    counter++;
  }else{
    myData[counter] += mm.charAt(i);
  }
 }
 double distanceKm = gps.distanceBetween(
                    latitude.toDouble(),
                    longitude.toDouble(),
                    myData[2].toDouble(),
                    myData[3].toDouble());
  if(distanceKm > myData[1].toDouble()){
  insideSafeZone = "outside";
 }else{
  insideSafeZone = "inside";
 }
}
```

Listing 4.2.3.9 Section code of Arduino for retrieve data from server to SIM808

Listing above shows the function of retrieving the data from the serial monitor and use **gps.distanceBetween()** to calculate the distance between the coordinates of the tracking device and the coordinates set by the user. If the calculated distance is bigger than the threshold distance then the pet is outside of the safe zone.

Notification Setup

The code below is to send a notification to the pet owner's device when their pet is outside of the safe zone.

```
<?php
function sendFCM(){
    $url = "https://fcm.googleapis.com/fcm/send";
    $apiKey =
"AAAAC0nSp1s:APA91bFFnhBRS6S29gJX6vBLD0ersADx2w02tOu8EvZ2HibMiMfEkj4Ug36F9FHbfUq_GUaxqutfTBn7WDaF95BCaERJmjZyNZ7uHsPwvB1D5Zkg7hIZPcuUt_7Dox0OtM9UshGuzdkE";
     $headers = array(
        'Authorization:key=' .$apiKey,
        'Content-Type:application/json'
    );
    $notifData = [
        'title' => "ALERT!",
        'body' => "Your Pet is outside of the SAFE ZONE"
    ];
    //Create API Body
    $apiBody = [
        'notification' => $notifData,
        'to' => 'e4snGxZcQNCfqAZT2w-6Oa:APA91bGxyofyiQI2j1ZHMcJpkN5yw91QRUg6Mim5ppdNQSiaLsU-j9xGurVC2G6i1T83sDDsBPB3X9YRmlo2epG3fzIW1I7iZFfUQ23a39aGdNlIEFFZtCm8IDauRLzaV7xjbcii3qjT'
    ];
    $ch = curl_init();
    curl_setopt($ch, CURLOPT_URL, $url);
```

```
    curl_setopt($ch, CURLOPT_POST, true);
    curl_setopt($ch, CURLOPT_HTTPHEADER, $headers);
    curl_setopt ($ch, CURLOPT_RETURNTRANSFER, true);
    curl_setopt($ch, CURLOPT_POSTFIELDS, json_encode($apiBody));
    //Execute
    $result = curl_exec($ch);
    print($result);
    curl_close($ch);
    return $result;
}
    ?>
```

Listing 4.2.3.10 Section code of the PHP for sending notifications to users

Kalman Algorithm

Kalman Algorithm has been used to filter the coordinates to increase the accuracy. The Kalman algorithm library is obtained from [24].

Source: https://github.com/andreynovikov/GeoTrackFilter

```
public class KalmanFilter {
        int timestep;
        /* These parameters define the size of the matrices. */
        int state_dimension, observation_dimension;

        /* This group of matrices must be specified by the user. */
        Matrix state_transition;
        Matrix observation_model;
        Matrix process_noise_covariance;
        Matrix observation_noise_covariance;

        /* The observation is modified by the user before every time step. */
        Matrix observation;

        /* This group of matrices are updated every time step by the filter. */
        /* x-hat_k|k-1 */
        Matrix predicted_state;
```

```
        /* P_k|k-1 */
        Matrix predicted_estimate_covariance;
        /* y-tilde_k */
        Matrix innovation;
        /* S_k */
        Matrix innovation_covariance;
        /* S_k^-1 */
        Matrix inverse_innovation_covariance;
        /* K_k */
        Matrix optimal_gain;
        /* x-hat_k|k */
        Matrix state_estimate;
        /* P_k|k */
        Matrix estimate_covariance;

        /* This group is used for meaningless intermediate calculations */
        Matrix vertical_scratch;
        Matrix small_square_scratch;
        Matrix big_square_scratch;

        public KalmanFilter(int state_dimension, int observation_dimension) {
                timestep = 0;
                this.state_dimension = state_dimension;
                this.observation_dimension = observation_dimension;

                state_transition = new Matrix(state_dimension, state_dimension);
                observation_model = new Matrix(observation_dimension,
state_dimension);
                process_noise_covariance = new Matrix(state_dimension,
state_dimension);
                observation_noise_covariance = new Matrix(observation_dimension,
observation_dimension);
```

```
        observation = new Matrix(observation_dimension, 1);

        predicted_state = new Matrix(state_dimension, 1);
        predicted_estimate_covariance = new Matrix(state_dimension,
    state_dimension);
        innovation = new Matrix(observation_dimension, 1);
        innovation_covariance = new Matrix(observation_dimension,
observation_dimension);
        inverse_innovation_covariance = new Matrix(observation_dimension,
observation_dimension);
        optimal_gain = new Matrix(state_dimension, observation_dimension);
        state_estimate = new Matrix(state_dimension, 1);
        estimate_covariance = new Matrix(state_dimension, state_dimension);

        vertical_scratch = new Matrix(state_dimension, observation_dimension);
        small_square_scratch = new
Matrix(observation_dimension,observation_dimension);
        big_square_scratch = new Matrix(state_dimension, state_dimension);
    }

    /*
     * Runs one timestep of prediction + estimation.
     *
     * Before each time step of running this, set f.observation to be the next
     * time step's observation.
     *
     * Before the first step, define the model by setting: f.state_transition
     * f.observation_model f.process_noise_covariance
     * f.observation_noise_covariance
     *
     * It is also advisable to initialize with reasonable guesses for
     * f.state_estimate f.estimate_covariance
     */
```

```
	void update() {
		predict();
		estimate();
	}

	/* Just the prediction phase of update. */
	void predict() {
		timestep++;

		/* Predict the state */
		Matrix.multiply_matrix(state_transition, state_estimate, predicted_state);

		/* Predict the state estimate covariance */
		Matrix.multiply_matrix(state_transition, estimate_covariance,
big_square_scratch);
		Matrix.multiply_by_transpose_matrix(big_square_scratch, state_transition,
predicted_estimate_covariance);
		Matrix.add_matrix(predicted_estimate_covariance,
process_noise_covariance, predicted_estimate_covariance);
	}

	/* Just the estimation phase of update. */
	void estimate() {
		/* Calculate innovation */
		Matrix.multiply_matrix(observation_model, predicted_state, innovation);
		Matrix.subtract_matrix(observation, innovation, innovation);

		/* Calculate innovation covariance */
		Matrix.multiply_by_transpose_matrix(predicted_estimate_covariance,
observation_model, vertical_scratch);
		Matrix.multiply_matrix(observation_model, vertical_scratch,
innovation_covariance);
```

```
            Matrix.add_matrix(innovation_covariance, observation_noise_covariance,
innovation_covariance);

            /*
             * Invert the innovation covariance. Note: this destroys the innovation
             * covariance. TODO: handle inversion failure intelligently.
             */
            Matrix.destructive_invert_matrix(innovation_covariance,
inverse_innovation_covariance);

            /*
             * Calculate the optimal Kalman gain. Note we still have a useful
             * partial product in vertical scratch from the innovation covariance.
             */
            Matrix.multiply_matrix(vertical_scratch, inverse_innovation_covariance,
optimal_gain);

            /* Estimate the state */
            Matrix.multiply_matrix(optimal_gain, innovation, state_estimate);
            Matrix.add_matrix(state_estimate, predicted_state, state_estimate);

            /* Estimate the state covariance */
            Matrix.multiply_matrix(optimal_gain, observation_model,
big_square_scratch);
            Matrix.subtract_from_identity_matrix(big_square_scratch);
            Matrix.multiply_matrix(big_square_scratch,
predicted_estimate_covariance, estimate_covariance);
    }
}
```

Listing 4.2.3.11 Kalman Algorithm

4.2.4 Android Studio Setup

1. Download Android Studio from the official website and create a new project with an empty activity.

2. Enter your application name and package name.
3. Save the project location.
4. Select the programming language either is Kotlin or Java.
5. Select the minimum SDK the lower the API the more devices available to support.
6. Click on finish and wait the project to be created.

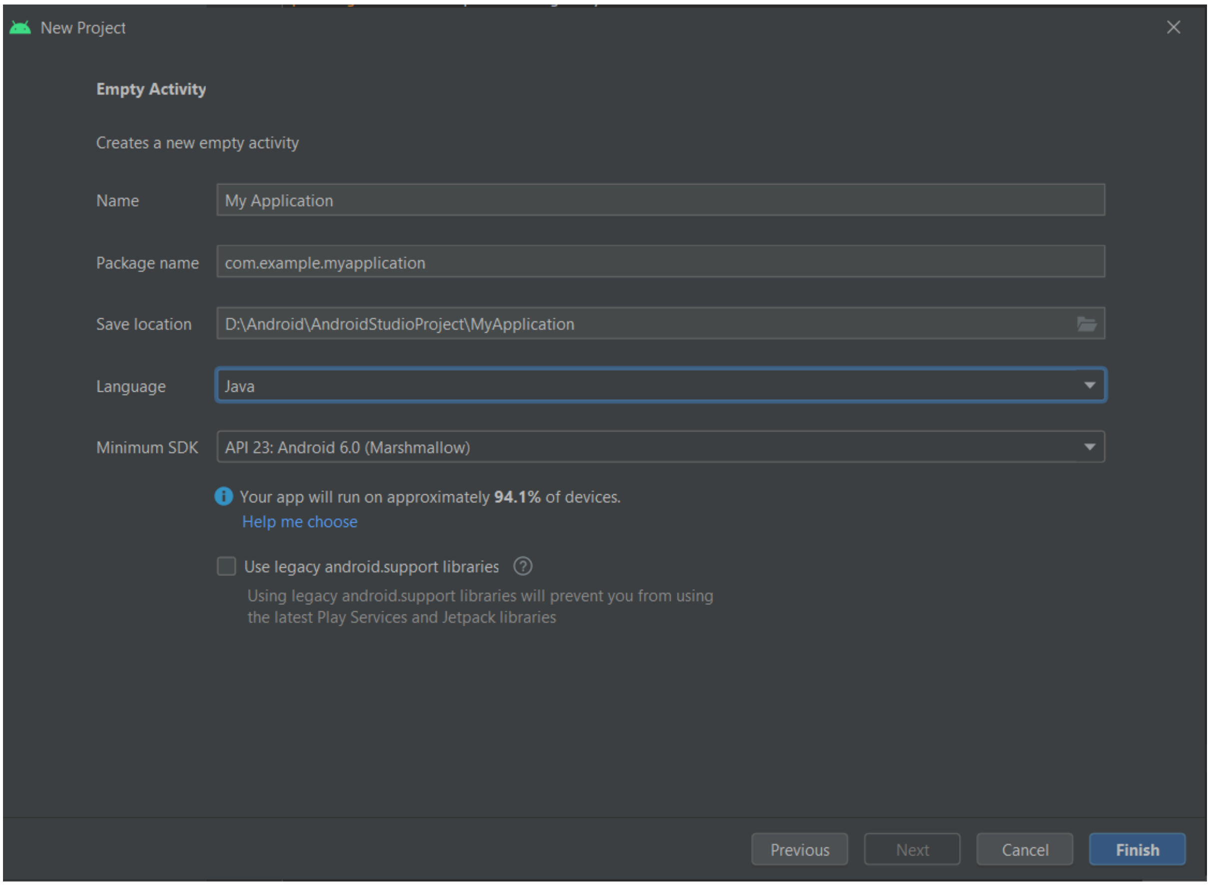


Figure 4.2.4.1 Creating new project in Android Studio

4.2.5 Firebase Setup with Android studio

After installed Android Studio, users have two options to connect the Android app to Firebase. The steps shown below are using Android Studio Firebase Assistant to set up the Authentication using Google Sign-In.

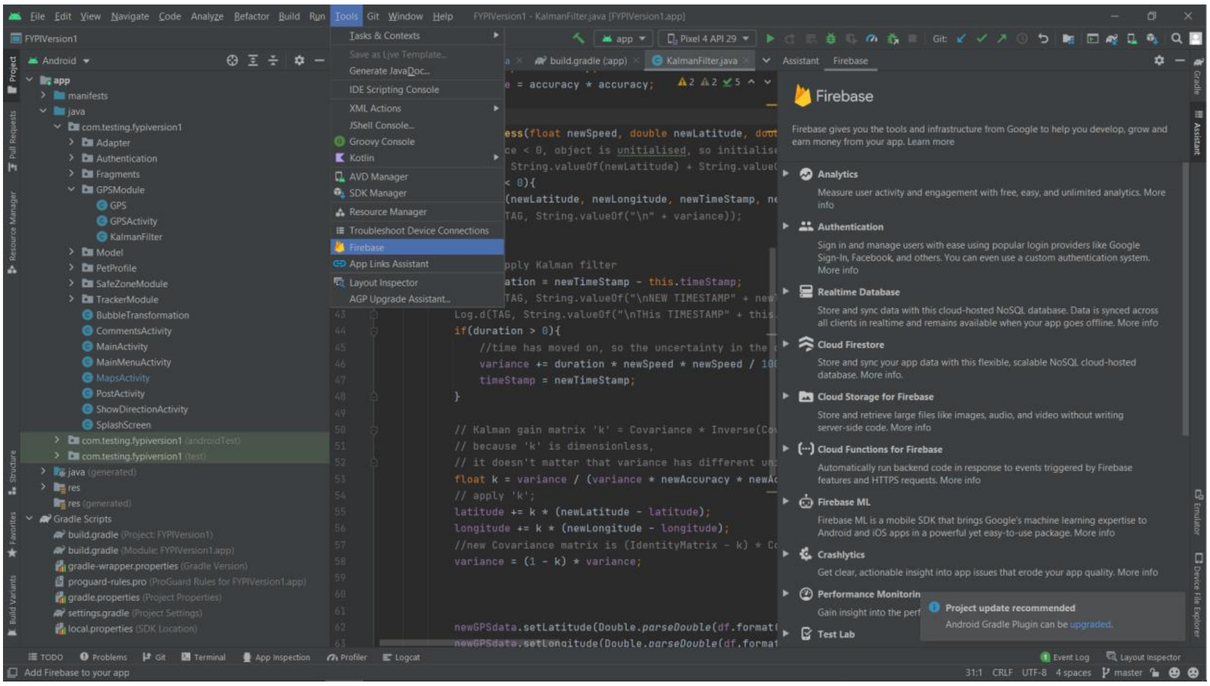


Figure 4.2.5.1 Steps to connect Firebase with Android Studio

1. Select Tools → Firebase, then an assistance window will pop up on the left side.

2. In this project, several services have been selected, which are Authentication for login and sign up, Cloud Firestore and Realtime database for storing and retrieving data and Cloud Storage to store large file like images.

3. Follow the steps provided by the assistance and now the application can sign in using Google account.

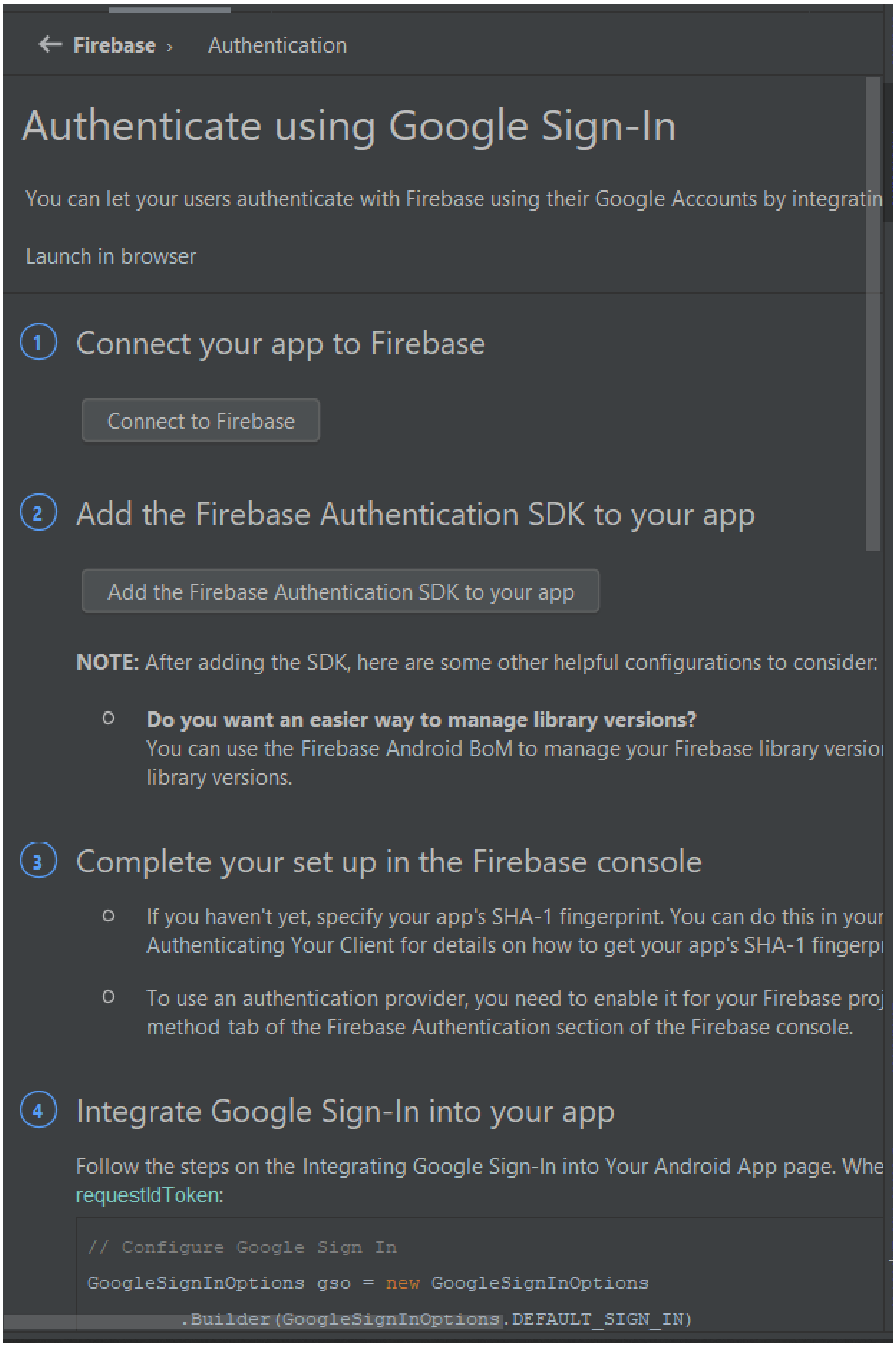


Figure 4.2.5.2 Steps given by assistant to use Google Sign-In authentication in the project

4.3 Verification Plan (Testing)

Testing is the process of making objective judgments about how well a system meets, surpasses, or fails to achieve its declared objectives and capabilities. Black box testing has been chosen for this project. This testing approach focuses on the input that goes into the system and the output that is produced. The black box testing is tested based on the requirements and checks the system to validate against predefined requirements.

There are several benefits of black box testing:

A. It works for a more extensive coverage.
B. Test cases can be generated before development and right after specification.
C. Defects and inconsistencies can be identified in the early stages of testing.

Firstly, test case and test procedures will be designed for unit and integration based on requirements specifications and software components identification. The results of test cases and test procedures will be documented in the report. The test cases can be classified into two types:

i) Testing the system works with correct input to show that the system is work as expected.
ii) Testing the system with incorrect input to ensure that the system can perform properly without failure and error.

<u>Test Cases example</u>

Test case module: Login using email module unit testing

Test description: To test the input of email and password fields.

Test Steps	Step Description	Data Utilized	Expected Result	Actual Result	Pass/Fail
1	Test a valid email and password Actual Data: email: khortsuming@hotmail.com password:123456	Email and password are registered in the database	Login user account successful	Redirect new user to create a new pet profile or redirect existing user to the main menu	-
2	Test a valid email but invalid password Actual Data: email: khortsuming@hotmail.com password: 123	Email is registered in the database.	Display error: Incorrect email or password entered	"Incorrect email or password entered"	-
3	Test an invalid email and password Actual Data: email: 123@hotmail.com password:123	Email is not registered in the database.	Display error: Email is not registered yet and go to the sign up page	"Email is not registered yet" and redirect user to the sign up page	
….	…				

Table 4.3.1 Example of a Test Case

CHAPTER 5 SYSTEM IMPLEMENTATION

5.1 Introduction

This chapter will discussed about tools used, system requirements, hardware used and the preliminary work which have been completed in this semester. Thus, each module or function will be described in details and label with screenshot picture.

5.2 Tool Involved:

Tools	Description
Software: Java programming in Android Studio.	This pet location tracking system will be developed in Android Studio using Java which is a simple and free development environment to build applications in Android applications.
Firebase	Google Firebase is an open-source framework for developing mobile applications. The authentication and pet data of users will be saved in the firebase Realtime database.
Google API	Google API will be used to locate the pet's location and view in the form of Google Maps.
Hardware: Arduino UNO	Arduino UNO is an open-source hardware which can be used to connect the GPS tracking chip to the Arduino to obtain the coordinates data.

SIM808 GPS GRPS GSM Shield SKU TEL0097	It is a quad-band GSM or GPRS Arduino expansion shield with GPS. It'll serve as a GPS tracking chip.
Algorithm: Kalman Filtering	The coordinates that are retrieved from the remote database will be input into Kalman Filtering to improve the accuracy of location tracking.

Table 5.2.1 Tools that will be used to develop this project.

5.3 System Requirements

Table 5.3.1 and Table 5.3.2 are the list of software and hardware requirements in detail for references by other researchers to acknowledge the minimum requirements to develop and run the pet location tracking system.

Software Requirement:	
Operating system	Windows 10
Android Studio	Version 4.2.1
Android Platform Version	API level 29
Arduino IDE	Version 1.8.14
Firebase	Cloud FireStore Realtime Database Authentication Storage

Table 5.3.1 Software Requirements

Computer Hardware Requirement	
Operating System	64 bits
RAM	4Gb
Hard disc storage	256Gb

Table 5.3.2 Computer Hardware Requirements

Hardware that I will be using:

Arduino Uno R3

Figure 5.3.3 Arduino UNO R3

The Arduino UNO R3 is a microcontroller board with 14 digital input/output pins, 6 analogue inputs, a 16MHz ceramic resonator, a USB connection, a power connector, and an ICSP header, as well as a reset button. To get started, it may be readily linked to a computer by USB connection or powered by an adapter or batteries.

SIM808 GPRS GSM GPS Module

Figure 5.3.4 SIM808 GPRS GSM GPS Module

This module can perform location-tracking, voice, text and SMS. It is compatible with Arduino UNO. A strong GSM cellular module with integrated GPS is at the core of the device. To use the cellular capabilities, a SIM card will be required. This microcontroller has been used to get latitude and longitude for the pet. For doing that, an Arduino IDE software will be used to program the code. The library of DFRobot_sim808, SoftwareSerial and TinyGPS++ will be used to obtain the data from the module and set up a virtual safe zone.

5.4 User Interface of Application

5.4.1 Splash Screen and Tracker Request

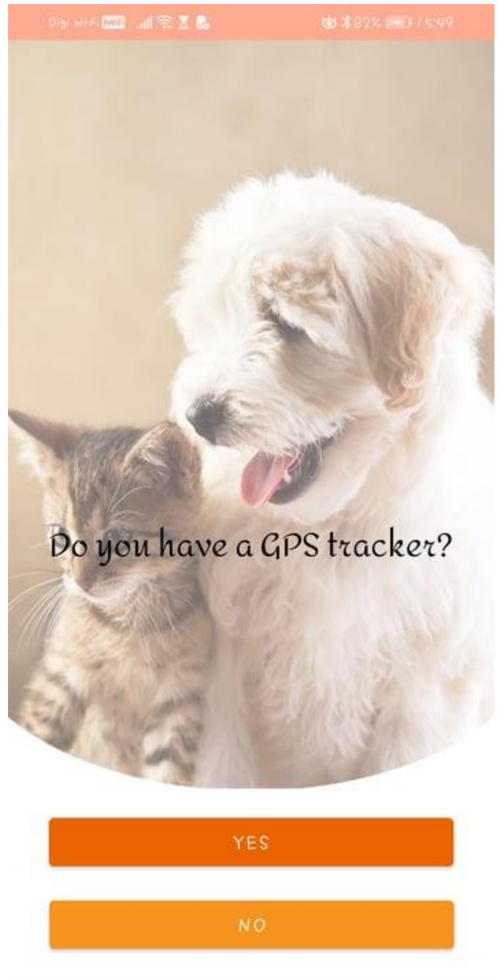


Figure 5.4.1.1 Splash Screen.

Figure 5.4.1.2 Request GPS tracker

From figure 5.2.1 is the splash screen of the proposed system. When the users open the application, it will lead to the splash screen which show the name of the application. Next, it will asks if the users have a GPS tracker if no it will display a Toast message asks them to buy a tracker. If yes, it will lead the user to the login page.

5.4.2 Login and Sign Up Screen

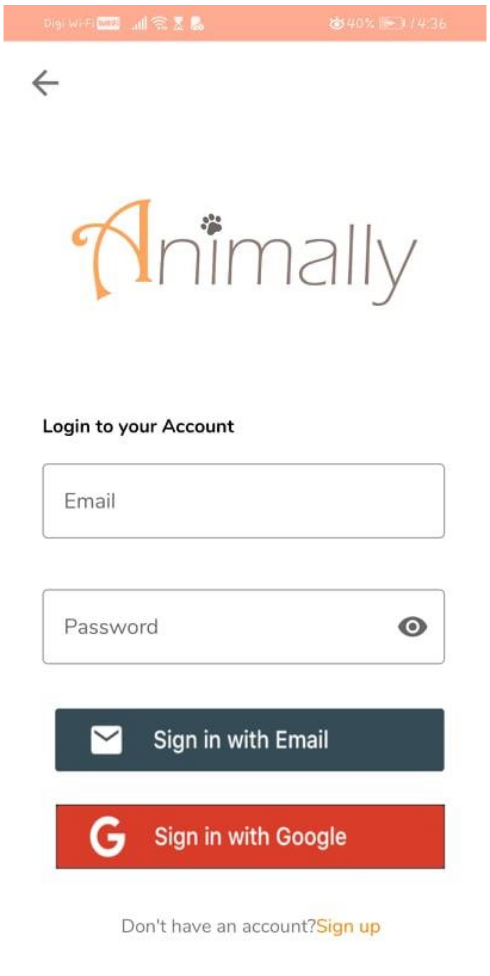


Figure 5.4.2.1 Login Page

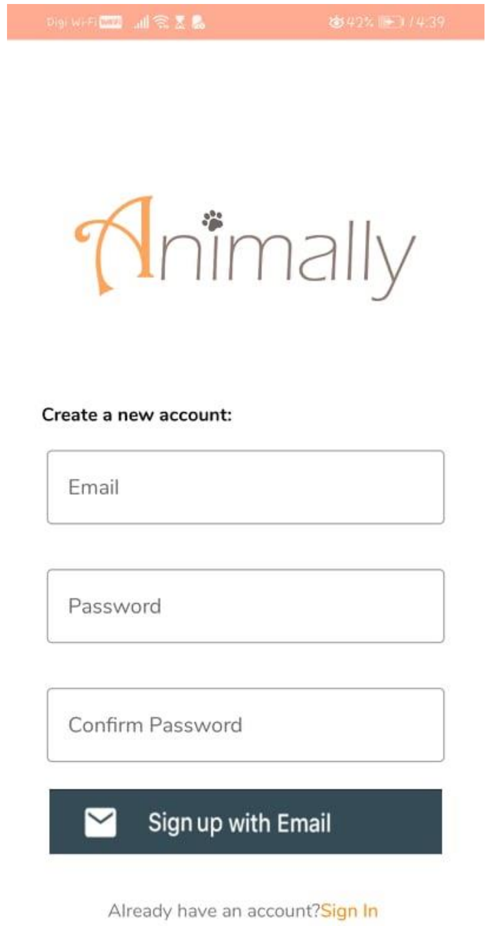


Figure 5.4.2.2 Sign Up

After that, the users can sign in via email or google. For new user, they can click the sign-up link which will lead to Figure 5.4.2.2. This module is implemented using Firebase Authentication. If the user chooses to sign in through Google, they can straight select their registered email and log in. Users can create a new account with the email and password in Figure 5.4.2.2.

5.4.3 Connecting to the Tracking Device

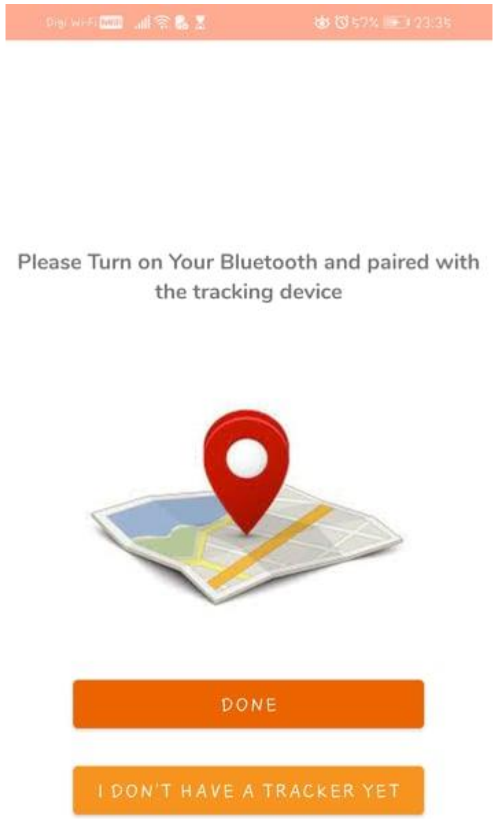


Figure 5.4.3.1 Connect to tracking device Interface

Users can connect their application with the tracking device through Bluetooth. After they had power on their tracking device, they had to switch on the Bluetooth on their device. After they had successfully paired with the tracking device they are required to click done and proceed to create a pet profile. If they don't have a tracking device a message will pop up to tell them to purchase the tracking device.

5.4.4 Create a pet profile

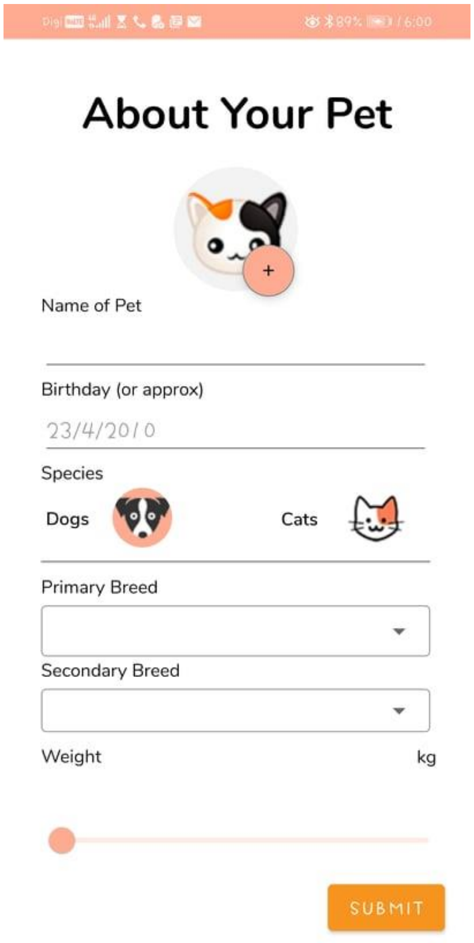


Figure 5.4.4.1: Add a new pet.

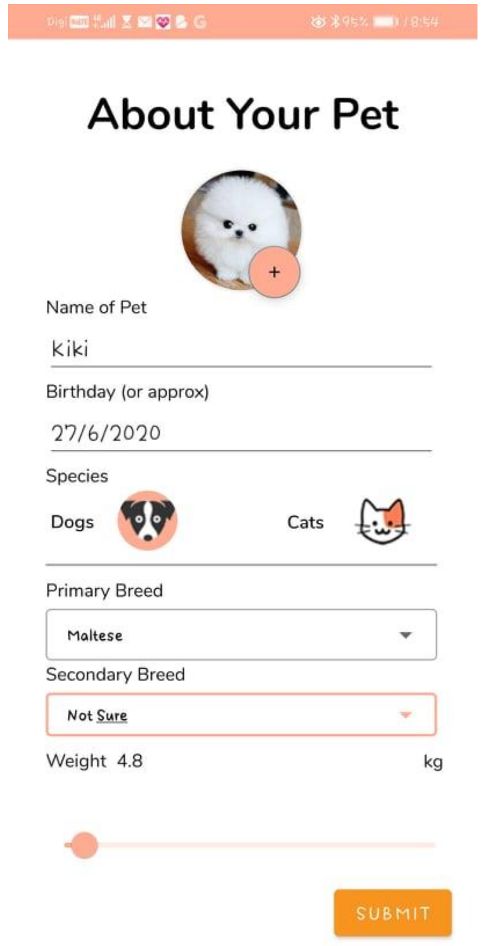


Figure 5.4.4.2: Example of a pet profile

Figure above shows that the users can create a new pet by input their pet details including the image, name, birthday, species, primary breed, secondary breed and weight. The user are required to input all the fields otherwise it would pop up an error to remind users to fill in all the information. After the user click the submit button and the data will be store in the Firestore. If the data is stored successfully, the application will direct the users to the home page.

5.4.5 Home Page

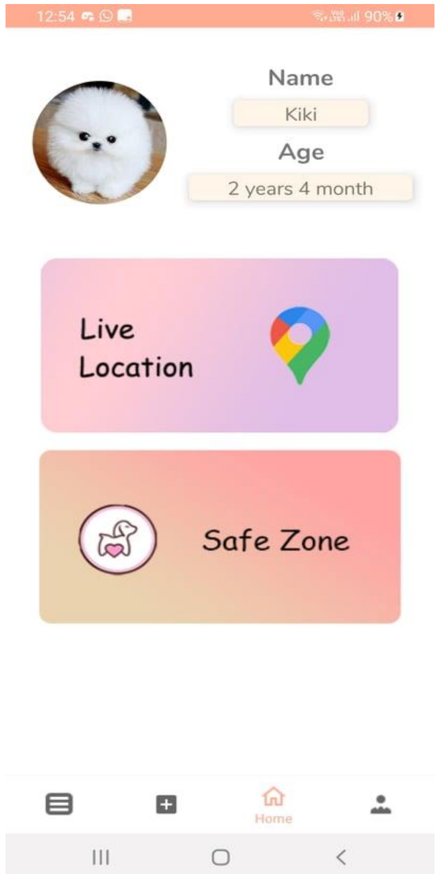
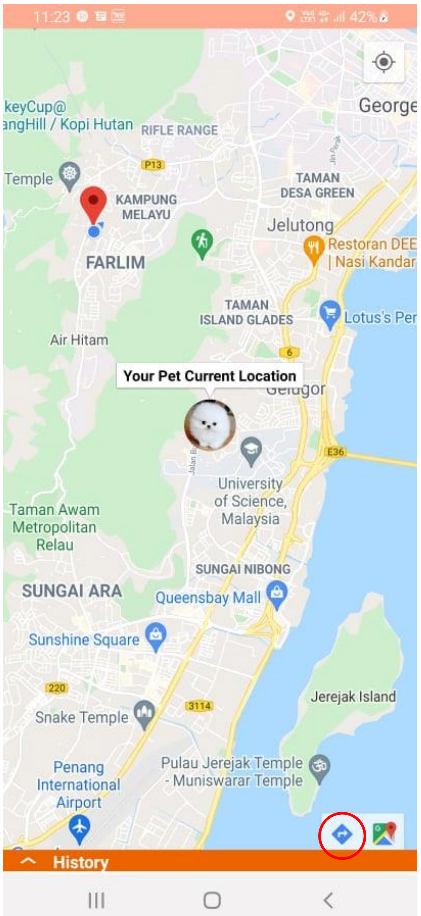


Figure 5.4.5.1 Home page.

Users can view the live location and configure the safe zone in the home page. The bottom navigation bar shows that users can view the news feed, publish a post, view the home page and configure their settings. The application will request users to turn on their location services to live tracking their pets.

5.4.6 Live Tracking and View History



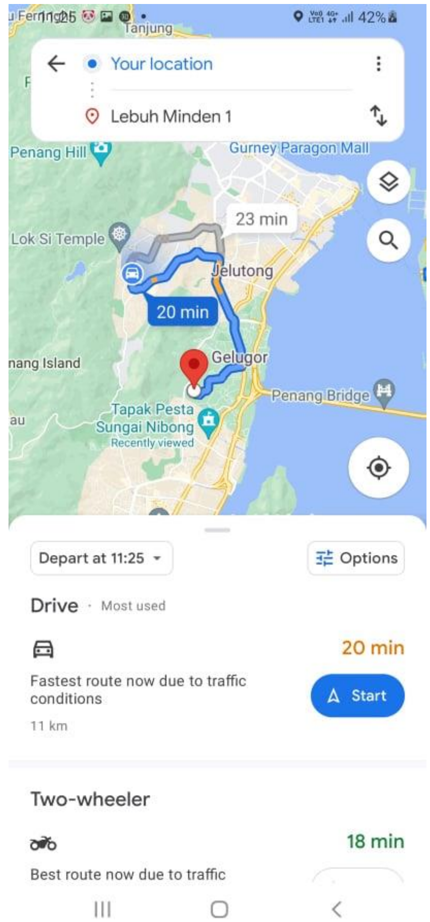


Figure 5.4.6.1 Show the pet current location   Figure 5.4.6.2 Direction to the pet location

After the users select for live tracking, the users can view the live location of their pet. They are able see their current location and the pet current location. Users can drive to the location of their pet when they click the first button on the bottom right. This will direct them to the Google Maps and show the duration of travel to their pet location. Other than that, users can view the places that their pet went when they click on the up arrow on the bottom of the screen then it will pop up a slide up panel to show the history.

5.4.7 Safe Zone Function

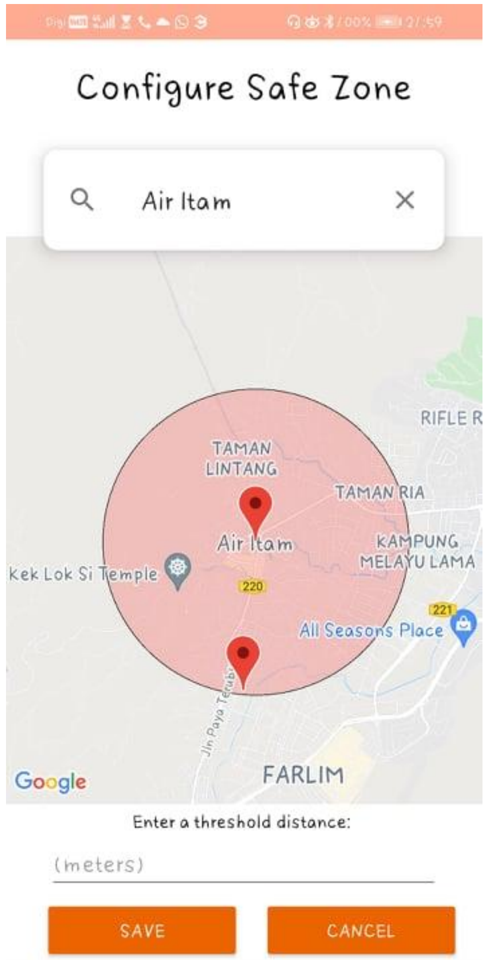


Figure 5.4.7.1 Safe Zone UI

Users can configure the safe zone which set a base location and threshold distance. The data will be stored in the Realtime database in Firebase. After that, the tracking device will retrieve the data from the server after calculation the result of whether the pet is in the safe zone will sent to the server and trigger an alert to the user.

5.4.8 News Feed Module

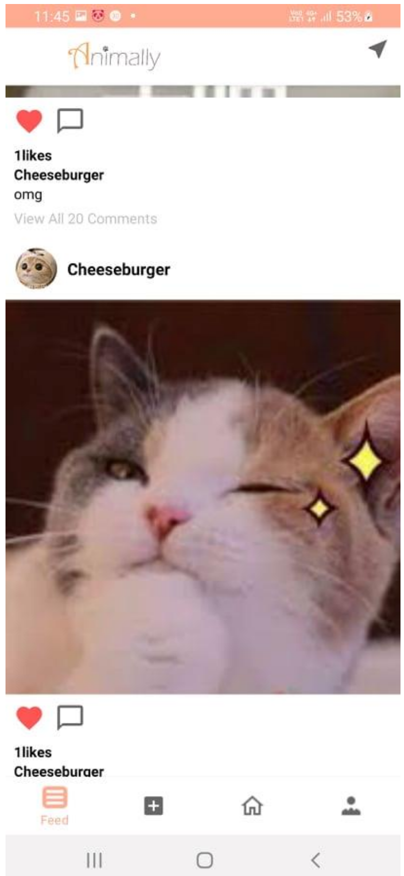


Figure 5.4.8.1 News Feed UI

Users can post news feed when they click the second button of the bottom navigation bar. Then they can view, like and comment the images shared by others.

5.4.9 Settings Page

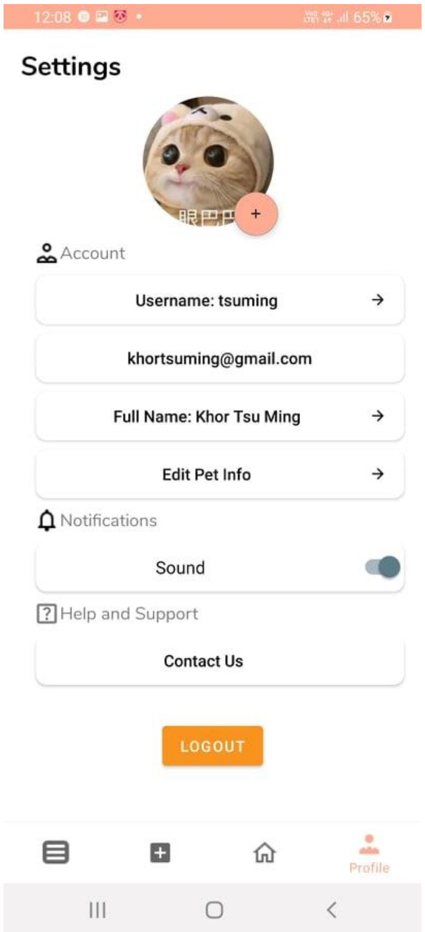


Figure 5.4.9.1 Settings Page

Users can configure the profile image, username, full name, edit the pet info, turn on the notification and contact the customer support.

5.5 Conclusion

This chapter had discussed about the tools used, hardware used, software used, system requirements and the user interface and explanations and descriptions of each functions are documented and label with screenshot pictures.

CHAPTER 6 SYSTEM EVALUATION AND DISCUSSION

6.1 Introduction

This chapter will discuss about the comparison of results in coordinates after filtering the coordinates with Kalman Algorithm. Next, the test cases for each module will be documented. The results and analysis of the survey will also discussed and the project timeline for FYP 1 and FYP2 and lastly planning for the current semester.

6.2 Comparison of results in coordinates after using Kalman Algorithm

There are three sets of data has been collected in different locations to observe the effectiveness of Kalman Algorithm. The table below shows the first set of results which is route from Jalan PJU8/2, Bandar Damansara Perdana, Petaling Jaya to Jalan PJU 8/3, Bandar Damansara Perdana, Petaling Jaya before and after filter the coordinates with Kalman Algorithm. The distance is approximately 1km. The GPS coordinates will be updated every 1 minute.

Before Kalman Algorithm		After Kalman Algorithm		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
3.09836	101.36378	3.16136	101.61379	0.06300	0.25001
3.07852	101.36703	3.14365	101.60595	0.06513	0.23892
3.09623	101.36563	3.16359	101.60580	0.06736	0.24017
3.09657	101.36579	3.15950	101.61572	0.06293	0.24993
3.09700	101.36691	3.16406	101.60335	0.06706	0.23644
3.09720	101.36732	3.16121	101.58726	0.06401	0.21994
3.09708	101.36744	3.16410	101.57389	0.06702	0.20645
3.09722	101.36788	3.16528	101.60788	0.06806	0.24000

Table 6.2.1 Comparison table between coordinates before Kalman Algorithm and after Kalman Algorithm

From the table above, you can observed that there is at least 0.06 to 0.07 difference between the latitude coordinates before Kalman filtering and after Kalman filtering for latitude and there is a range of 0.2 to 0.25 difference of the longitude coordinates.

Before Kalman Algorithm		Real-time Location		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
3.09836	101.36378	3.16339	101.61449	0.06503	0.25071
3.07852	101.36703	3.14485	101.60655	0.06633	0.23952
3.09623	101.36563	3.16554	101.60660	0.06931	0.24097
3.09657	101.36579	3.16160	101.61642	0.06503	0.25063
3.09700	101.36691	3.16590	101.60395	0.06890	0.23704
3.09720	101.36732	3.16352	101.58786	0.06632	0.22054
3.09708	101.36744	3.16620	101.57459	0.06912	0.20715
3.09722	101.36788	3.16720	101.60848	0.06998	0.24060

Table 6.2.2 Comparison table between coordinates before Kalman Algorithm and real-time location

After Kalman Algorithm		Real-time Location		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
3.16136	101.61379	3.16339	101.61449	0.00203	0.0007
3.14365	101.60595	3.14485	101.60655	0.00120	0.0006
3.16359	101.60580	3.16554	101.60660	0.00195	0.0008
3.15950	101.61572	3.16160	101.61642	0.00210	0.0007
3.16406	101.60335	3.16590	101.60395	0.00184	0.0006
3.16121	101.58726	3.16352	101.58786	0.00231	0.0006
3.16410	101.57389	3.16620	101.57459	0.00210	0.0007
3.16528	101.60788	3.16720	101.60848	0.00192	0.0006

Table 6.2.3 Comparison table between coordinates after Kalman Algorithm and real-time location

From table 6.2.2 the differences of latitude are from 0.065 to 0.07 and differences of longitude are 0.2 to 0.25 while from table 6.2.3 the differences of latitude are from 0.001 to 0.002 and differences of longitude is 0.006 to 0.008. The results shows that the coordinates are closer to real-time location after filter the coordinates with Kalman Algorithm.

The second set of data is recorded in 59, Jalan USJ 2/2e, Subang Jaya to 39, Jalan USJ 2/2c, Subang Jaya.

Before Kalman Algorithm		After Kalman Algorithm		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
2.98640	101.38796	3.05663	101.58936	0.07023	0.20140
2.99199	101.35727	3.05614	101.58912	0.06415	0.23185
2.99455	101.32078	3.05559	101.58912	0.06104	0.26834
2.99284	101.35084	3.05523	101.58948	0.06239	0.23864
2.98623	101.37015	3.05561	101.58953	0.06938	0.21938
2.98779	101.34135	3.05551	101.58947	0.06772	0.24812

Table 6.2.4 Comparison table between coordinates after Kalman Algorithm and after Kalman Algorithm

From the table above, you can observed that there is at least 0.06 to 0.07 difference between the latitude coordinates before Kalman filtering and after Kalman filtering for latitude and there is a range of 0.2 to 0.25 difference of the longitude coordinates.

Before Kalman Algorithm		Real-time Location		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
2.98640	101.38796	3.05815	101.58996	0.07175	0.20200
2.99199	101.35727	3.05810	101.58982	0.06611	0.23255
2.99455	101.32078	3.05791	101.58982	0.06336	0.26904
2.99284	101.35084	3.05722	101.58998	0.06438	0.23914
2.98623	101.37015	3.05771	101.59023	0.07148	0.22008
2.98779	101.34135	3.05752	101.59027	0.06973	0.24892

Table 6.2.5 Comparison table between coordinates before Kalman Algorithm and real-time location

After Kalman Algorithm		Real-time Location		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
3.05663	101.58936	3.05815	101.58996	0.00152	0.0006
3.05614	101.58912	3.05810	101.58982	0.00196	0.0007
3.05559	101.58912	3.05791	101.58982	0.00232	0.0007
3.05523	101.58948	3.05722	101.58998	0.00199	0.0005
3.05561	101.58953	3.05771	101.59023	0.00210	0.0007
3.05551	101.58947	3.05752	101.59027	0.00201	0.0008

Table 6.2.6 Comparison table between coordinates after Kalman Algorithm and real-time location

From table 6.2.5 the differences of latitude are from 0.06 to 0.075 and differences of longitude are 0.2 to 0.25 while from table 6.2.6 the differences of latitude are from 0.001 to 0.002 and differences of longitude is 0.006 to 0.008. The results shows that the coordinates are closer to real-time location after filter the coordinates with Kalman Algorithm.

The third set of data is recorded from Case Green, Jalan Jalil Perwira 2, Bukit Jalil to 1, Jalan 8/155, Jalan 5/155, Bukit Jalil.

Before Kalman Algorithm		After Kalman Algorithm		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
2.97926	101.40684	3.06160	101.66307	0.08234	0.25623
2.98658	101.42813	3.06150	101.66385	0.07492	0.23572
2.99391	101.45153	3.06123	101.66383	0.06732	0.21230
2.99990	101.45964	3.06229	101.66380	0.06239	0.20419
3.01053	101.39409	3.06291	101.66432	0.05238	0.25023
2.98171	101.40858	3.06132	101.66392	0.07961	0.25534

Table 6.2.7 Comparison table between coordinates after Kalman Algorithm and after Kalman Algorithm

Before Kalman Algorithm		Real-time Location		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude

2.97926	101.40684	3.06411	101.66427	0.08485	0.25743
2.98658	101.42813	3.06413	101.66445	0.07755	0.23632
2.99391	101.45153	3.06416	101.66463	0.07025	0.21310
2.99990	101.45964	3.06411	101.66480	0.06421	0.20516
3.01053	101.39409	3.06392	101.66482	0.05339	0.27073
2.98171	101.40858	3.06334	101.66482	0.08163	0.25624

Table 6.2.8 Comparison table between coordinates before Kalman Algorithm and real-time location

After Kalman Algorithm		Real-time Location		Differences	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
3.06160	101.66307	3.06411	101.66427	0.00251	0.0012
3.06150	101.66385	3.06413	101.66445	0.00263	0.0006
3.06123	101.66383	3.06416	101.66463	0.00293	0.0008
3.06229	101.66380	3.06411	101.66480	0.00182	0.0010
3.06291	101.66432	3.06392	101.66482	0.00101	0.0005
3.06132	101.66392	3.06334	101.66482	0.00202	0.0009

Table 6.2.9 Comparison table between coordinates after Kalman Algorithm and real-time location

From table 6.2.8 the differences of latitude are from 0.05 to 0.08 and differences of longitude are 0.2 to 0.28 while from table 6.2.9 the differences of latitude are from 0.001 to 0.003 and differences of longitude is 0.0005 to 0.002. The results shows that the coordinates are closer to real-time location after filter the coordinates with Kalman Algorithm.

Hence, the results above can show that Kalman Algorithm can improve the accuracy for locating the pets. Other than that, the real-time location also has been recorded which proofs that the coordinates after filter with Kalman Algorithm is closer to the real-time location.

6.3 Test Cases for Completed Module

The test cases for each module will be documented in below. Each of the input, buttons, functions, page and expected result after the database operation will be tested in each module. Other than that, the tracking device will be packaged at wear it on an outdoor cat to retrieve the history and live location of the pet. Location data that are filtered by Kalman algorithm will be verified to ensure that the tracking device obtained the exact location of the pet. Besides that, the battery of the tracking device will be tested to ensure that the battery can lasts up to 3 days.

6.3.1 Login module for pet owners

Test case module: Login Module unit testing

Test Description: To test Login using email and password

Test steps	Step Description	Data Utilized	Expected Result	Actual Result	Pass/Fail /Haven't
1	Test a valid email and password email: khortsuming@gmail.com password: 123456	Email and password are registered in Firebase	Login successful and go to the next page	Redirect new user to create a new pet profile or redirect existing user to the main menu	Pass
2	Test a valid email but invalid password	Email and password are registered in Firebase	Display error: Sorry invalid email and password.	"Incorrect email or password entered"	Pass
4	Test an invalid email	-	Display error: Invalid email format.	"Email is not registered yet" and	Pass

				redirect user to the sign up page	
5	Leave email and password text fields empty and click "Login" button	-	Display error: Please fill in all the empty values.	Display error: Please fill in all the empty values.	Pass

Table 6.3.1.1 Login Module unit testing

6.3.2 Connecting to Tracking Device using Bluetooth Module

Test case module: Connecting to tracking device using Bluetooth unit testing

Test description: To test if the application is connected to the tracking device

Test steps	Step Description	Data Utilized	Expected Result	Actual Result	Pass/Fail /Haven't
1	Power on tracking device and paired with the tracking device	-	A message will display the ID of the tracking device and redirect users to create a new pet profile.	Display: Your tracker ID is SIM808	Pass

2	Did not power on the tracking device		Display error: You are not connected to a tracking device	Display error: You are not connected to a tracking device	Pass
3	Power on tracking device and did not paired with the tracking device		Display error: You are not connected to a tracking device	Display error: You are not connected to a tracking device	Pass
3	Power on tracking device but did not turn on Bluetooth		Redirect users to Bluetooth settings page and remind them to turn on the Bluetooth to pair up the tracking device.	Redirect users to Bluetooth settings page and remind them to turn on the Bluetooth to pair up the tracking device.	Pass

Table 6.3.2.1 Connecting to Tracking Device using Bluetooth Module

6.3.3 Pet Profile Module

Test case module: Pet Profile Module unit testing

Test Description: To test create a new profile for pet

Test steps	Step Description	Data Utilized	Expected Result	Actual Result	Pass/Fail /Haven't
1	Input all the required fields	-	Successfully create a pet profile and redirect to the home page	Successfully create a pet profile and redirect to the home page	Pass
2	Input an invalid birthday which is not in date format	-	Display error: invalid birthday format	Display error: invalid birthday format	Pass
3	Did not upload an image for pet	-	Display error: pet image is empty	Display error: Pet image is empty	Pass

4	Leave name, birthday, pet primary breed or pet secondary breed empty	-	Display error for the stated that it is empty	Display error: Pet name is empty	Pass

Table 6.3.3.1 Pet Profile Module unit testing

6.3.4 Safe Zone Module

Test case module: Safe Zone module unit testing

Test Description: To test configuration of safe zone threshold distance

Test steps	Step Description	Data Utilized	Expected Result	Actual Result	Pass/Fail /Haven't
1	Set a location and input the threshold distance	-	Successfully create a configure the safe zone radius within the location.	Successfully create a configure the safe zone radius within the location.	Pass
3	Set location and did not input threshold distance	-	Display error: Please enter a threshold distance	Display error: Please enter a threshold distance	Pass

4	Set threshold distance and did not set location	-	Display error: Please set a location	Display error: Please set a location	Pass
2	Did not set location and did not input threshold distance	-	Display error: Please enter a threshold distance	Display error: Please enter a threshold distance	Pass

Table 6.3.4.1 Safe Zone Module unit testing

6.3.5 News Feed Module

Test case module: News Feed module unit testing

Test Description: To test the news feed function

Test steps	Step Description	Data Utilized	Expected Result	Actual Result	Pass/Fail /Haven't
1	Input comment into the text field and click post.	-	Successfully create a comment in the news feed on a particular post.		Pass

2	Leave the text field blank and click post.	-	Display error: You can't leave an empty comment!		Pass

Table 6.3.5.1 News Feed Module unit testing

6.3.6 Post Image and Status Module

Test case module: Post Image and status module unit testing

Test Description: To test the post image and status function

Test steps	Step Description	Data Utilized	Expected Result	Actual Result	Pass/Fail /Haven't
1	Input comment into the text field and click post.	-	Successfully create a comment in the news feed on a particular post.		Pass
2	Leave the text field blank and click post.	-	Display error: You can't leave an empty comment!		Pass

Table 6.3.6.1 Post Image and Status module unit testing

6.4 Tracking Device

The tracking device has been tested and attached to the dog collar. The tracking device was first wrapped in plastic and then wrapped in cloth and tied to the dog collar.

Figure 6.4.1 Tracking device tested on a dog

6.5 Analysis of Survey

The online questionnaire survey has been conducted based on the functions obtained from the existing applications. The survey has collected 42 valid responses from the pet owners using Google Form to collect and analyze data. The analysis of the survey is presented in tables and histograms.

6.5.1 Demographic data

The demographic data had shown that only 13 (31%) of respondents had experience using tracking system to locate their pets even though the pets location tracking system has been exist for 9 years.

Demographics		Sample	Percentage
Gender	Female	25	59.5%
	Male	17	40.5%
Age	<20	8	19%
	21 – 30	18	42.9%
	31 – 40	11	26.2%
	41 – 50	3	7.1%
	51 - 60	2	4.8%
Nationality	Malaysian	42	100%
	Non-Malaysian	0	0%
Do you have any experience using any system to track your pets?	Yes	13	31%
	No	29	69%

Table 6.5.1.1 Demographic data of the respondents

6.5.2 Survey results

The results of the survey in Table 6.5.2.1 showed the combined responses in percentages and figures. The "strongly agree" and "agree" are combined as "agree responses" while "strongly disagree" and "disagree" are combined as "disagree" responses.

The results in Table A and Table B in Appendix showed that 31 (73.8%) of respondents agreed that "The accuracy of location provided by the tracking device must be precise." and 30 (71.4%) of respondents agreed that "I am concern about my pet health when wearing electronic sensors and devices". Other than that, there are 29 (69.1%) of respondents agreed that "I can find and track the pets which can the pet position and report for lost pet.".

Preferred Features	Agree (%)	Disagree (%)	Unsure (%)
Tracking Device	54.4	27	18.6
Features of Mobile Application	54.4	25.2	20.4

Table 6.5.2.1 Percentage of combined respondents' responses by preferred features

From the table above, it shows that the tracking device and features of mobile application have the equal percentage of agree which determine that users expressed that the feature of the mobile application is as significant as the tracking device. Other than that, the statement "The tracking device don't have to be water resistance" have the highest disagreement which concludes that users demand a tracking device that is water resistant. Furthermore, the statement "I can contact administration to solve the problems I met when using the application" has 25 (59.5%) of respondents agreed which expressed that user need for support when they faced problems in the mobile application or tracking device.

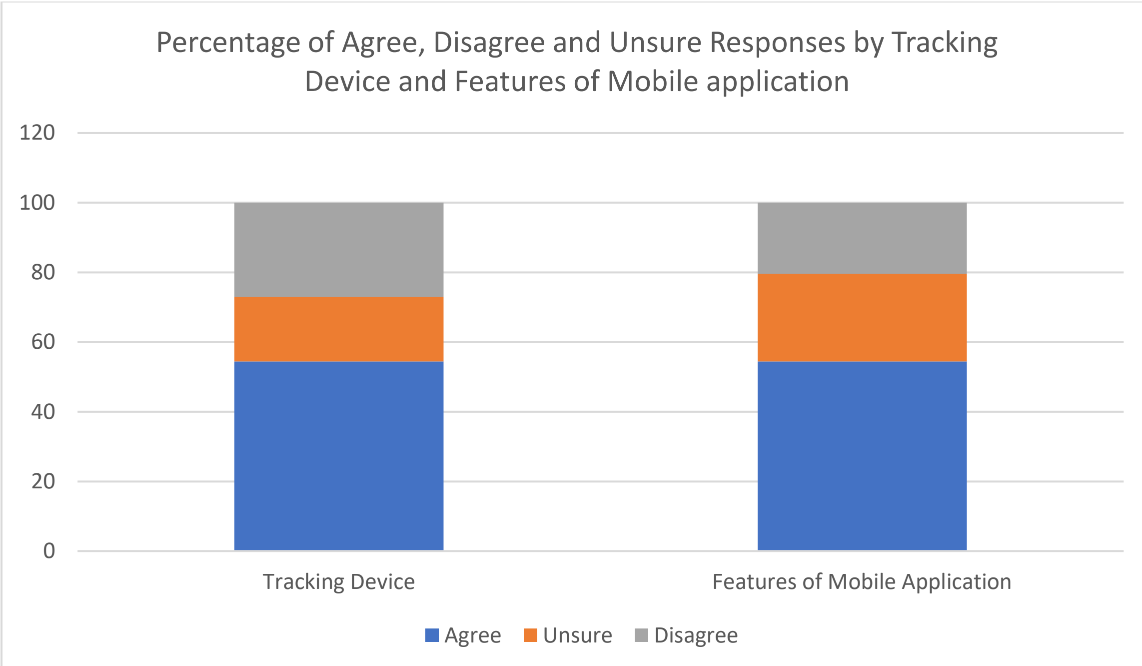


Figure 6.5.2.2 Percentage of Agree, Disagree and Unsure Responses by Tracking Device and Features of Mobile application

The functional and non-functional requirements are constructed in Chapter 3 are results from the online survey questionnaire from 42 pet owners.

6.6 Algorithm Results

The tables below is the conclusion of the results from table 6.2.2, table 6.2.3, table 6.2.5, table 6.2.6, table 6.2.8 and table 6.2.9. The tables show the differences between 3 sets of data obtained from Petaling Jaya, Subang Jaya and Bukit Jalil. The differences between before Kalman Algorithm and real-time location has a range of 0.05 to 0.08 for latitude and 0.2 to 0.28 of difference for longitude.

Differences between before Kalman Algorithm and real-time location					
Set 1		Set 2		Set 3	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
0.065 to 0.07	0.2 to 0.25	0.06 to 0.075	0.2 to 0.25	0.05 to 0.08	0.2 to 0.28

Table 6.6.1 Differences between before Kalman Algorithm and real-time location

Differences between after Kalman Algorithm and real-time location					
Set 1		Set 2		Set 3	
Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
0.001 to 0.002	0.006 to 0.008	0.001 to 0.002	0.006 to 0.008	0.001 to 0.003	0.0005 to 0.002

Table 6.6.2 Differences between after Kalman Algorithm and real-time location

From table 6.6.2, the differences between after Kalman Algorithm and real-time location has 0.001 to 0.003 for latitude and 0.0005 to 0.002 for longitude. It can be observe that the differences of the actual result with the coordinates without filtering with Kalman Algorithm are higher than the differences between the actual result and the coordinates with Kalman Algorithm. Hence, it can conclude that Kalman Algorithm will improve the accuracy of the coordinates.

6.7 Project Challenges

During implementation, the documentation, or tutorials regarding the SIM808 module are very less and there's not much discussion regarding the getting the GPS data and sending it to the Firebase. After intensive research, it can obtain GPS data from the SIM808 Module but the module and Arduino UNO are connected to the computer and power supply as the coordinates are not accurate since the implementation had been done indoors. Besides that, the SIM808 Module required a cold start for about 2 to 5 minutes in order to power up the GPRS and GSM. It has been tested with batteries with 2 7V lithium batteries which it could only sustain for a few days. Other than that, it is found that SIM808 can only POST/GET HTTP requests while Firebase only accepts HTTPS requests. So, it required a proxy server to receive the data from SIM808 and transfer using HTTPS requests to the Firebase. Other than that, GPS and Bluetooth will drained the battery very quickly. It is estimates that the battery only will lasts for 2 to 3 days. In addition, Arduino UNO only have 2K bytes of SRAM which is more than 100,000 times less physical memory than a low-end PC. So, if there's too much functions Arduino UNO may run out of memory and stability issues may occur.

When implementing the Kalman Algorithm, the libraries found in Github are mainly for Python implementation or Java which is intended to be used in Android (filter location data obtained from the mobile). It is very challenging for a beginner to implement the algorithm that filters the longitude, latitude and timestamp to get more accurate results.

6.8 Timeline

6.8.1 Gantt chart of FYP1

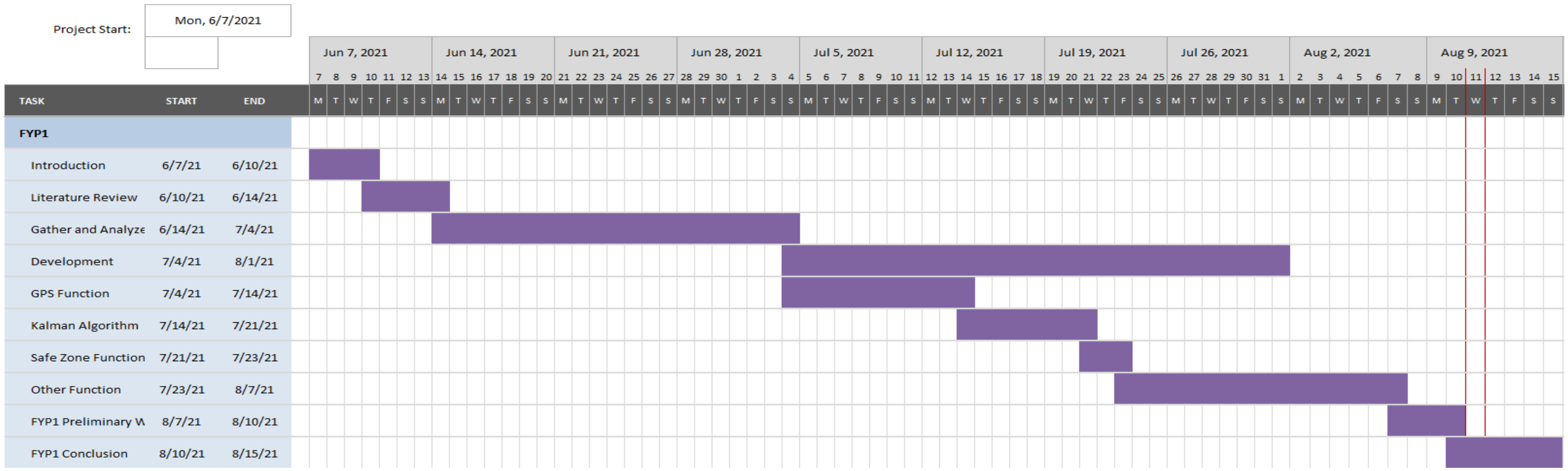


Figure 6.8.1.1 Gantt chart of FYP 1 from 7th Jun 2021 to 15th August 2021

6.8.2 Work done in FYP1 on last semester

There are several objectives that have been done in FYP1 last semester. The introduction, literature review and system design has been documented in FYP1 for reference in FYP2. Most of the primary functions of the applications have been done in FYP1. The estimated outcome of FYP1 that has finished around 50 to 60 percent of the prototype of this project. Figure 4.10.1.1 and Table 4.10.3.1 show the Gantt chart the details of the time that each tasks taken to complete.

TASK	Start Date	Expected Days	End Date	Done(%)	Days to Complete
Introduction	7/6/2021	4	10/6/2021	100	3

Literature Review	10/6/2021	5	14/6/2021	100	6
Gather and Analyze Requirements	14/6/2021	21	4/7/2021	100	19
Development	4/7/2021	51	1/8/2021	100	63
GPS Function	4/7/2021	11	14/7/2021	80	4
Kalman Algorithm	14/7/2021	8	21/7/2021	100	3
Safe Zone Function	21/7/2021	3	23/7/2021	50	7
Other Function	23/7/2021	10	7/8/2021	100	10
FYP1 Preliminary Work	7/8/2021	4	10/8/2021	100	5
FYP1 Conclusion	10/8/2021	6	15/8/2021	100	4

Table 6.8.2.1 Gantt chart of Overall FYP1 timeline

6.8.3 Planning for current semester (FYP2)

The planning for this semester would be complete each module and functionality that are listed in the project objectives and user requirements. During the development phase, each module will be improvised and issues that are faced in FYP1 will be solved. Other than that, other GPS chips will be considered and tested to have a smaller tracking device and battery saving device. Besides that, the UML diagram will be updated if there is any changes during the development. Starting from week 10, each module will be tested to ensure the features functioned properly and error freed. Finally, on week 12, every module will be combined in one application. Figure 6.8.3.1 and table 6.8.3.2 has shown the timeline of each task.

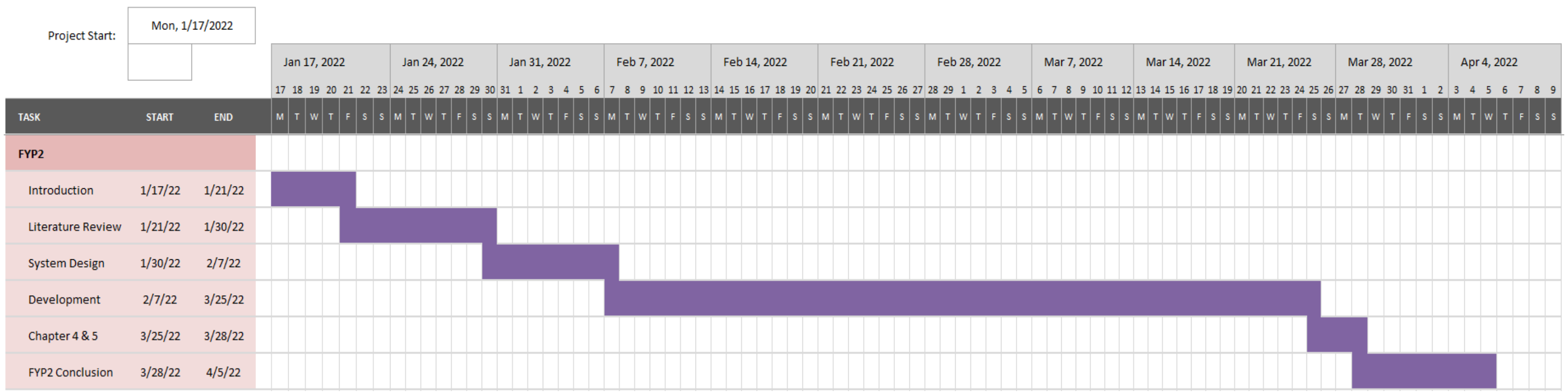


Figure 6.8.3.1 Gantt Chart of FYP2 from 17th Jan 2022 to 5th April 2022

6.8.4 Gantt chart of FYP 2 timeline

TASK	Start Date	Expected Days	End Date	Done(%)	Days to Complete
Introduction	17/1/2022	4	21/1/2022	100	5

Literature Review	21/1/2022	9	30/1/2022	100	8
System Design	30/1/2022	9	7/2/2022	100	9
Development	7/2/2022	18	25/3/2022	100	20
Chapter 4 & 5	25/3/2022	3	28/3/2022	100	5
FYP1 Conclusion	28/3/2022	9	5/4/2022	100	5

Table 6.8.4.1 Gantt chart of Overall FYP2 timeline

6.9 Conclusion

In conclusion, this chapter had compare the results in coordinates after using Kalman Algorithm. Other than that, the unit tests of each completed module have been discussed in detail. All the result of the modules meets the expected result. The results and analysis of the survey and project timeline for FYP 1 and FYP2 and lastly planning for the current semester was also documented.

CHAPTER 7 CONCLUSION AND RECOMMENDATION

7.1 Introduction

In conclusion, the proposed project aims to provide a solution for improving the existing technologies used to find back the lost pets and set up a virtual safe zone which pet owners will get an alert when the pet leaves the safe zone. In addition, the accuracy of the GPS coordinates has been improved by using Kalman algorithm. Pet owners can remotely monitor their pet's location. A GPS tracking device has been set up and pet owners are able to connect to the tracking device easily by pairing it with Bluetooth. Other than that, users can post the images and status regarding their pets to the community as an extra feature of this application.

By the end of this project, some of the objectives and modules that had been achieved will be stated in the following part. The solutions to solve the problems faced in this project will also be documented. This project has help pet owners to set up a virtual safe zone which they would be alerted when their pet leaves the neighborhood and users are able to live track their pets immediately if they lost track of their pet. With the GPS technology, they would not lost their valuable family again.

In the end of this project report, the goals and objectives that have been achieved are stated in the next session. Based on the limitation, possible solutions have been provided for future work to improve the problem faced will also be documented.

7.2 Findings

In the end of this project report, the goals and objectives that have been achieved are stated in the next session. Based on the limitation, possible solutions have been provided for future work to improve the problem faced will also be documented.

The objectives and sub-objectives that have been achieved:

1st Objective: To determine user requirements by using online survey questionnaires.

a) Questions will be designed to determine the user requirements on the proposed system. (Done)
b) Questionnaires will be distributed and results will be analyzed. (Done)

2^{nd} Objective: To authenticate users which provide sign up and sign in functions in the mobile application.

a) Users can sign up and sign in using Google and email which implements through Firebase. (Done)

3^{rd} Objective: To connect the tracking device with the mobile application.

a) Users will be able to use Bluetooth to pair the tracking device with the mobile application. (Done)

4^{th} Objective: To set up a virtual safe zone for the pets which the owner will be notified when the pets leave.

a) Users are able to use the function of setting up a virtual safe zone using GPS technology through the user interface of the mobile application. (Done)
b) Users would receive an alert if the pets left the safe zone (Done)

5^{th} Objective: To store data of the pets.

a) Pets' data will be stored in the Firebase Realtime Database. (Done)
b) Users can store and view the data of their pets. (Done)

6^{th} Objective: To receive coordinates from the tracking device to the remote database.

a) The tracking device will upload the location coordinates (X(k), Y(k)) and time instant k to the remote database (Firebase) and the data obtained will be filtered using Kalman algorithm to increase the accuracy. The filtered location data will be used by the mobile application to track pets' location. (Done)

7^{th} Objective: To track the live location of the pets.

a) Coordinates are obtained from the remote database (Firebase) and filtered with Kalman algorithm. Users can view the location of their pets in Google Maps. (Done)
b) Track the path and history that the pets have gone. (Done)

8^{th} Objective: To post details about their pets

a) Users are able to publish the images and status of their pets and interact with other users. (Done)

The modules that have been achieved:

a. Sign up and sign in to the mobile application. (Fully)
b. Connect the tracking device to the application using Bluetooth. (Fully)
c. Create a pet profile. (Fully)
d. Receive coordinates from the tracking device to the remote database. (Fully)
e. Track the live location of the pets. (Fully)
f. Set up a virtual safe zone using GPS technology. (Fully)
g. Able to post news feed. (Fully)

7.3 Limitation

During the development process of the tracking device and mobile application, there is some limitations and issues need to be taken into consideration:

1. The tracking device would not get the exact location if it were in indoor.

2. The tracking device would drained the battery very quickly. It is estimated the battery only lasts for 2 to 3 days. Other than that, the size and weight of the tracking device may not be suitable for small pets.

3. The project only available for android user to use the pet's location tracking mobile application with purchased tracking device.

4. Users only are able to register one pet to one account due to the only one tracking device is allowed to link to one account.

5. There may exist security concern which everyone that used the application is able to view the posts and comments and some users may speak vulgarly to annoy other users.

6. Due to cost and skill constraint, incapability to research other GPS chips to compare and analysis the effectiveness and size of the tracking device.

7.4 Future Recommendation

This section is to improve the limitation stated above:

1. Only perform live tracking when the pets are in outdoor.

2. The tracking device and the live tracking should be configured to the sleep mode when the users did not report lost pet. A lighter and smaller battery should be research and used in the tracking device.

3. This project only plans to develop for the android user. However, other researchers are able to develop a cross-platform or iOS-based application in future.

4. Users are able to link several tracking devices to an account and create several pet profiles on different tracking device.

5. Forbidden users to enter vulgar comments and spam comments.

6. Research on more effective, smaller size and waterproof GPS chips.

7.5 Conclusion

In conclusion, this chapter had summarised the problem of the existing solutions and had described the issues of proposed system and method that will be implemented to solve the issues. Other than that, the list of objectives and modules that are achieved and the limitation of this project has been documented in this chapter. Lastly, the recommendation listed can be done to enhance the pet location tracking system in the aspect of effectiveness and security measures. In the final analysis, the result of this proposed project considers as a prototype product and has achieved all the objectives listed in section 1.6.

From this project, majority of the features are not just for solving the problem of tracking pets, the idea and concept could be implemented in tracking children and elders. For both systems, the main priority is to solve the issue of security and size issue. In order to secure the safety of children and elderly, watch-like device could be invented to track the users exact location but privacy issue must be considered.

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APPENDIX

TABLE A. SUMMARY OF RESPONSES TO 48 SURVEY QUESTIONS USING 5 POINT LIKERT SCALE

PF/N		Survey Questions	% Strongly agree	% Agree	% Neutral	% Disagree	% Strongly disagree
TD	1	The tracking device battery life is more important than the duration of charging time.	26.2	28.6	23.8	11.9	9.5
	2	The tracking device don't have to be water resistance.	19	4.8	9.5	38.1	28.6
	3	The location provided by the tracking device must be precise.	28.6	45.2	7.1	14.3	4.8
	4	The accuracy of location provided are more important the time taken to obtain the location.	21.4	28.6	26.2	19	4.8
	5	I am concern about my pet health when wearing electronic sensors and devices.	19	52.4	19	4.8	4.8
	6	I am concern that the tracking device will be too heavy for my pets.	19	33.3	26.2	11.9	9.5
F	7	I can register and log in to the mobile application.	35.7	26.2	9.5	16.7	11.9
	8	I can add, edit, delete, and view the pet position and report for lost pet.	21.4	35.7	19	11.9	11.9
	9	I can find and track the pets which can get the pet position and report for lost pet.	16.7	52.4	11.9	9.5	9.5
	10	I can post information about my pets.	14.3	35.7	21.4	14.3	14.3
	11	I can contact administration to solve the problems I met when using the application.	21.4	38.1	19	16.7	4.8
	12	I can configure a safe zone that I will receive a notification when my pet leaves the area.	16.7	16.7	33.3	14.3	19

	13	I am able to discuss and exchange ideas with people about my pets.	23.8	26.2	28.6	16.7	4.8

TABLE B. COMBINED RESPONSES OF RESPONDENTS

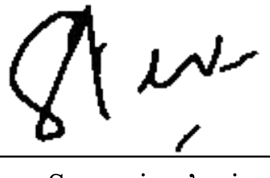
PF/N		Survey Questions	Agree	Disagree
TD	1	The tracking device battery life is more important than the duration of charging time.	23(54.8%)	9(21.4%)
	2	The tracking device don't have to be water resistance.	10(23.8%)	28(66.7%)
	3	The location provided by the tracking device must be precise.	31(73.8%)	8(19.1%)
	4	The accuracy of location provided are more important the time taken to obtain the location.	21(50%)	10(23.8%)
	5	I am concern about my pet health when wearing electronic sensors and devices.	30(71.4%)	4(9.6%)
	6	I am concern that the tracking device will be too heavy for my pets.	18(52.3%)	9(21.4%)
F	7	I can register and log in to the mobile application.	26(61.9%)	12(28.6%)
	8	I can add, edit, delete, and view the pet position and report for lost pet.	24(57.1%)	10(23.8%)
	9	I can find and track the pets which can get the pet position and report for lost pet.	29(69.1%)	8(19.1%)
	10	I can post information about my pets.	21(50%)	12(28.6%)
	11	I can contact administration to solve the problems I met when using the application.	25(59.5%)	9(21.4%)
	12	I can configure a safe zone that I will receive a notification when my pet leaves the area.	14(33.4%)	14(33.4%)
	13	I am able to discuss and exchange ideas with people about my pets.	21(50%)	9(21.4%)

FINAL YEAR PROJECT WEEKLY REPORT

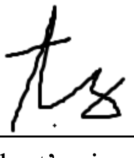
(Project II)

Trimester, Year: 2,3	**Study week no.:1**
Student Name & ID: KHOR TSU MING 1906240	
Supervisor: Mr. Phan Khoo Yuen	
Project Title: Pets Location Mobile Tracking System using Kalman Algorithm	

1. WORK DONE
• Rewrite chapter 1 and 2 • Review IIPSW report and guideline
2. WORK TO BE DONE
• Complete Chapter 1 and 2 • Progressing on Safe Zone module
3. PROBLEMS ENCOUNTERED
N/A
4. SELF EVALUATION OF THE PROGRESS
Keep up on the good work



Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT
(Project II)

Trimester, Year: 2,3	**Study week no.: 3**
Student Name & ID: KHOR TSU MING 1906240	
Supervisor: Mr. Phan Khoo Yuen	
Project Title: Pets Location Mobile Tracking System using Kalman Algorithm	

1. WORK DONE • Complete chapter 1 and 2 • Complete Safe Zone module
2. WORK TO BE DONE • Complete chapter 3 • Complete Live Tracking module
3. PROBLEMS ENCOUNTERED Arduino lack of memory can't insert too many functions into Arduino
4. SELF EVALUATION OF THE PROGRESS Don't give up

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT
(Project II)

Trimester, Year: 2,3	**Study week no.: 5**
Student Name & ID: KHOR TSU MING 1906240	
Supervisor: Mr. Phan Khoo Yuen	
Project Title: Pets Location Mobile Tracking System using Kalman Algorithm	

1. WORK DONE

- Complete chapter 3
- Complete Live Tracking module

2. WORK TO BE DONE

- Work on chapter 4
- Test each module

3. PROBLEMS ENCOUNTERED

problems occur when tracking the location history of the pets

4. SELF EVALUATION OF THE PROGRESS

Don't give up

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: 2,3	**Study week no.: 7**
Student Name & ID: KHOR TSU MING 1906240	
Supervisor: Mr. Phan Khoo Yuen	
Project Title: Pets Location Mobile Tracking System using Kalman Algorithm	

1. WORK DONE

- Complete chapter 4

2. WORK TO BE DONE

- Fix bugs on the module

3. PROBLEMS ENCOUNTERED

N/A

4. SELF EVALUATION OF THE PROGRESS

N/A

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: 2,3	**Study week no.: 9**
Student Name & ID: KHOR TSU MING 1906240	
Supervisor: Mr. Phan Khoo Yuen	
Project Title: Pets Location Mobile Tracking System using Kalman Algorithm	

1. WORK DONE

- Fixed the bugs on some of the module
- Finish the testing on each module

2. WORK TO BE DONE

- Complete chapter 5

3. PROBLEMS ENCOUNTERED

N/A

4. SELF EVALUATION OF THE PROGRESS

Just do it

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT
(Project II)

Trimester, Year: 2,3	**Study week no.: 11**
Student Name & ID: KHOR TSU MING 1906240	
Supervisor: Mr. Phan Khoo Yuen	
Project Title: Pets Location Mobile Tracking System using Kalman Algorithm	

1. WORK DONE • Complete chapter 5
2. WORK TO BE DONE • Complete chapter 6
3. PROBLEMS ENCOUNTERED N/A
4. SELF EVALUATION OF THE PROGRESS N/A

_________________________ Supervisor's signature

_________________________ Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: 2,3	**Study week no.: 13**
Student Name & ID: KHOR TSU MING 1906240	
Supervisor: Mr. Phan Khoo Yuen	
Project Title: Pets Location Mobile Tracking System using Kalman Algorithm	

1. WORK DONE

- Complete chapter 6

2. WORK TO BE DONE

- Complete everything

3. PROBLEMS ENCOUNTERED

N/A

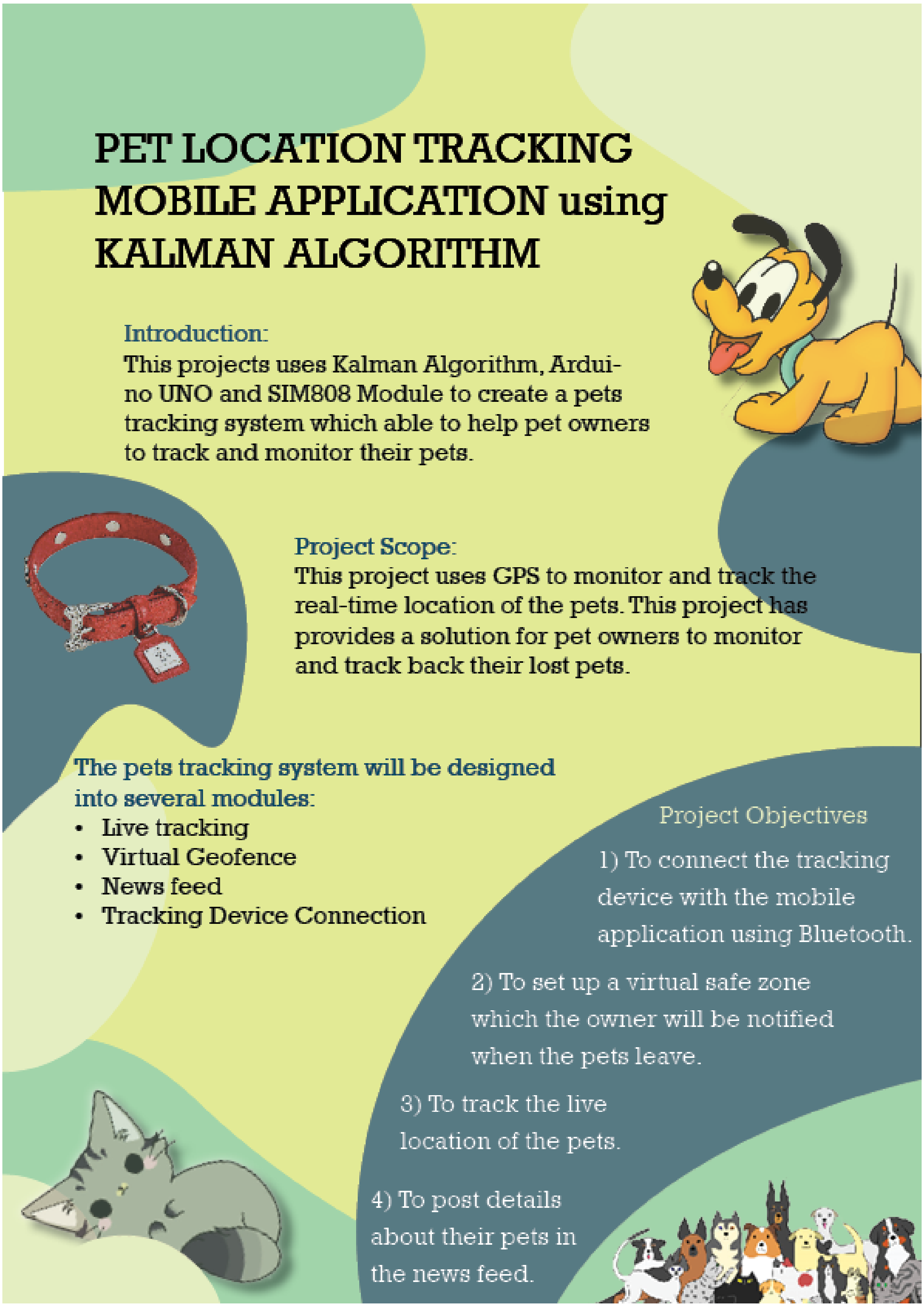
4. SELF EVALUATION OF THE PROGRESS

I can do it

Supervisor's signature

Student's signature

POSTER



PET LOCATION TRACKING MOBILE APPLICATION using KALMAN ALGORITHM
Introduction:
This projects uses Kalman Algorithm, Arduino UNO and SIM808 Module to create a pets tracking system which able to help pet owners to track and monitor their pets.
Project Scope:
This project uses GPS to monitor and track the real-time location of the pets. This project has provides a solution for pet owners to monitor and track back their lost pets.
The pets tracking system will be designed into several modules:
• Live tracking
• Virtual Geofence
• News feed
• Tracking Device Connection
Project Objectives
1) To connect the tracking device with the mobile application using Bluetooth.
2) To set up a virtual safe zone which the owner will be notified when the pets leave.
3) To track the live location of the pets.
4) To post details about their pets in the news feed.

PLAGIARISM CHECK RESULT

fyp2

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Form Number: FM-IAD-005	Rev No.: 0	Effective Date: 01/10/2013	Page No.: 1of 1

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FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Khor Tsu Ming
ID Number(s)	19ACB06240
Programme / Course	Bachelor of Computer Science (Honours)
Title of Final Year Project	Pets location mobile tracking application using Kalman Algorithm

Similarity	**Supervisor's Comments** **(Compulsory if parameters of originality exceeds the limits approved by UTAR)**
Overall similarity index: 17 **%** **Similarity by source** Internet Sources: 15 % Publications: 5 % Student Papers: 7 %	
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Note Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor	Signature of Co-Supervisor
Name: Phan Koo Yuen	Name:
Date: 18/4/2022	Date:

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

CHECKLIST FOR FYP2 THESIS SUBMISSION

Student Id	19ACB06240
Student Name	Khor Tsu Ming
Supervisor Name	Mr. Phan Khoo Yuen

TICK (√)	**DOCUMENT ITEMS** Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
	Front Plastic Cover (for hardcopy)
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√	Signed Report Status Declaration Form
√	Signed FYP Thesis Submission Form
√	Signed form of the Declaration of Originality
√	Acknowledgement
√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
√	List of Symbols (if applicable)
√	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
√	Appendices (if applicable)
√	Weekly Log
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√	I agree 5 marks will be deducted due to incorrect format, declare wrongly the ticked of these items, and/or any dispute happening for these items in this report.

*Include this form (checklist) in the thesis (Bind together as the last page)

I, the author, have checked and confirmed all the items listed in the table are included in my report.

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(Signature of Student)

Date:18/4/2022